Departmental Review Period: 2015-2021

Department of Mechanical Engineering
IIT Kanpur India

November 07-08, 2022

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Welcome to the

Department of Mechanical Engineering

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Annexure A: Department Information

Department of Mechanical Engineering

One of the founding units of the Institute, the Department of Mechanical Engineering at IIT Kanpur has played a leading role in defining and executing a unique engineering science curriculum that has served as a model for academic programs around the country. It has played a prominent role by setting highest standards in teaching, while creating new interdisciplinary programs in industrial engineering, mechatronics, design, and nuclear engineering and technology. Developments in the field of electronics, computers, lasers and automation have been integrated into academic programmes, thus creating an edge in its professional activities. Newer domains such as Artificial Intelligence and Machine Learning are in the process of inclusion.

The Department graduates around 150 undergraduates, 80-100 Masters and 15-20 PhDs per year. Many of its alumni hold eminent positions in academia and industry around the world. A wide spectrum of courses is offered at levels ranging from the undergraduate to doctoral degree program. Many subjects such as computational mechanics, laser measurements, micro scale transport phenomena, smart materials and structures, multi-scale simulation, rapid prototyping, futuristic manufacturing, design of thermal systems, artificial intelligence and machine learning, are offered as electives. On an average, at least two to three new courses are proposed every year, keeping in mind the development of the discipline. We are also well-recognized for leading student initiatives such as the nano-satellite and the Boeing-supported autonomous vehicle program.

Faculty members, 45 in number at present, have excellent academic credentials and are highly regarded by peers. They have been conferred awards at national and international levels. The fellowships received by the faculty members include Boyscast, Swarnajayanti, Bhatnagar, Humboldt and JSPS. Many of the faculty members have membership in one or more professional societies and a few are elected Fellows of various professional bodies such as INAE, INSA and ASME. Several serve on the editorial boards of international and national journals, review technical articles for journals on a regular basis and are technical and organizing committee members of international symposia and conferences. Several others have excelled in teaching, and have been conferred awards and recognitions for their seminal contributions. We also have a very healthy tradition of disseminating knowledge via writing books and monographs. Faculty members have authored quite a few textbooks and some are recognized as classics in their respective domains. Publication statistics reveal at least 3 good papers per faculty per year. Emphasis is also laid on patents and technology development. The Department has identified the following strengths, that form the basis of its future aspirations:

- **Advanced mechanics and multi-scale modelling**: Major disciplines such as condensed matter physics, fluid dynamics, optics, non-linear dynamics and structural mechanics derive ideas from classical mechanics. The primary aim is to understand, follow, and ultimately predict critical parameters such as peak stress or maximum temperature or largest deformation or highest current density or incipient failure of a system, given knowledge of its interaction with the environment, and the stress response of the material composing the system. There is an ever-growing requirement for detailed analyses, addressing complex loading patterns, non-mechanical interactions such as thermal or electromagnetic fields, incorporating real geometry and realistic material behaviour.

- **Non-invasive measurements**: Techniques have been developed for measuring transport properties in solids, fluids, and fluid mixtures using lasers, γ-rays, ultra-sound and Infra-red emissions. Other applications are seen in non-destructive testing, void fraction measurements in nuclear reactors, and process control in power plants, understanding the physics of phase-change thermal systems.

- **Manufacturing processes for new-era machines and components**: There is substantial interest and expertise in process development, optimization and control related to conventional and non-conventional manufacturing processes, micro- and nano-manufacturing and CNC machining. Development of new-era machines of small length scales based on self-organizing smart materials, including generative processes, micro-fabrication, bio-material mechanics, and self-assembly is one of the current research areas. Such machines are envisioned to have multiple applications in molecular recognition, achieve displacements and precise actuation at micro- to nano-scales. It includes the concepts of error-free manufacturing, the self-correcting nature of shaping process, advanced metrology, and software development for CAD-to-product processes. One other research area is concerned with nano-finishing of large components and controlled patterning of surfaces. A thorough evaluation of nano-tribological aspects of surfaces is also included, particularly in micro and nano scale machining. One of the mandates is also to develop hybrid processes for surface texturing using modern machining techniques which can alter the functionality of new-era machines. A line of interest lies in process modelling and simulation for metal forming, solidification processes, component design and thermal and transport phenomena of various manufacturing processes with an aim towards the development of improved manufacturing and materials processes. These include casting, high-energy beam assisted manufacturing, surface coating and deposition processes, texturing and electromagnetic materials processing.

- **Energy**: The present-day concern with shortages in energy resources and the quality of emissions and environment has pitched the subject to the forefront. The discussions on bio-fuels, hydrogen economy, gas-hydrates, fuel cells, and CO_2 disposal have a societal angle to them. We try to understand combustion in a transparent internal combustion engine with an aim to reduce emissions and improve thermal efficiency. Several gaseous and liquid alternative fuels and advanced engine technology such as laser ignition and homogeneous charge compression ignition are being developed in addition to large bore engines and exhaust gas after-treatment systems. The department is home to expertise in heat pipes, particularly pulsating heat pipes and loop heat pipes, a technology of critical importance in thermal management of high-power electronics. New initiatives can be seen in the area of thermal energy storage using phase change materials. New projects have been acquired in areas such as thermal management of EV vehicles/batteries, solar thermal water desalination, dropwise condensation on textured surfaces, understanding transport processes in extracting gas hydrates, and clean coal combustion.

- **Computational mechanics and transport**: This includes domains of composite materials, structural analysis, fluids and turbulence, heat and mass transfer, multi-body dynamics, and optimization. The next era will require greater creativity in mathematical modelling, multi-scale simulation and ultra-fast computation of unstable systems in the engineered as well as natural world. Validation of models and theories against experiments is one of our research targets.

Vision and future plans

As a discipline, Mechanical Engineering has a come a long way; in contemporary times it encompasses a vast canvas, including a gamut of sub-disciplines. Since the invention of wheels, axels and fire, our art has sprouted, and continuously evolved into one that contains, within its confines, the design of energy conversion systems, automobiles, aerospace, marine and defence equipment, biotechnology, computers, electronics, micro-electro-mechanical systems, robotics and automation, and manufacturing systems. From “We turn wheels”, our art has come to “We also turn wheels”. A present-day mechanical engineers contribute to a wide-ranging technology spectrum, starting from ideation, material selection, design, manufacturing, quality assurance, all the way to introducing a socially useful product or technology in the diverse and complex marketplace.

Accordingly, the skill set requirements and expectations of GenNext are equally diverse and intricate. Managing complexities in inter-disciplinary domains, solutions requiring critical thinking and deep analyses, art of syntheses with a focus on creativity and innovation, working in man-machine-analog-digital co-working environments – advent of artificial intelligence and machine learning, sweeping societal changes due to internet-of-things and technologies such as block chains, online platforms, and major strides in communications systems, are some of the facets of contemporary dynamic tech-spectrum which is certainly going to affect pedagogy of mechanical engineering in particular.

It is critical that, rather than focussing on ‘covering the entire spectrum’, the programs we design, aim at percolating the ‘essentials’ - conveying universality of ideas instead of ‘compartmentalizing’, and in the process, inculcate the practice of ‘how to learn’ and respond to the changing environment. It is central to our thinking that we inculcate the art of connecting apparently diverse domains of science and engineering through common threads. Simultaneously, it is crucial for engineers to work on interactive platforms, indulge in tinkering, DIY and project-based learning and internship paradigms. Last but not the least, modern-day citizens and evolving tech-designs cannot remain insensitive towards challenges of Energy, Environment, Ecology and Sustainability. Accordingly, a well-trained mechanical engineer must understand and appreciate the thermo-mechanical environment in which the element/product/system/sub-system functions, and the various forces which affect its operation, efficiency and sustainability. With society seeking ‘Solutions’ and not just

‘Technology’, per se, any modern teaching and learning eco-system catering to the discipline must respond to these changing expectations. Young minds must not only be groomed in the fundamentals of the art, but also to the fact that technology cannot remain isolated from the society it serves and the environment in which it operates.

The department will continue to focus on imparting fundamental domain knowledge through its core curriculum, responding to the changing developments via offering a vibrant bunch of electives, and enrich our teaching via cutting-edge research and technology development, working in cross-disciplinary platforms, covering multiple scales. To this end, we will continue to be receptive in broadening ourselves, and be a continuing source of ideas, working with the industry for human development, and set highest academic standards for the society.

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Academic Information

Data for Last Seven Years

Number of Students

Degree \ Year	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
B. Tech.	388	421	422	448	474	519	561
B. Tech.-M. Tech.	38	24	23	28	35	38	34
M. Tech.	94	116	112	135	158	215	197
MS by Research	14	39	31	25	23	32	6
PhD	152	167	180	175	174	194	204

Number of Faculty

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
37	37	36	39	37	38	46

Number of Faculty who left the Department

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	1	2	1	0	0	2

Number of Visiting Faculty

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
0	0	1	3	2	0	1

Number of Adjunct Faculty

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
0	0	0	0	1	0	1

Number of Visitors from Academia & Industry

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
34	32	32	25	32	0	03

Number of New courses proposed

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
03	02	01	02	02	0	03

Books / monographs published

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
10	15	06	2	05	04	12

Number of short-term courses conducted

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
09	06	03	06	10	01	05

Number of video/web courses

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
08	10	13	14	14	23	27

Current Data

Department Facilities: Laboratories and Workshops

Department UG Teaching Labs:

(1) Experimental Stress Analysis Laboratory

S. No.	Name of the Equipment
1	25 KN servo hydraulic universal testing machine
2	Strain conditioners and data acquisition systems
3	Drop weight testing machine
4	Field Emission Scanning Electron Microscope with EDS
5	Circular polariscope with loading train

Sessions	Name of the Experiments
1	Application of strain gauge techniques: • Lecture on strain gauge-based methods, Cantilever beam and Portal frame experiments. • Experiment on combined bending and torsion
2	Applications of photo-elasticity: • Demonstration of photo-elastic techniques • Calibration of the photo-elastic constant, Determination of the stress field in a beam under bending.
3	Applications of Digital Image Correlation: • Demonstration of DIC techniques • Determination of strain fields in the gauge section of a polymeric dog-bone specimen under tension.
4	Applications of DIC: • Determination of thermo-elastic stress and strain fields using DIC

(2) Fluid Mechanics Laboratory

The Fluid Mechanics Laboratory supports instructional experiments for undergraduate students in their second year and postgraduate students in their second semester. The UG laboratory is integrated with the theory course and the two are connected. Here, the focus is on measurement of forces, measurement of losses, determination of fluid properties, and visualizing important phenomena such as hydraulic jumps, shocks, and laminar-turbulent transition. For postgraduate students, experiments are concerned with measurements in a boundary-layer and turbulent mixing layer, apart from specialized measurement techniques involving data acquisition and optical techniques. The list of experiments carried out by students is presented below.

Undergraduate Lab:

(1) Jet impact on flat and curved surfaces

(2) Measurement of drag on a circular cylinder in high Reynolds number flow; Energy loss measurements in sub-critical and super-critical open channel flow

(3) Measurement of fluid viscosity (oil and air)

(4) Determination of friction factor as a function of Reynolds number in pipe flow

(5) Studying laminar-turbulent transition for flow in a tube

(6) Boundary-layer flow over a flat plate

(7) Pressure distribution around a circular cylinder in high Reynolds number flow

Postgraduate Lab:

1. Velocity profiles in laminar and turbulent boundary-layers
2. Drag coefficient for a circular cylinder including drag crisis
3. Flow visualization using smoke tunnel and PIV
4. Hot wire measurements in a turbulent mixing layer and determination of relevant statistics
5. Optical techniques:
    a. Interferometry
    b. Schlieren
    c. Shadowgraph
    d. Particle image velocimetry
    e. Thermography

(3) Heat Transfer Laboratory

Heat transfer laboratory is an undergraduate teaching laboratory housing a handful of experimental setups pertaining to fundamental heat transfer problems and their applications. The experimental setups in this laboratory are a part of the curriculum for third-year undergraduate students undertaking the course "ME341A: Heat and Mass Transfer". Listed below are the experiments performed by the enrolled students as part of their course:

1. **Unsteady heat conduction:**
    a. Estimate the heat transfer coefficient for a transient heat transfer situation from an isothermal working fluid to solid blocks of varied shapes made of a specific material
    b. Determine the thermal conductivity of a material with the help of the known thermal conductivity and heat transfer coefficient for a similar shaped block but made of a different material

2. **Extended surface heat transfer (forced convection):**
    a. Determine the temperature distribution along the length of a pin fin and the average heat transfer coefficient for the fin under forced convection configuration
    b. Compute the effectiveness and efficiency of the pin fin

3. **Heat transfer from an extended surface (combined modes of heat transfer):**
    a. Establish the temperature distribution along the length of a tip-insulated extended surface and compare with analytical predictions
    b. Compute the individual heat transfer coefficients over its periphery under the influence of both free convection and radiation heat transfer
    c. Determine the thermal conductivity of the rod material using the observed data and computed heat transfer coefficients

4. **Measurement of critical heat flux (pool boiling):**
    a. Obtain the value of critical heat flux for pool boiling of water under sub-cooled (varied degree of sub-cooling) and saturated conditions
    b. Compare the experimentally obtained critical heat flux at the saturation temperature with that obtained using Zuber's correlation

5. **Natural convection from a vertical heated circular cylinder:**

- Determine the heat transfer coefficient for heat loss via natural convection from a vertical, uniformly-heated (uniform heat flux) cylinder
- Compare the experimentally obtained heat transfer coefficient with that estimated using a suitable empirical correlation

6. Measurement of emissivity of a grey body:

a. Determine the emissivity of a grey body at various surface temperatures using a physically identical, lamp black-coat ed body

7. Thermocouple calibration:

a. Make J-type thermocouples using a spot-welding machine
b. Develop a typical calibration curve for a J-type thermocouple using Fluke FMW 9143 dry well facility

(4) Material Testing Laboratory

Instruments/Equipment

(a) Universal testing machines

(b) Hardness tester (Brinell, Vickers, Rockwell Superficial Poldi portable, Shore A and D)

(c) Fatigue tester (Rotating bending, Reverse bending)

(d) Ellipsometer

Laboratory sessions

Sessions	Name of the Experiment
1 & 2	Studies of uniaxial stress-strain behaviour of steel, aluminium, plastic and elastomer (measurement of axial stress, lateral and longitudinal strains, elastic limit, Young's modulus, strain energy, plastic deformation, yield strength, and fracture strength)
3 & 4	Studies of hardness of steel, aluminium, composite, plastic and elastomer by Rockwell, Brinell, Vickers, Shore A and Shore D methods and its relationship with Young's modulus
5	Fatigue behaviour of metals
6	Optical constants of nanometer-thick films on a substrate

Total number of laboratory sessions: 06

(5) Manufacturing Science and Technology Laboratory

The lab supports learning of concepts motivated in the ME361 course through six well-designed experiments.

List of Experiments

S. No.	Experiment	Objective
1	Oblique cutting and cutting force coefficient identification	To measure cutting forces; identify cutting force coefficients; estimate cutting force coefficient from estimated chip thickness ratio; and study influence of cutting speed on cutting forces.
2	Electrical discharge machining	To study the EDM machine and the relevant measuring systems. To determine material removal rate (MRR) and tool wear rate (TWR) during machining of EN8 steel. To measure the initial and final out of roundness of the copper tool.
3	Deep drawing	To deep draw a cup, and measure: forming forces, and linear, area and volumetric strains.
4	Mechanistic identification of cutting force coefficients in milling	To measure cutting forces and identify the cutting force coefficients.
5	3D printing + Metrology	To fabricate a three-dimensional object using the fused deposition additive manufacturing process (part A), and to its measure dimensions using a coordinate measuring machine (part B).
6	Casting	To cast Aluminium in a metal mould. To measure temperature as the Aluminium solidifies. To evaluate cooling curves. To prepare samples from the cast piece to characterize their microstructure.

(6) Vibration and Control Lab

Instruments/Equipment

S. No.	Name of Equipment
1	Oscilloscope
2	Accelerometers
3	Mechanical Shaker
4	Small Shakers
5	Power amplifiers for Shakers
6	Vibration Testing machine
7	Charge Amplifier
8	Function Generator
9	Stroboscope
10	Machinery Fault Simulator
11	Universal Vibration System
12	Drive Train diagnostic
13	Rotor Kit
14	Dual Channel Analyser
15	Sound level Meter
16	Electrodynamic Shaker with amplifier

Laboratory Sessions

Sessions	Name of Experiment
1A	Study of a Beat Phenomenon of a Coupled Pendulum
1B	Determination of Effective Radius of Gyration of an Irregular Body through Torsional Oscillation of Trifilar Suspension.

2	Determination of Natural Frequencies of Beams under Simply Supported and Cantilever Boundary Conditions.
3	Study of Dynamic Vibration Absorber
4	DC Motor Speed Control with Various Sensors
5A	Measurement of Linear Displacement by Potentiometer
5B	Speed Torque Characteristics of DC Servomotor
6	Balancing of Ball and Beam System through PID Control
Demo	Active Vibration Control

(7) Energy Conversion Lab

The objective is to keep pace with the recent technological advancement in the field of Fluid Mechanics and Gas Turbine.

Experiments:

(1) Two-stages axial flow fan:

Test setup to estimate the performance characteristics of the fan.

Specifications:

- No. of stages: 2
- Design R.P.M.: 2400
- Design Discharge: 1.7 m^3/s
- Design Pressure: 15.0 cm of water
- No. of stator blades: 37
- No. of Rotor blades: 24

(2) Impulse Turbine

A small-scale hydro power unit designed to demonstrate the principles of operation and to evaluate the characteristics of a Pelton turbine. Equipped with electronic measurement sensors for inlet pressure, rotational speed and break force PC controlled data processing.

Specifications:

- 70 mm diameter, 10 buckets rotor
- 4.5 mm diameter nozzle
- Adjustable spear valve

(3) Serial and Parallel Pump: A small-scale series/parallel centrifugal pump to find the pump characteristic in serial and parallel mode. Equipped with electronic measurement sensors for pump differential. pressure, flow rate, temperature and rotational speed. PC controlled data processing via the IFD6 interface console.

(4) High Speed Centrifugal Compressor: Multi-stage centrifugal compressor to evaluate efficiency and performance characteristics. Sensors for inlet and exit temperature, flow rate, speed and power.

(5) Rankine Cycler: A steam-electric power plant including components such as a multi-pass boiler, axial - flow steam turbine, AC/DC generator and a condenser tower to evaluate the thermal efficiency and output.

Specifications:

- Boiler: Pressure 120 psi (827 kPa), Temperature 482°F (250°C)
- Generator: 15.0 Volts, 1.0 Amp (Total Load of 15.0 Watts)
- Fuel: Liquid Petroleum
- Digital: High Speed Data Acquisition System

(6) Performance study of Four-stroke compression ignition engine

(7) Cascade Tunnel:

- Variable incident mechanism
- End and side wall bleed
- Low inlet turbulence level
- Variable speed motors
- Five identical blades
- End passage bleed

Specifications:

- Test section size: 610 mm x 230 mm
- Test section velocity: 20 m/s
- Cascade inlet flow angle: 0° to 43°

(8) UG Core Laboratories (Operated by ME Department):

- ### The Technical Arts (TA) 101 Lab

  The Technical Arts (TA) 101 Laboratory caters to the first year B. Tech. students of IIT Kanpur from all disciplines of Engineering and Sciences. Basic Engineering Drawing is taught in TA 101 as a Core Course. About 12-13 sessions, each of three hours, are held in the Laboratory. Around 850 students use the lab throughout the year, and close to 425 each semester. Using the conventional, paper-pencil approach, students solve problems on Orthographic, Axonometric, Oblique and Perspective projections, Section Drawing, Lines and Planes and their interactions, Auxiliary views, intersection and development of solids. The laboratory also has numerous physical models to demonstrate a variety of concepts on Engineering Drawing. The laboratory holds two exams per semester. Every semester, a group of students is divided into 12 batches and a Tutor (Faculty member/a senior student) is assigned to each batch. Two Teaching Assistants are assigned to each Tutor. The instructor who delivers lectures also manages the entire course. This model, used generically, for all Core courses within the institute has been very successful over many years. The AutoCAD Lab, which can accommodate around 100 students at a time, is also a part of the TA 101 Laboratory. Herein, students learn the basics of engineering Drawing via the AutoCAD software.

- ### TA202A Lab

  TA202A is a core course for all second-year undergraduate students. The course is lab-based, with three hours of lab exercises a week to support one hour of classroom instruction a week. Since the course is about secondary manufacturing processes, the labs are designed to introduce students to traditional machining processes, which forms a large part of the family of secondary manufacturing processes. Main activity in the labs include students working in groups to conceive a project, design it, manufacture its parts, and assemble it. As part of training the students for them to work independently on their projects, the students learn how to operate manual turning, milling, and drilling machines. Students also get trained to operate CNC machines. That training includes training on CAD and CAM. Of late, students have also been encouraged to use 3D printed PLA parts within their designs. And, for this, they are also trained to use 3D printers. In addition to 3D printing, students also get trained on motor control using Arduino boards that they must integrate into their projects. Fourteen trained and skilled staff members mentor students through to completion of their respective projects.

List of Machines in TA Laboratory (not comprehensive)

S. No.	Type of Machine	Qty.	Specification and Power
1	Lathe M/C, LB 17 HMT	01	St. Bed 1000 Length 350 swing 7 kW
2	Lathe M/C, LB20 Gap Bed	01	St. Bed 1500 Length 450 swing, 7 kW
3	Lathe M/C Qetcos	05	St. Bed 800 Length 420 swing, 3.5 kW
4	Lathe M/C Kirloskar	02	St. Bed 800 Length 350 swing 2.2 kW
5	Lathe Craft Master HMT	01	St. Bed 1000 Length 350 swing, 2.2 kW
6	Lathe Craft Master	06	St. Bed 800 Length 350 swing, 2.2 kW
7	Lathe Enterprises	03	St. Bed 800 Length 350 swing 2.2 kW
8	Universal Milling M/C HMT M2U , M2PU, HMT	03	Longitudinal 650 X Cross 225 X Vertical 350, 5.5 kW
9	Lathe Hi-Cut Universal Milling BFW with Vertical & Rack cutting attachment with DRO	01	L 800 X Cross 260 X Vertical 420 5.5 kW
10	Vertical Milling M/C HMT Tool Cutter	01	650 X 225 X 350
11	Grinder HMT with Surface Cylindrical grinding attachment	01	GCT 28 T
12	Drilling M/C with PIV Drive CLAUSING 20	06	20-inch Capacity 30 mm drill capacity
13	Radial Drilling M/C ADM 32	02	850 Max drill s capacity 50 mm

14	Band Saw M/C 100-V2 with VFD drive	03	Cutting Range 100 X 100 Ht. 100mm
15	Hydraulic Power Saw with power Pack PSB 250 U	03	Max 250 diameter can be cut
16	Surface Plate 500 X 500	02	--
17	CNC Lathe-Concept Turn 105,155 with Interchangeable Control Fanuc21 and Sinumeric	02	X-100, Z-300 Power 2.8 kW control Fanuc 21 and Siemens 820D
18	Concept Mill CNC Milling 105,155with interchangeable control	02	X control Fanuc 21 and Siemens 820D -300, Z, 300 Y150 Power 2.8 kW
19	CNC Machining Centre Mill 250	01	X-350, Y-250, Z- 330 with fourth Axis
20	Off line Class Room Teaching Software for 10 Persons	10	Simulation with original Key board
21	3D printers	15	Ender 3D
22	Arduino boards (Uno) and kit. Kit includes motors, their drivers, cables, SMPS and battery supply.	60	

Space for PhD students

There are about 200 plus PhD students and every student is given one desk in the department. Many students who are involved in experimental work, prefer seating arrangement in their respective research laboratory space itself.

Additionally, the department has now created exclusive sitting arrangement for PhD students in the manufacturing laboratory and a separate new facility behind NL lab (28 seats), as shown below.

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Degrees and Disciplines offered by the department

Disciplines \ Degrees	B.Tech	B.Tech-M.Tech Dual Degree	M.Tech	MSR	Ph.D
Mechanical Engineering	4 Years	approx. 5 Years	2 years	2 years+	4 Years+

Other Proposed Degrees:

1. **B. Tech. (Hons): 4 years, B.Tech + additional credit requirement**
2. **B. Tech. (Management): 4 years, B. Tech + replacement credits from Management Science**

Course Details: B. Tech. Degree Program:

FIRST SEMESTER	SECOND SEMESTER	THIRD SEMESTER	FOURTH SEMESTER	FIFTH SEMESTER	SIXTH SEMESTER	SEVENTH SEMESTER	EIGHTH SEMESTER
ENG112A/ HSS-1 3-1-0-0(11)	CHM101A 0-0-3-0(03)	ME251A 1-0-2-0(05)	HSS-1 1-0-2-0(05)	HSS-2 3-0-0-0(9)	HSS-2 3-0-0-0(9)	HSS-2 3-0-0-0(9)	HSS-2/DE 3-0-0-0(9)
LIF101A 2-0-0-0(06)	CHM102A 2-1-0-0(08)	ESC201A 3-1-3-0(14)	ESO202A 3-1-0-0(11)	ME301A 2-0-0-0(06)	DE 3-0-0-0(9)	DE 3-0-0-0(9)	DE 3-0-0-0(9)
MTH101A 3-1-0-0(11)	ESC101A 3-1-3-0(14)	ESO201A 3-1-0-0(11)	ESO203A 3-1-2-0(13)	ME321A 2-0-1-0(7)	ME341A 3-0-1-0(10)	ME401A 3-0-1-0(10)	UGP3/ ME452A 0-0-6-0(6)
PE101A 0-0-0-0(03)	MTH102A 3-1-0-0(11)	ESO209A 3-1-0-0(08)	HSS-1 3-1-0-0(11)	OE 3-0-0-0(09)	ME351A 2-1-0-0(8)	UGP2/ ME451A 3-0-0-0(9)	ME461A 3-0-0-0(0)
PHY101A 0-0-3-0(03)	PE102A 0-0-0-0(03)	MSO202A 3-1-0-0(06) MSO203B 3-1-0-0(06)	ME22A 2-1-0-0(08)	ME352A 2-0-1-0(7)	ME354A 3-0-1-0(10)	OE 3-0-0-0(09)	OE 3-0-0-0(09)
PHY102A 3-1-0-0(11)	PHY103A 3-1-0-0(11)		ME231A 3-0-1-0(10)	ME361A 3-0-1-0(10)	OE 3-0-0-0(9)	OE/DE 3-0-0-0(9)	OE 3-0-0-0(9)
TA101A 2-0-3-0(09)		TA201A 1-0-3-0(06)	TA202A 1-0-3-0(06)	ME399A 0-0-0-2(02)	UGP/ ME398 0-0-0-4(4)	UGP4 ME498A 0-0-0-9(9)	

Note: Besides the UG core and UG departmental compulsory courses, students take advanced elective courses from within the department and outside the department. The breakdown is:

1. ***Minimum 42 credits of Departmental Electives***
2. ***Minimum 54 credits of Open Electives (outside the department)***
3. ***Minimum 49 credits on Humanities and Social Sciences.***

Number of courses offered

UG Core	UG Dept	PG
13	18	77

UG Compulsory Courses *:

Code	Course Title	Code	Course Title
TA101*	ENGINEERING GRAPHICS	TA201*	MANUFACTURING PROCESSES I
TA202*	MANUFACTURING PROCESSES II	ESO201*	THERMODYNAMICS
ESO202*	MECHANICS OF SOLIDS	ESO203*	INTRODUCTION TO ELECTRICAL ENGG.
ESO209*	DYNAMICS	ME222	NATURE AND PROPERTIES OF MATERIALS
ME231	FLUID MECHANICS	ME251	ENGG. DESIGN AND GRAPHICS
ME301	ENERGY SYSTEMS-I	ME321	ADVANCED MECHANICS OF SOLIDS
ME341	HEAT AND MASS TRANSFER	ME351	DESIGN OF MACHINE ELEMENTS
ME352	THEORY OF MECHANISMS AND MACHINES	ME354	VIBRATION & CONTROL
ME361	MANUFACTURING SCIENCE AND TECHNOLOGY	ME401	ENERGY SYSTEMS-II
ME451	BTECH PROJECT-I	ME452	BTECH PROJECT-II
ME461	MANUFACTURING SYSTEMS	ME398	UG PROJECT 1
ME498	UG PROJECT 4		

Apart from the above-mentioned courses UG students need to take several UG Core courses in Mathematics, Physics, Chemistry and Physical Education offered by respective departments.

Courses open for other departments

UG	PG
4	68

Minors offered (Any three courses from the basket)

Minor Name	Course 1	Course 2	Course 3	Course 4
Manufacturing Sciences	Casting and Solidification	Biomems	CAD	CAM
Computational Techniques in ME	CFD	Applied Numerical Methods	CAD	Atomistic Simulations

Number of TAs

UG	Masters	PhD
12	155	190

Credits required for various programs

Program Name	Course Credit	Thesis Credit
B. Tech.	425	0
BT-MT Dual	425	72
M. Tech.	72	72
MSR	54	90
PhD	36*	144

***Students without a master degree need to gather 54 more course credits**

Staff strength

Technical Staff	Office Staff
24	02

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Student Placement Data (2015-2021)

Year	B. Tech.				BT-MT Dual			
	Registered	Placed	Core	Non-Core	Registered	Placed	Core	Non-Core
2015-16	43	30	N/A	N/A	32	30	N/A	N/A
2016-17	59	41	N/A	N/A	37	34	N/A	N/A
2017-18	51	41	11	30	24	24	13	11
2018-19	56	48	12	36	26	26	12	14
2019-20	74	63	13	50	29	29	9	20
2020-21	60	49	11	38	15	13	4	9
2021-22	93	89	8	81	24	24	10	14

Year	M. Tech.				MSR			
	Registered	Placed	Core	Non-Core	Registered	Placed	Core	Non-Core
2015-16	23	12	N/A	N/A	0	0	0	0
2016-17	24	20	N/A	N/A	0	0	0	0
2017-18	50	42	31	11	0	0	0	0
2018-19	32	22	16	6	3	3	1	2
2019-20	36	23	15	8	5	4	2	2
2020-21	54	26	20	6	8	2	2	0
2021-22	94	74	36	38	19	14	5	9

Placement of PhD Students (2015-2021)

Number of PhD students graduated : 165
Placement information available : 145

#	Roll No.	Name	Advisor #1	Advisor #2. #3	Status
1	Y9205062	REKHA RAJA	Dr. Ashish Dutta	Dr. B. Dasgupta	Research Scientist, Wageningen University, Netherlands
2	Y9205061	ABHISHEK SARKAR	Dr. Ashish Dutta		Assistant Professor, BITS-Pilani, Hyderabad Campus, India
3	11205063	HUSAIN KANCHWALA	Dr. Anindya Chatterjee		Assistant Professor, CART, IIT Delhi
4	12105178	SAURABH BISWAS	Dr. Anindya Chatterjee		Assistant Professor, Mechanical Engineering, IIT Jammu
5	14205266	SANKALP TIWARI	Dr. Anindya Chatterjee		Visiting NARI (an NGO in Phaltan, Maharashtra)
6	13205062	ARINDAM BHATTACHARJEE	Dr. Anindya Chatterjee		Assistant Professor, Mechanical Engineering, Thapar Institute of Engineering and Technology
7	10205067	DIGENDRA NATH SWAIN	Dr. Anurag Gupta		Scientist, VSSC, ISRO
8	Y9105101	ANUP BASAK	Dr. Anurag Gupta		Assistant Professor, IIT Tirupati
9	10205063	AYAN ROYCHOWDHURY	Dr. Anurag Gupta		Simons Fellow, NCBS Bangalore
10	13105174	SATEESH KUMAR YADAV	Dr. Arvind Kumar		Research Engineer, IIT Kanpur
11	12105168	JITENDRA KUMAR KATIYAR	Dr. Arvind Kumar	Dr. Sujeet Kumar Sinha	Assistant Professor, SRM Institute of Science and Technology, Chennai
12	14105294	VIKRAM SONI	Dr. Arvind Kumar	Dr. V.K. Jain	Postdoctoral Fellow, University of Toronto, Canada

13	11205066	RAJESH KUMAR SHUKLA	Dr. Arvind Kumar		Assistant Professor, Thapar Institute of Engineering & Technology, Patiala
14	16105263	ALOK KUMAR	Dr. Arvind Kumar		Project Postdoctoral Fellow, IIT Kanpur
15	13205069	JITENDRA KUMAR	Dr. Ashish Dutta		Lecturer, Centre for Advanced Study, Abdul Kalam Technical University, Lucknow, India
16	14105269	BETELEY TEKA HAILU	Dr. Ashish Dutta		Lecturer, Centre for Advanced Study, AKTU, Lucknow
17	13105161	ANIRBAN CHOWDHURY	Dr. Ashish Dutta	Dr. Girijesh Prasad	Lecturer, Uni-Essex, UK
18	16105278	SHUBHI KATIYAR	Dr. Ashish Dutta		Project Engineer, Dept. of Electrical Engg., IIT Kanpur
19	10105129	AKHILENDRA PRATAP SINGH	Dr. Avinash Kumar Agarwal		Assistant Professor at IIT BHU, Varanasi
20	11105165	JAI GOPAL GUPTA	Dr. Avinash Kumar Agarwal		Associate Professor at Women Engineering College, Ajmer, Rajasthan
21	12105175	RAJESH KUMAR PRASAD	Dr. Avinash Kumar Agarwal		Assistant Professor at ICFAI University, Ranchi
22	13105171	NIKHIL SHARMA	Dr. Avinash Kumar Agarwal		Assistant Professor at MNIT Jaipur
23	12105186	VIKRAM KUMAR	Dr. Avinash Kumar Agarwal	Dr. Sujeet Kumar Sinha	Project Engineer at ERL, IIT Kanpur
24	10105143	PATEL CHETANKUMAR PRATAPBHAI	Dr. Avinash Kumar Agarwal	Dr. Nachiketa Tiwari	Assistant Professor at S. N. Patel Institute of Technology and Research Centre, Bardoli, Gujrat
25	13105166	GAURAV MAURYA	Dr. Basant Lal Sharma		Postdoc in IISc
26	Y7105073	RAVI DALMEYA	Dr. Ishan Sharma	Dr. C.S Upadhyay	Joined 3dPLM Software

27	12105182	PRASAD RANGANATH SONAR	Dr. Ishan Sharma	Dr. Jayant Kumar Singh	Post-doc scholar at Department of Earth Sciences, Osaka University
28	Y8205062	ASHISH BHATEJA	Dr. Ishan Sharma	Dr. Jayant Kumar Singh	Associate Professor, Mechanical Engineering, IIT Goa
29	11105173	VINEET NAIR	Dr. Ishan Sharma	Dr. V. Shankar	Senior Project Engineer at Department of Mechanical Engineering, IIT Kanpur
30	10105149	VENUGOPAL SWAMI PUNATI	Dr. Ishan Sharma	Dr. Pankaj Wahi	Fluidyn Consultancy Pvt Ltd. Bangalore
31	10205061	ABHINAV RAVINDRA DEHADRAI	Dr. Ishan Sharma	Dr. Shakti Singh Gupta	Post Doc Scholar, University of Nevada, USA
32	14105271	DEEPAK SACHAN	Dr. Ishan Sharma	Dr. T. Muthukumar	Assistant Professor, School of Engineering, IIT Mandi
33	10105134	Bisheswar Choudhary	Dr. J. Ramkumar		Air Force Lieutenant Commander, Indian Air Force
34	14105274	GAGANPREET SINGH	Dr. J. Ramkumar		Post-doc Sweden
35	16105280	VYOM SHARMA	Dr. J. Ramkumar		Post doc IIT Bombay
36	14205267	SHASHANK	Dr. J. Ramkumar	Dr. S. Anantha Ramakrishna	Post doc University of Texas
37	12205069	LEELADHAR NAGDEVE	Dr. J. Ramkumar	Dr. V.K. Jain	Assistant Professor, NIT Delhi
38	10205066	SYED NADEEM AKHTAR	Dr. J. Ramkumar	Dr. S. Anantha Ramakrishna	Dean, Integral University
39	14112261	S Kiran Kumar	Dr. J. Ramkumar		Post doc IIT Hyderabad
40	16112261	Arun Rajput	Dr. J. Ramkumar		Post doc IIT Kanpur
41	13104177	Krishna Kumar Singh Tomar	Dr. J. Ramkumar		Assistant Engineer KESCO
42	14212262	Ajay B S Vardhaman	Dr. J. Ramkumar		Post doc South Korea

43	15112264	Pragya Tripathi	Dr. J. Ramkumar		Raman Fellow, Post doc IISC Bangalore
44	12112064	Yaswanth Kumar Penke	Dr. J. Ramkumar		Post doc North Carolina
45	16105273	MAHAVIR SINGH	Dr. J. Ramkumar		Post doc IIT Bombay
46	14105281	MANMEET SINGH	Dr. Jishnu Bhattacharya		Not yet defended
47	14105286	PUNEET JINDAL	Dr. Jishnu Bhattacharya		Working In Energy Systems R&D division of Mahindra Electric Mobility Limited, Bangalore
48	16205268	MANOJ KUMAR SHARMA	Dr. Jishnu Bhattacharya		Postdoc in Rice University, USA
49	13105162	ARIHANT BHANDARI	Dr. Jishnu Bhattacharya	Dr. Rajganesh Pala	Postdoc in University of Southampton, UK
50	16105118	Daniel Adamu Fentahun	Dr. Kamal K. Kar		Faculty, Department of Mechanical Engineering, Assosa University, Ethiopia
51	13115066	VIKESH SINGH BHADOURIA	Dr. M. Jaleel Akhtar	Dr. Prabhat Munshi	Postdoc at Dancook University, South Korea
52	13105172	PAWAN KUMAR PANDEY	Dr. Malay Kumar Das		Project Postdoctoral Fellow, IIT Kanpur
53	11105175	Jithin M	Dr. Malay Kumar Das	Dr. Ashoke De	Assistant Professor, AJ College of Engineering, Kerala
54	11105163	BABU R	Dr. Malay Kumar Das		Postdoctoral Fellow, Helmholtz Zentrum Berlin
55	15205266	GOVIND NARAYAN SAHU	Dr. Mohit Law		Postdoc at the Fraunhofer IWU in Germany. Supported by the IGSTC Industry postdoc fellowship
56	10215062	DINKAR VERMA	Dr. Pankaj Wahi	Dr. M.S. Kalra	Faculty at GD Goenka, Gurgaon
57	Y9105102	ASHOK KUMAR MANDAL	Dr. Pankaj Wahi		Assistant Professor at NIT Jamshedpur

58	11105176	SANTANU DAS	Dr. Pankaj Wahi		Assistant Professor at IIEST, Shibpur
59	11205071	SUNIT KUMAR GUPTA	Dr. Pankaj Wahi		Post-doctoral Fellow at Virginia Tech, Blacksburg, USA
60	16105275	PRITAM BARI	Dr. Pankaj Wahi	Dr. Mohit Law	Postdoc at IIT Delhi
61	11205073	ANISH KUMAR	Dr. Pankaj Wahi	Dr. Sovan Das	Assistant Professor at J K Laxmipat University, Jaipur, Rajasthan, India
62	10205062	ASHISH AGRAWAL	Dr. Partha S. Ghoshdastidar		Assistant Professor, MITS Gwalior, M.P.
63	14105268	ATINDER PAL SINGH	Dr. Partha S. Ghoshdastidar		Postdoc at IIT Delhi
64	13115061	DEEPAK KUMAR YADAV	Dr. Prabhat Munshi	Dr. Amitava Gupta	Postdoc at University of Trento, Italy
65	Y9115062	MAYANK GOSWAMI	Dr. Prabhat Munshi	Dr. Anupam Saxena	Assistant Professor, IIT Roorkee
66	11115061	SATYA PRAKASH SARASWAT	Dr. Prabhat Munshi	Dr. Chris Allison	MSCA fellow at PISA University
67	13115062	MADHUSREE SARKAR	Dr. Prabhat Munshi	Dr. Om Pal Singh, Dr. K. Velusamy	Postdoc at IIT Madras
68	11215061	KAVITA RATHORE	Dr. Prabhat Munshi	Dr. S. Bhattacharjee	Postdoc at Texas A & M University USA
69	10105145	SANJEEV KUMAR	Dr. Prabhat Munshi	Dr. Arun Kumar Saha	Postdoc at IIT Delhi
70	10105139	MANOJ KUMAR	Dr. Prakash M. Dixit		Asst. Professor, National Institute of Technology Jalandhar
71	13215062	GAURAV MISHRA	Dr. Sachchidanand Tripathi		Postdoc IRSN, France
72	11205064	MAHESH KUMAR YADAV	Dr. Sameer Khandekar		Faculty, PEC, Chandigarh
73	11205068	VYAS S	Dr. Sameer Khandekar		Senior Research Engineer, Dassault Aviation, France
74	13205078	RAM KRISHNA SHA	Dr. Sameer Khandekar		Faculty, Uttarakhand Technical University

75	14105280	MANEESH PUNETHA	Dr. Sameer Khandekar		Post-Doc Scholar, Sweden
76	17205262	ANKUSH KUMAR JAISWAL	Dr. Sameer Khandekar		Post-Doc Scholar, Cranfield University, UK (selected)
77	Y7205061	BALKRISHNA MEHTA	Dr. Sameer Khandekar		Faculty, IIT Bhilai
78	13105173	PREM KUMAR	Dr. Sameer Khandekar		Raman Post-Doc Fellowship, IISc, Bangalore
79	14105288	SANJEEV KUMAR GHAI	Dr. Santanu De		Postdoc in Newcastle University, UK
80	15205272	SAURABH GUPTA	Dr. Santanu De		Senior Research Engineer, Donaldson Company
81	14105264	AMIT KUMAR RAI	Dr. Shakti Singh Gupta		Assistant Professor, NIT Calicut
82	10105131	ANKUR GUPTA	Dr. Shantanu Bhattacharya		Assistant Professor, Department of Mechanical Engineering, IIT Jodhpur
83	10105150	VINAY KUMAR PATEL	Dr. Shantanu Bhattacharya		Professor, GBPIET, Ghurdauri, Pauri
84	13205080	SANJAY KUMAR	Dr. Shantanu Bhattacharya		Post-Doctoral Research Associate, National University of Singapore
85	14105276	GEETA BHATT	Dr. Shantanu Bhattacharya		Post-Doctoral Research, TCIP Pvt. Ltd., incubated @ IIT Kanpur
86	14105285	POONAM SUNDRIYAL	Dr. Shantanu Bhattacharya		Assistant Professor, Department of Mechanical Engineering, IIT Kharagpur
87	14205263	PANKAJ SINGH CHAUHAN	Dr. Shantanu Bhattacharya	Dr. Niraj Sinha	C.V. Raman Fellow, Indian Institute of Science, Bangalore
88	Y8105088	RISHI KANT	Dr. Shantanu Bhattacharya		Assistant Professor, Department of Mechanical Engineering, HBTI, Kanpur

89	14205262	KAPIL MANOHARAN	Dr. Shantanu Bhattacharya		Post-Doctoral Research, TCIP Pvt. Ltd., incubated @ IIT Kanpur
90	11205072	VIJAY KUMAR PAL	Dr. Sounak Kumar Choudhury		Faculty member in IIT Jammu
91	12105163	ANAND PRAKASH DWIVEDI	Dr. Sounak Kumar Choudhury		Post-doc in China (selected)
92	13205071	KASHFULL ORRA	Dr. Sounak Kumar Choudhury		Faculty member in IIITKDM Kanchipuram
93	15105273	MUHAMMED MUAZ	Dr. Sounak Kumar Choudhury		Faculty member in Aligarh Muslim University
94	Y8105083	DESAI CHAITANYA KIRITKUMAR	Dr. Sumit Basu	Dr. P. Venkitanarayanan	Associate Professor, Mech Engg, CK Pithawala College of Engineering
95	Y7105079	V. SUDARKODI	Dr. Sumit Basu		Patent Agent, Crescent Innovation and Incubation Council (CIIC)
96	Y7205067	BRUNDA RAO KATTEKOLA	Dr. Sumit Basu		Team Lead: Materials Engineering Group, Saint Gobain Research, Chennai
97	12105167	GURU PRASAD T	Dr. Sumit Basu	Dr. Shantanu Bhattacharya	Assistant Professor, Manipal Institute of Technology
98	13205063	ARPIT KUMAR SRIVASTAVA	Dr. Sumit Basu		Post-Doctoral Researcher, Slovak Academy of Sciences
99	13205072	MAYANK CHOUKSEY	Dr. Sumit Basu		Post-Doctoral Researcher, University of Texas at Austin
100	12105179	SAYYAD MANNAN MOULA	Dr. Sumit Basu	Dr. P. Venkitanarayanan	Assistant Professor, AISSMS College of Engineering, Pune
101	12105170	MOHAMMAD RASHID ZAFAR ANSARI	Dr. Sumit Basu		Assistant Professor, Aligarh Muslim University
102	13105165	DIVYANSH PATEL	Dr. V. K. Jain	Dr. J. Ramkumar	Faculty member at BITS Pilani (presently in Germany on Fellowship)

103	12105161	ABDULLAH YOUSUF USMANI	Dr. K. Muralidhar		Assistant Professor, Aligarh Muslim University, Aligarh
104	12105166	SHIRSATH GANESH BAPU	Dr. K. Muralidhar	Dr. Raj Ganesh Pala	Postdoctoral Fellow, IIT Delhi
105	12205068	KRISHNA CHANDRAN	Dr. K. Muralidhar		Postdoctoral Fellow, IIT Palakkad
106	12205070	RAGHVENDRA PRATAP SINGH	Dr. K. Muralidhar	Dr. Malay Kumar Das	Postdoctoral Fellow, IIT Bombay
107	14105292	SUPRIYA UPADHYAY	Dr. K. Muralidhar	Dr. Raj Ganesh Pala	Employed on a sponsored project, IIT Kanpur
108	12105181	SOMWANSHI PRAVEEN MOHANRAO	Dr. K. Muralidhar	Dr. Sameer Khandekar	Senior Lecturer, Novosibirsk State University, Novosibirsk, Russia
109	Y8105084	NARENDRA LAXMAN GAJBHIYE	Dr. K. Muralidhar	Dr. V. Eswaran	Assistant Professor, MANIT Bhopal
110	10102070	YOGESH NIMDEO	Dr. K. Muralidhar	Dr. Yogesh M. Joshi	Assistant Professor, IIT Jammu India
111	16105274	OM PRAKASH YADAV	Dr. Nalinaksh S. Vyas		Post-Doctoral Fellow at Royal KTH Institute, Stockholm
112	10105136	DALAWAI PRASHANTH BEERAPPA	Dr. Nalinaksh S. Vyas	Dr. N. N. Kishore	Assistant Professor, BMS College of Engineering, Bangalore
113	Y7105069	MOHAMMED ASFER	Dr. P. K. Panigrahi		Assistant Professor, College of Engg., Shaqra University, Saudi Arabia
114	15205273	SUNIL KUMAR SAROJ	Dr. Pradipta K. Panigrahi		PDF, IIT Mumbai
115	11105164	BHARTI OMPRAKASH SETOORAM	Dr. Arun Kumar Saha	Dr. Malay Kumar Das	Post-Doctoral Research Associate, Dept of Civil Engg., IIT Kanpur
116	11205062	GAURAV SAXENA	Dr. Arun Kumar Saha		CFD Engineer, Siemens India, Gurgaon
117	11205069	SACHIDANANDA BEHERA	Dr. Arun Kumar Saha		Assistant Professor, Dept of Mech Engg., IIT Hyderabad

118	14105262	Ajay Bhandari	Dr. Niraj Sinha		Assistant Professor, IIT ISM Dhanbad
119	14105279	KARTIKEYA DIXIT	Dr. NIraj Sinha		Postdoctoral Fellow, Mission Hridyantra, IIT Kanpur
120	13205076	RAGHUBEER SINGH BANGARI	Dr. Niraj Sinha		Assistant Professor, Graphic Era Hill University, Dehradun
121	10105144	RAMESH ERELLI	Dr. Arun Kumar Saha		Assistant Professor, Dept of Mech Engg., KITS Warangal
122	14105279	KARTIKEYA DIXIT	Dr. NIraj Sinha		Postdoctoral Fellow, Mission Hridyantra, IIT Kanpur
123	13205076	RAGHUBEER SINGH BANGARI	Dr. Niraj Sinha		Assistant Professor, Graphic Era Hill University, Dehradun
124	10105146	SERVESH KUMAR AGNIHOTRI	Dr. P. Venkitanarayanan		Assistant Professor, L. N Mittal Institute of Information Technology, Jaipur
125	11205067	RAVI SANKAR H	Dr. P. Venkitanarayanan		Research Assistant Professor, University of North Texas, USA
126	11205070	SANAN HUSAIN KHAN	Dr. P. Venkitanarayanan		Assistant Professor, United Arab Emirates University, UAE
127	10105132	ANSHUL FAYE	Dr. P. Venkitanarayanan	Dr. Sumit Basu	Assistant Professor, IIT Bhilai
128	11105162	SHARMA ANKUSH PUNAMCHAND	Dr. P. Venkitanarayanan	Dr. Rajesh Kitey	Post-doctoral fellow, IIT Madras
129	16205274	SHASHWAT BHATTACHARYA	Dr. Anirban Guha	Dr. Mahendra Kumar Verma	Doctor of Philosophy, Technische Universität Ilmenau | TUI · Institut für Thermo- und Fluid-dynamik
130	13205065	ARUN KUMAR SHARMA	Dr. Bishakh Bhattacharya		Shell Technology Centre, Bengaluru
131	13205068	JITENDRA BHASKAR	Dr. Bishakh Bhattacharya		Assistant Professor, HBTI, Kanpur

132	14205265	RUPAL SRIVASTAVA	Dr. Bishakh Bhattacharya		Marie Skłodowska-Curie Post-doc Fellow, SMART4.0 Fellow at CONFIRM Smart Manufacturing (SFI), Limerick, Ireland
133	15105269	MANISH PANDEY	Dr. Bishakh Bhattacharya		Deputy Director, RDSO Lucknow
134	13205079	SAHIL KALRA	Dr. Bishakh Bhattacharya		Assistant Prof., IIT Jammu
135	15205262	ANKUR DWIVEDI	Dr. Bishakh Bhattacharya		Postdoctoral Associate at the University of Exeter, England, United Kingdom
136	12205065	DEV PRAKASH SATSANGI	Dr. Nachiketa Tiwari	Dr. Avinash K. Agarwal	Assistant Professor, Uttarakhand University
137	12105183	SREEJITH V S	Dr. Nachiketa Tiwari		Post-Doctoral Fellow, Univ. of North Texas
138	12205071	RAHUL OORATH	Dr. Nachiketa Tiwari		Manager, CEAT Corporation
139	10105142	PARITOSH MAHATA	Dr. Sovan lal Das		Assistant Professor, BIT Mesra, Ranchi
140	Y9105105	MURALEEDHARAN NAIR K	Dr. Subrata Sarkar		Professor & Dean (Admin), MAR BASELIOS College of Engineering and Technology, Kerala
141	Y8205064	HARISH BABU	Dr. Subrata Sarkar		Associate Professor, CMR Institute of Technology, Bengaluru
142	Y9105100	K. ANAND	Dr. Subrata Sarkar		Assistant Professor at Sastra University
143	Y8105089	SIVA PRASAD A V S	Dr. Sumit Basu		Assistant Professor, IIITDM Kancheepuram
144	Y9105104	K. SANDEEP REDDY	Dr. V. Eswaran	Dr. M. K. Verma	Post doc, Department of Applied Mathematics, University of Leeds.
145	Y7105076	DIRBUDE SUMER BHARAT	Dr. V. Eswaran	Dr. A Kushari	Assistant Professor, National Institute of Technology Calicut

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Research & Development (Data for past seven years)

Graduate Research Laboratories

Department of Mechanical Engineering
Indian Institute of Technology Kanpur
Kanpur (UP) 208016

Engine Research Laboratory

Laboratory Coordinator: Dr Avinash Kumar Agarwal

List of Major Equipment:

- Single Cylinder Optical Research CRDI Engine with AC Dynamometer (AVL, Austria)
- Single Cylinder Optical Research GDI Engine (SCORE) with AC Dynamometer (EngineTech, Korea)
- Two Cylinder Engine for Diesel HCCI Experiment.
- Single Cylinder Engine for Laser Ignition of CNG and Hydrogen.
- Single Cylinder Engine for Combustion Endoscopy.
- Tata Safari Dicor (3 Liters) CRDI Engine with Eddy Current Dynamometer (300 HP; Tata)
- Tata Safari Dicor (2.2 Liters) CRDI Engine with Eddy Current Dynamometer (300 HP; Tata)
- Wagon-R Gasoline PFI Engine with Eddy Current Dynamometer (80 kW; Maruti)
- Two-Wheeler Chassis Dynamometer up to 150 kmph (Dynomerk, India)
- Two-wheeler Transient Engine Dynamometer (Dynomerk, India)
- Transient Dynamometer for Heavy-Duty Engine (75 KW) (Dynomerk, India)
- 4-Cylinder Genset, 140 kW (Cummins)
- 2-Cylinder Genset, 15 kW (Caterpillar)
- High Speed 8 Channel Combustion Data Acquisition System (Hi-Technique, USA)
- High-Speed Combustion Analysis System (Indi-smart, AVL, Austria)
- High-Speed Combustion Analysis System (Ki-Box, Kistler, Switzerland)
- SPC Smart Particle Sampler (SPC 432 AVL, Austria)
- FTIR Emission Analyzer (FTE-6000 Horiba, Japan)
- Exhaust Emission Particle Sizer with Thermo-diluter (EEPS 3090, TSI, USA)
- Nd-YAG Laser and Optics (Litron, UK)
- Time-Resolved 2D, 3D and Tomographic PIV (La-Vision, Germany)
- 2D and 3D Phase Doppler Interferometry (Artium, USA)
- High-Speed Cameras (Photron, USA)
- Laser Beam Profiler (Data-Ray, USA)
- Bomb Calorimeter (Parr 6200, USA)
- Kinematic Viscometer (Setavis, UK)
- Rancimat Instrument (Metrohm, Switzerland)
- Copper Corrosion Bath (Setavis, UK)
- Engine Endoscope (Karl-Storz, Germany)

- Constant Volume Spray Chambers and Constant Volume Combustion Chambers for Various Experiments (6 Types)
- Pressure Transducers with Charge Amplifiers (AVL, Kistler), Precision Shaft Encoders
- 3-D Simulations Software (Convergent Science)
- 1-D Simulations Software (Gamma Technology-Suite; GT-Suite)
- High-Speed Computing System (W0rkstations, 24 Core, and 32 Core)

Brief description of the laboratory:

Engine Research Laboratory was created in the Department of Mechanical Engineering on October 16th, 2005. This laboratory aims to develop state-of-art experiments related to Internal Combustion Engines and Vehicles apart from emission and engine-related tribological investigations. This laboratory aims to develop highly efficient engines using state-of-the-art facilities via conducting experiments for various investigations such as performance, emission, combustion and in-cylinder flow visualization. This is a dedicated laboratory for IC engines, the country's first laboratory to use laser diagnostics and micro-sensors for engines. This dedicated engine research laboratory paves the way for a balanced development of this front-line area of research. The laboratory has several fully instrumented single and multi-cylinder test benches for different engines/ dynamometers. Presently ERL is working on several advanced research topics such as Particle Image Velocimetry (PIV) for in-cylinder flow visualization, Phase Doppler Interferometry (PDI) for spray characterization, combustion visualization and optical diagnostics, Gasoline Direct Injection (GDI), Gasoline Compression Injection (GCI), HCCI/ PCCI of gasoline and diesel-like fuels, engine noise and vibration, laser ignition of CNG and hydrogen. Presently, ERL is working on developing methanol fuelled engines and DME fuelled engines for the Indian automotive sector under the guidance of the National Institution for Transforming India (NITI AYOG).

Laboratory research keywords:

Engines, laser ignition, advanced combustion technologies, alternative fuels, spray and combustion dynamics, optical engines, methanol-fueled engines, DME-fueled engines

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	▪ **R&D 1: ECU Calibration for Methanol Adaptation in Motorcycles** The ECU calibration is required for methanol adaptation in the existing SI engines equipped with an electronic fuel injection (EFI) system. An ECU was calibrated by tuning fuel injection quantity, AFR, volumetric efficiency, and ignition timing to optimize engine performance, combustion, and emissions in M85-fueled (85%v/v methanol + 15% v/v gasoline) single-cylinder port-fuel-injected SI engine. M85 produced better results compared to baseline gasoline. The BTE was increased by up to 23% at lower loads and up to 8% at higher loads with M85 than gasoline. CO and HC emissions were reduced considerably. NO emissions were higher at lower speeds and comparable/lower at higher speeds compared to gasoline. ▪ **R&D 2: Combustion Control in Gasoline Compression Ignition Engine** A detailed study was done to understand the role of combustion chamber design on vertical plane air-flow structures. A realistic bowl geometry was modelled and simulated using CONVERGE under non-firing conditions to study the flow dynamics, fluid vortex location, the importance of the interfacial

	region, variation of r-θ velocity components, turbulent kinetic energy production regions, etc. These results were validated with the flow-field results of a light-duty optical engine obtained through Time-Resolved Particle Image Velocimetry (TR-PIV). Secondly, GCI combustion engine simulations for varying swirl ratios (SR) were performed in CONVERGE CFD software to understand the effect of in-cylinder air motion on the mixture stratification and combustion. A 1/7th sector geometry for a conventional re-entry piston bowl was modelled and simulated. Two different mechanisms were used for model validation. The results indicated that the large-scale flow structures control the fuel dispersion in the combustion chamber. The charge convection because of increased swirl substantially influences the combustion. A distinguished ignition kernel was observed for all test cases. Lastly, the results of both the studies were combined, and a shallow piston (bathtub) geometry was investigated for the GCI engine. The bathtub geometry showed satisfactory results because of the absence of interfacial regions in the counter-rotating vortices. Overall, bathtub geometry showed good potential in lowering the HC and CO emissions from the GCI. ▪ **R&D 3: Development of Fuel Injection System for Di-Methyl Ether Applications in Compression Ignition Engines** This study's objective was to investigate the technical feasibility of operating a commercial single-cylinder diesel engine equipped with a mechanical fuel injection system with dimethyl ether (DME) without any significant engine-level modifications. A dedicated fuel supply line was designed to add the lubricating additives and supply the liquefied DME to the diesel engine. The existing high-pressure (HP) pump was inadequate to pump the required DME; hence a pneumatic pre-supply pump was connected in series in the low-pressure line. Using a heat exchanger, the injector return line was modified to handle and cool the liquefied DME. >75% rated load could be achieved with these arrangements by reducing the injector nozzle opening pressure. In-cylinder combustion was dominated by diffusion combustion for the DME engine. Engine emissions such as HC, CO, NOx, and soot were reduced significantly for the DME engine. The DME engine noise was lower due to superior spray atomization and DME evaporation.
2019-2020	▪ **R&D 4: Development and Experimental Evaluation of Diethyl Ether (DEE)-Diesel Blend Fueled Tractor Engine Prototype** This study investigates the combustion, performance and emission characteristics of a three-cylinder naturally aspirated water-cooled tractor engine fueled with different blends of DEE with mineral diesel ranging from 15% v/v to 45% v/v. test engine prototype was developed and operated at different loads at a constant speed without significant structural modifications for DEE blend adaptation. Engine combustion and performance for test fuel blends were comparable to that of mineral diesel; however, due to the lower calorific value of the test fuel, the engine could not be operated on complete load conditions. A significant reduction in NOx and particulate emissions were observed, with slight increase in HC emissions. With the addition of DEE fraction beyond 45% v/v in the test fuel, stable engine operation could not be achieved due to higher volatility and lower lubricity of DEE compared to diesel ▪ **R&D 5: Development of Port Fuel Injected Methanol (M85) Fueled Two–Wheeler Prototype**

	A functional two–wheeler prototype used M85 (85% v/v methanol + 15% v/v gasoline) in an ECU-controlled port fuel-injected engine. Various strategies of methanol utilization, in this two–wheeler engine were evaluated. Finally, a retro fitment kit for the existing PFI two-wheeler with minimal structural changes was developed for successful M85 adaptation. This thesis describes the entire process of ECU recalibration for methanol utilization. In addition, a comparative study was performed for simulated on-road two-wheeler performance on a chassis dynamometer using a gasoline-fueled motorcycle with stock ECU vis-à-vis M85 fueled motorcycle using recalibrated ECU, followed by a comparison of emissions.
2018-2019	▪ **R&D 6: Laser Plasma Ignited Hydrogen Enriched Compressed Natural Gas Engine Development and Experimental Evaluation** This experimental study aims to assess the challenges and benefits of using hydrogen-enriched compressed natural gas (HCNG) blends as fuel and laser as the source of ignition in a prototype IC engine. Experiments in this study were conducted in two phases. In the first phase of experiments, a constant volume combustion chamber (CVCC) was used to study the fundamental aspects of LI. In the second phase, an experimental engine setup was developed to compare LI vs SI systems for HCNG blends for their combustion, performance and emissions characteristics. Fuel was introduced using a port fuel injection system in the prototype HCNG fueled engine. This study investigated HCNG mixtures for different lambdas (λ) ranging from rich to lean fuel-air mixtures using a Q-switched Nd: YAG laser (200 mJ; 30 Hz; 6-9 ns) in the CVCC. Experiments were conducted at different ambient pressures of 5 bar and 10 bar. These pressures simulated the in-cylinder pressures at the time of spark ignition in an engine cycle. Flame kernel evolution in HCNG blends of varying compositions (10%, 20%, 30%, and 40% v/v hydrogen) was compared with baseline CNG for a specified λ. A high-speed camera was used to trigger the laser and the data acquisition system. Flame kernel evolution was recorded using the shadowgraphy technique. Images were captured at 54000 fps and further analyzed to obtain the temporal propagation of flames in different orthogonal directions. It was noted that for any typical initial chamber pressure, P_{max} during combustion reduced with increasing λ. Peak pressure and flame speed were higher at λ = 1.1 for HCNG mixtures. ▪ **R&D 7: Spray, combustion, emissions and particulate investigations of gasohol fueled gasoline direct injection engine** A macroscopic spray investigation was performed to determine spray penetration length and cone angle. A section of this thesis focuses on microscopic spray investigations using the phase Doppler interferometry (PDI) technique for the measurement of various spray characteristics such as arithmetic mean diameter (AMD) and Sauter mean diameter (SMD), spray droplet size distributions and spray droplet velocity distributions etc. After performing spray experiments, the same test fuels were experimentally investigated in the engine. The engine could be operated either with a thermal cylinder head or with an optical cylinder head. In optical engine investigations, phase Doppler interferometry (PDI) was implemented in the engine cylinder to evaluate real-time spray droplet velocity and droplet diameter distribution under various engine operating conditions. Many questions were answered by these comprehensive experiments, which otherwise remained unanswered in a constant volume spray chamber experiment. The results obtained from

	these experiments helped optimize parameters for engine experiments with thermal heads. Effects in variation in spark timings (ST), fuel injection pressures (FIP), engine load and engine speed (rpm) on combustion, performance and emission characteristics were investigated experimentally. In engine experiments with a thermal head, detailed investigations were conducted to evaluate engine performance, combustion and emission characteristics for the test fuels. Engine exhaust particle sizer (EEPS) was used to obtain particle number-size distribution and mass-size distribution. Primary alcohol investigation can be implemented on a large scale with the lowest environmental impact.
2017-2018	▪ **R & D 8: Feasibility of Using Methanol-Diesel Blends in an Unmodified Compression Ignition Genset Engine with Mechanical Fuel Injection Equipment** Miscibility of methanol in mineral diesel and stability of methanol–diesel blends are the main obstacles faced in using methanol in compression ignition engines. In this experimental study, combustion, performance, emissions, and particulate characteristics of a single-cylinder engine fueled with MD10 (10% v/v methanol blended with 90% v/v mineral diesel) and MD15 (15% v/v methanol blended with 85% v/v mineral diesel) are compared with baseline mineral diesel using a fuel additive (1-dodecanol). The results indicated that methanol blending with mineral diesel resulted in superior combustion, performance, and emission characteristics compared with baseline mineral diesel. MD15 emitted a lesser number of particulates and NOx emissions compared with MD10 and mineral diesel. This investigation demonstrated that methanol–diesel blends stabilized using suitable additives can resolve several issues of diesel engines, improve their thermal efficiency, and reduce NOx and particulate emissions simultaneously. ▪ **R & D 9: Enhancement of Tribological Properties of Epoxy Composite Coatings for Engine Applications** This research focuses on achieving improved mechanical properties with a low coefficient of friction ≤0.1 and a minimal wear rate ≤10 -7 mm 3 / Nm for such coatings. The applications of epoxy composite coatings can be in extreme contact conditions such as engine piston rings and bearings. The present work is divided into five parts. The first part involves tribological and mechanical investigations of epoxy and its composites, adding graphene and graphite by ten wt. %, coating on steel substrate under dry and lubricated conditions at different loads and speeds. It was observed that epoxy/graphene composites exhibit a lower coefficient of friction (~0.18) and a wear rate of 5.5 x 10 -6 mm 3 /N-m at 3 N load and 0.63 m/s sliding speed under dry contact conditions when it was compared to epoxy. The second part of the thesis includes investigations of the tribological and mechanical properties of epoxy composite filled with nano-particles and liquid lubricants coated on D2 steel. Friction reduction by liquid lubricant (SN150 and PFPE by 10 wt. %) filled epoxy composites and associated lubrication mechanism have been studied. It was observed that the in-situ lubricant at the interface assisted in making the partial fluid film. The wear life improved by more than 200 times, and the coefficient of friction became half that of the composite without the lubricant.
2016-2017	▪ **R & D 10: Acoustics, Vibrations, Performance, Combustion and Emissions Characterization of Diesohol Fuelled Single Cylinder**

Compression Ignition Engine

This research work's comprehensiveness and focus on alcohol-diesel blends' noise and vibration characteristics are markedly different from earlier investigations. Towards this goal, 18 different diesel-alcohol blends were evaluated as potential candidates for partially replacing diesel using a single cylinder four stroke CI genset engine. Three different alcohols were used to prepare these blends: methanol, ethanol, and n-butanol. For specific formulations, co-solvents like dodecanol, and butanol, were used to eliminate the phase separation problem of the blends. The engine was run at a constant speed of 1500 rpm. However, investigations were conducted at six different loads. An elaborate experimental setup was developed to record data needed for calculating engine performance, combustion, noise, vibration, and emission characteristics from the engine fuelled by these 18 different diesel-alcohol blends. Before running tests on the engine, each test blend was characterized for its phase stability, density, calorific value, viscosity, oxidation stability, and corrosiveness. Results showed strong correlations between trends related to noise, combustion, emissions, engine performance parameters. Experimental data were also analyzed to understand the effect of the inherent fuel oxygen content of alcohols on these parameters. Overall, it was found that most of the test fuels could partially replace diesel for Genset applications if they are also found to be economically viable.

- **R & D 11: Mode Switching Prototype Engine Development for Low-Temperature Combustion**

Low-temperature combustion (LTC) concept has evolved over the last two decades in response to the demand for lowering NOx and soot emissions from direct injection (DI) diesel engines. In LTC, auto-ignition can be controlled by modifying fuel properties to make it more chemically reactive or inhibitive by adding an ignition promoter or inhibitor, as per the requirement. The fuel properties directly control the vital properties of the fuel-air mixture. Based on fuel properties, three distinct fuel-air mixture preparation techniques, namely, port fuel injection, early direct injection, and late direct injection, can be applied to LTC engines. Different derivatives of LTC, such as PCCI, PHCCI, etc., have been thoroughly investigated, and the suitability of each derivative was determined for a particular operating range. To explore the applicability of each LTC derivative for developing a production-grade LTC engine, this study was divided into three sections, namely (i) partially homogeneous charge compression ignition (PHCCI) combustion, (ii) premixed charge compression ignition (PCCI) combustion and (iii) mode switching between conventional CI combustion and LTC. Depending on the operating condition, mode switching involves dual combustion modes, which is an effective solution for commercializing LTC technology. In PHCCI combustion investigations, five test fuels were investigated at different loads, EGR rates and intake charge temperatures. These experiments validated the feasibility of LTC using low volatility fuels such as mineral diesel. PCCI experiments were carried out to explore the possibility of using a fuel injection strategy for different combustion modes. After successfully achieving control over PCCI combustion, an optimized fuel injection strategy was implemented on a production-grade engine to achieve mode switching between conventional CI combustion and LTC. This experimental study involved a journey starting with the fundamental combustion investigations of PCCI and culminating in developing a commercially viable mode switching LTC engine prototype,

	which will be energy efficient and environmentally friendly.
2015-2016	▪ **R & D 12: Spray, Engine Combustion, Performance, Emissions, Vibrations and Acoustics Studies of Biodiesel and SVO Blends** Initial investigations were carried out to measure important fuel properties, including density, viscosity, and calorific value for all test fuels. This was followed up by detailed investigations of spray characteristics for different test fuels. Finally, and most importantly, an exhaustive suite of experiments was conducted to understand performance, emissions, noise, and vibration characteristics for the test engine run on 12 different biofuel-diesel blends. Four of the fuels studied were 20% blends of different vegetable oils (Karanja (K20), Jatropha, Rapeseed, and Soybean) and diesel. These blends are named K20, J20, R20, and S20, respectively. Then there were 20% blends of four different biodiesels derived from Karanja, Jatropha, Rapeseed, and Soybean. These blends are named KB20, JB20, RB20, and SB20. Finally, we also tested pure biodiesels for Karanja, Jatropha, Rapeseed, and Soybean. These are named KB100, JB100, RB100, and SB100. Characteristics of these test fuels were compared against that of mineral diesel. Biodiesel properties such as viscosity and density significantly affect spray characteristics, resulting in relatively inferior spray atomization compared to mineral diesel. Biodiesel showed a slight improvement in noise and vibration characteristics due to a reduction in HRR max because of higher SMD of spray droplets compared to mineral diesel. Biodiesel engines emitted lower HC and NO x emissions, while CO emission and smoke opacity were relatively higher than mineral diesel, with a slight reduction in BTE.

Figure #1: Single cylinder optical research engine (SCRE)

This flexible internal combustion system provides varying fuel injection strategies, injection timings, supercharging boost pressure, compression ratio (slightly) etc. It is equipped with fuel conditioning, lubricating oil conditioning and coolant condition systems for conducting investigations under standard controlled conditions. This facility provides measurement and control of fuel injection pressure and injection pattern (two pilots, one primary and one post-injection). It has an AC dynamometer, a state-of-the-art intake air measurement system, and a gravimetric fuel flow meter. For particulate characterization, Smart Particulate Sampler (SPC) is installed in this system. This facility has installed a water-cooled piezo-electric pressure transducer, fuel-line pressure sensor and crank angle encoders for in-situ combustion analysis. For Combustion visualization, it has a transparent quartz liner and quartz window in the piston crown. The engine also has provisions for the installation of an endoscope for combustion visualization, which is particularly very useful at higher engine load conditions.

Figure #2: Experimental Setup of GDI Engine with the thermal head

It employs a 6-hole GDI injector (Bosch, GDI HDEV5). A fully programmable MOTEC open ECU (M400) controls the fuel injection quantity, timing, and spark timing. A peak and hold injector driver module (ZB-5100G, Zenobalti) connected to the engine via open ECU is used to operate the injector upon the encoder signal. For combustion analysis, a spark plugs pressure transducer (ZI31_Y5S, AVL) is connected to a data acquisition (DAQ) system (Indi micro, AVL). This DAQ system has an in-built charge amplifier, which converts the charge into voltage and provides the in-cylinder pressure signal. The crank angle position is measured by an optical crank angle encoder (365C, AVL) which gives 720 pulses per revolution. Sensors for lubricating oil pressure and temperature, barometric pressure, coolant in and coolant out temperatures, exhaust gas temperature and engine speed (rpm) are installed on the engine. Connections of the ECU include sensors for reference trigger, synchronization trigger, throttle position, manifold pressure, engine temperature, intake air temperature and narrow-band lambda sensor.

Figure #3: Two-Wheeler Chassis Dynamometer

The vehicle testing facility at ERL can do development emission testing for 2-wheelers (Max. Speed up to 150 Kmph). Testing facility capabilities include vehicle performance and tailpipe emissions testing per Indian standards.

Capabilities

- Max. Speed test, Power Test, Acceleration Test
- Road Load Simulation (RLS) and Wide-Open Throttle (WOT) mode
- Fuel Consumption Test
- Road Load Simulation (RLS) mode
- Emission Test
- Constant speed tailpipe emission using Road Load Simulation (RLS) and Wide-Open Throttle (WOT) mode
- Driving cycle evaluation
- World Motorcycle Test Cycle (WMTC), Indian driving cycle (IDC) etc. using driver's aid mode on portable emission analyzer (AVL-MDS 450)
- Calibration of Fuel Supply Device (ECU/ Carburettor) and Catalytic Converters
- Road Load Simulation (RLS) and Wide-Open Throttle (WOT) mode

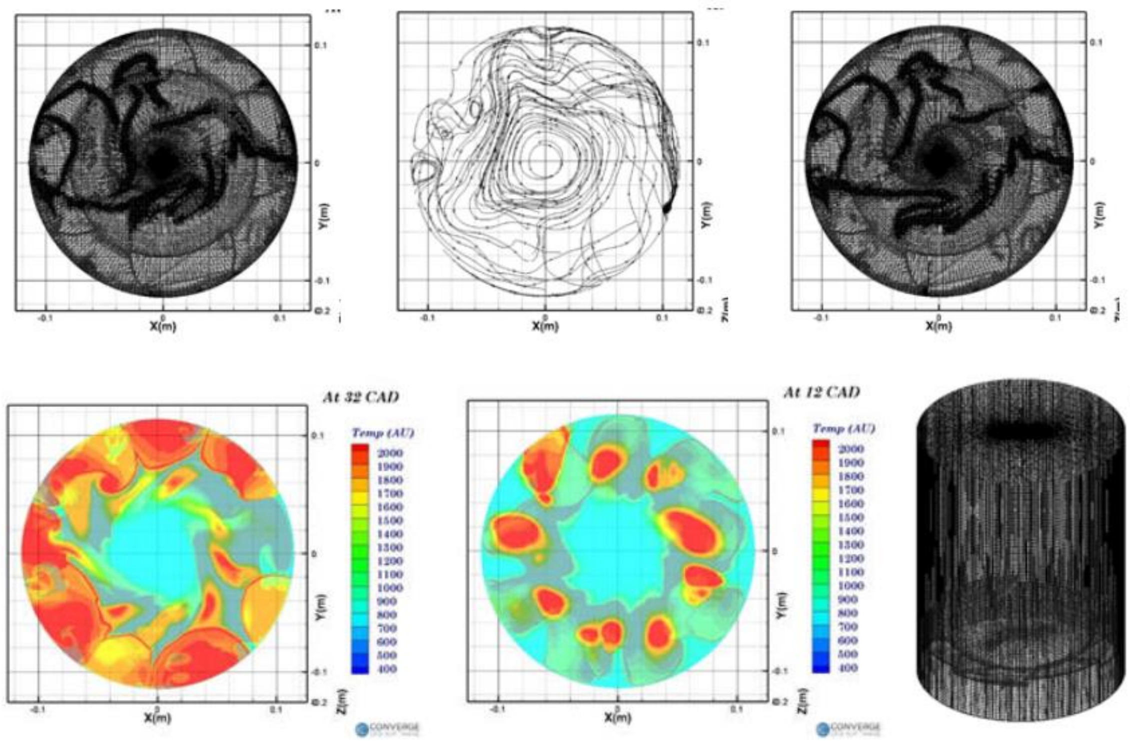


Figure #4: Simulation capabilities

Engine Research Lab's simulation facility can comprehensively study the combustion, performance and emission parameters of engines. This facility is an excellent tool for adaptations of preliminary investigations of newer alternative fuels in existing engines and developing new engines for alternative fuels. ERL has a dedicated workstation equipped with 1-D and 3-D software, GT Suite and Converge, for carrying out simulations. GT-Power is designed for steady state and transient simulations suitable for engine/powertrain control. The software uses 1-D gas dynamics to represent the flow and heat transfer in the components of the engine model. Converge CFD is a 3D modelling software that lets us view the element's graphical interface that cannot be easily modelled and visualized with 1-D software such as GT-Power.

Smart Materials, Structures and Systems (SMSS) Laboratory

Laboratory Coordinator: Dr. Bishakh Bhattacharya

Website: https://www.iitk.ac.in/smss/

List of Major Equipment:

- 3D Laser Doppler Vibrometer,
- Acoustic Camera
- GPU Cluster – Server
- ViperX 300 Robot Arm 6DOF
- 3D Printers - Creality Ender-3 V2 and Ultimaker 3 Extended
- d33 PiezoMeter Systems - PM300
- Amplified Piezo Actuator
- Intel® RealSense™ Tracking Camera
- Vibration Exciters - LDS Shaker V101, V201 and Modal Exciter 2025E
- dSpace ACE 1103, 1104, Multi-channel SMA amplifiers
- Magnetic Levitation Control
- Accelerometers and Force Sensors ICP
- 4 channel active vibration control system
- Data Acquisition System: Graphtec GL2000
- Micro Syringe Assembly GS1200
- Laser Distance Meter

Brief description of the laboratory:

Please provide a brief description of the laboratory in about 8-10 lines, focusing on the main thrust area of the laboratory activities.

Smart Materials, Structures and Systems (SMSS) Lab actively works towards novel scientific and technological inventions. SMSS lab works in a diverse field ranging from smart materials (Shape Memory Alloy, Piezoelectric) and meta-structures to robotics and neuronal modelling. Over the past two decades, SMSS lab in the department of Mechanical Engineering at IIT Kanpur, has excelled consistently in various domains of mechanical science, at national as well as international levels. The lab has a long-standing reputation of grooming quality engineers and motivated researchers. Research activities and facilities in SMSS lab attract many aspiring students and research scholars across various disciplines. This lab is an epitome of working towards the betterment of society and nation-building through technological innovations and transfer.

Laboratory research keywords:

Shape Memory Alloy; Robotics; Metastructure; Vibration & Control; Dynamical System; Telemedicine & Prosthetics; Neuronal Modelling; Cognitive Science.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity

2020-2021	1. Bioinspired SMA based Actuator
	• Objective - DC motor-based actuators are being widely used in various fields; however, they mostly depend upon the embedded gear train mechanism to provide required torque output. The use of gear trains, in turn, increases the cost, size, and weight of the actuators. Therefore, the current project proposes to provide a solution to tackle the challenge. The idea behind the project is based on the biomimetic approach, which provides an abundance of designs and solutions which are optimized and efficient in nature to solve complex human problems. The solution to this problem can be obtained from the biomimicry of muscles located in the human body. These types of muscles generally allow higher force production but a smaller range of motion. The design of muscle provides the flexibility of controlling the length of fibre (in our case, SMA wire) to obtain the torque requirement without having any significant effect on the overall dimensions, weight, and cost of the actuator.
	• Research Impact –
	  • Kanhaiya Lal Chaurasiya, A. Sri Harsha, Yashaswi Sinha, Bishakh Bhattacharya (2022). Design and development of non-magnetic hierarchical actuator powered by shape memory alloy based bipennate muscle. Scientific Reports.
	  • Bishakh Bhattacharya, A Sri Harsha, Kanhaiya Lal Chaurasiya (2021). Shape Memory Alloy Embedded Bipennate Actuator System for Enhancing Output Torque or Force. IPA: 202111028327.
	  • Bishakh Bhattacharya, Kapil Das Sahu, Kanhaiya Lal Chaurasiya, Ujjain Kumar Bidila, P Mani Kumar, Johnson Controls (2021). AN ACTUATOR FOR A VALVE. IPA: 202111039151
	2. Cognitive Robotics based study of Child-Robot Interaction (CRI) - Characterization of Critical Parameters and Interaction Design
	• Objective - The principles of Child-Robot Interaction is yet underdeveloped and a lot of work is in progress to develop the foundation. Though rapid progress in the field of artificial intelligence is paving a path towards the goal, that machines becoming adaptively intelligent, the complexity associated for designing such a framework is increasingly challenging. Humans subconsciously adapts their behaviour to the surrounding environment to make the interaction run smoothly. Replicating such smooth interaction is difficult for a machine (Robot). The challenge lies in the parameter identification for interactions and subsequently designing an efficient model to handle the same. For an adult these models are even more complex than a child owing to the order of heterogeneity associated with these interactions. This project aims to study several critical parameters that affect interaction with Robots for children with different age groups and develop suitable models that helps in implementing

	smooth and untethered interaction. Several physical design related issues of a Robot along with the capabilities that enhances interaction will be studied in an experiment based setup. Pre-defined interaction through a Robot (NAO) will be programmed and subjects (children with several age groups) will be engaged with the same. The response from the subjects will be recorded and analysed with the state-of-art data analytics tools to draw inferences. The inferences will help in modelling a more socially adaptive robot and also identify active and passive characteristics that should be inculcated in the Robot's hardware and software designs.
	• Outcome
	    • Developed a Reinforcement Learning (RL) based model for the robot to react in a trustworthy manner while interacting with children
	    • Replicated human-like gestures in the NAO humanoid robot for different emotions
	3. Design and Development of Autonomous Power Substation Inspection Robot
	• Objective: POWERGRID is presently operating 1,70,224 ckms of transmission lines along with 262 substations with 4,51,351 MVA transformation capacity. To maintain such vast network with more than 99% availability, it is challenging and requires lot of resources. Substations are the nodes of electrical grids, ensuring reliability, efficiency, and sustainability of electricity transmission and delivery.
	In order to address the demands that arise during construction, refurbishment, and operation and maintenance (O&M) of substations, substantial efforts have been made to develop robots capable of assisting or replacing engineers in the performance of repetitive and/or dangerous tasks comprising the substation lifecycle. A further advantage of O&M robotics is that it can increase availability, as many facilities are unattended, yet must be continuously operational. POWERGRID and IIT Kanpur are jointly developing an autonomous mobile robot for inspection of substations to take care of repetitive and time-consuming inspection activities on a regular basis. The robot will be equipped with a wide array of sensors (IRIS control cameras, IR thermal sensors, LIDAR, fire alarms) and an autonomously (along with tele-operation feature) navigating platform which roams around a substation and perform inspection for damages in components that are essential for continuous running of the sub-station
	• Outcome – The robot will utilize advanced vision processing and machine learning algorithms to independently identify and flag any damages or failure to any critical components in the substation and automatically trigger an alarm. Use of such robot will also allow ground staff to access areas in a substation that are manually difficult to inspect. The robot will be trained using condition monitoring algorithms based on machine learning. This will enable the robot in damage identification, classification and prognosis of every sub-system. The procedure will upgrade the maintenance from routine monitoring to a continuous monitoring system and enhance the life of

	the components significantly.

2019-2020	4. Design and Development of Autonomous Robot for Crop-Monitoring and Localized Pest Neutralization
	• Objective:
	  • Monitoring local conditions (temperature, humidity etc.) in the farm
	  • Autonomous navigation (manual override option available)
	  • Smart sensors (high resolution camera) and algorithms (AI/ML based) to detect local infestation of crops
	  • Efficient deterrence by localised pesticides delivery mechanism to the affected area
	  • Advance precision farming technique
	  • Display for real-time image feeds from inaccessible regions.
	• Research Impact:
	  • Mahendra Kumar Gohil, Anirudha Bhattacharjee, Bishakh Bhattacharya, Samir Kumar Biswas (2022). A ROBOT SYSTEM FOR AUTOMATICALLY MANAGING AGRICULTURAL ACTIVITIES. IPA: 202211034166.
	  • Mahendra Kumar Gohil, Aniruddha Bhattacharjee, Divya Jyoti Pandey, Chetan Vashishtha, Bishakh Bhattacharya (2021). A SYSTEM FOR FACILITATING TWO-DIMENSIONAL FLUID MOVEMENT OF AN OBJECT OVER AN AREA. Patent No: 401748.
	5. Pipe Health Monitoring Robot (PHMR)
	• Objective: The project aims at developing a pipe health monitoring system based on smart sensors which can be transported inside compressed gas pipes with the help of a conduit crawler robot to determine the extent of anomalies present in the pipeline. The pipe health monitoring system will comprise a sensor network for anomalies detection, a micro-controller for processing the data from various sensor units and a storage unit to store the processed data, and an autonomous platform or robot, to carry these components inside the pipeline.
	• Research Impact:
	  • Santhakumar Sampath, Kanhaiya Lal Chaurasiya, Pouria Aryan, Bishakh Bhattacharya (2021). An innovative approach towards defect detection and localization in gas pipelines using integrated in-line inspection methods. Journal of Natural Gas Science and Engineering.
	  • Santhakumar Sampath, Bishakh Bhattacharya, Pouria Aryan, Hoon Sohn (2019). A Real-Time, Non-Contact Method for In-Line Inspection of Oil and Gas Pipelines Using Optical Sensor Array. Sensors
	  • Kanhaiya Lal Chaurasiya, Bishakh Bhattacharya, S Barathy, Sanjeev Kumar (2020). Speed Control System for Pipe Health

	Monitoring Robot. IPA: 202011016379. • Bishakh Bhattacharya, Nachiketa Tiwari, Nayan Jyoti Baishya, Himanshu Panday, Vaibhav Verma, S. Barathy, Raj Kumar Kashyap, Parivesh Chugh, T.P. Yuvaraj, Pushpit Kant, Sumit Kumar (2015). A Novel Self Powered, Intelligent Pipe Health Monitoring Robot (PHMR) for Inspecting Gas Pipe Line. Patent No: 403841.

2018-2019	6. Smart Stick
	• Objective: This project aims to develop a smart, adaptive, and intelligent walking aid for elderly people, which can provide adequate force in a Sit-to-Stand and vice-versa transfer. The proposed device is equipped with sensors and intelligent algorithms that actuates itself adaptively to provide the force deficiency that older people encounters while executing the daily activities. Sit-to-stand or stand-to-sit (STS) motion is a very common and vital activity in everyday mobility. Elderly people often looks for external help/support to gather adequate support to execute the same. This project intends to develop a smart adaptive walking aid for elderly people equipped with sensors and feedback mechanism that actuates itself adaptively to provide the force deficiency.
	• Outcome:
	  ◦ Adaptive reconfigurable STS smart walking assistance stick with active actuation to adjust height
	  ◦ Sensors and learning algorithms to train to provide personalized comfort.
	  ◦ Gait calibrated auto adjustment of momentum transfer for effortless walking assistance.
	  ◦ Smart stick integrated with auto calibration.
	  ◦ Uniquely designed vibration dampers (honeycomb flex) integrated to prevent shock and falling.

2017-2018	7. Design of shape memory alloy actuated intelligent parabolic antenna for space applications • Outcome: The deployment of large flexible antennas is becoming critical for space applications today. Such antenna systems can be reconfigured in space for variable antenna footprint, and hence can be utilized for signal transmission to different geographic locations. Due to quasi-static shape change requirements, coupled with the demand of large deflection, shape memory alloy (SMA) based actuators are uniquely suitable for this system. In this paper, we discuss the design and development of a reconfigurable parabolic antenna structure. The reflector skin of the antenna is vacuum formed using a metalized polycarbonate shell. Two different strategies are chosen for the antenna actuation. Initially, an SMA wire based offset network is formed on the back side of the reflector. A computational model is developed using equivalent coefficient of thermal expansion (ECTE) for the SMA wire. For power-minimization, an auto-locking device is developed. The performance of the new configuration is compared with the offset-network configuration. It is envisaged that the study

	will provide a comprehensive procedure for the design of intelligent flexible structures especially suitable for space applications.
	• Research Impact:
	  • Kalra S, Bhattacharya B, Munjal BS. Design of shape memory alloy actuated intelligent parabolic antenna for space applications. Smart Materials and Structures. 2017 Aug 9;26(9):095015.
	  • Kalra S, Bhattacharya B, Munjal BS. Development of shape memory alloy actuator integrated flexible poly-ether-ether-ketone antenna with simultaneous beam steering and shaping ability. Journal of Intelligent Material Systems and Structures. 2018 Nov;29(18):3634-47.
	8. Exploring the dynamics of hourglass shaped lattice metastructures
	• Objective: Continuous demand for the improvement of mechanical performance of engineering structures pushes the need for metastructures to fulfil multiple functions. Extensive work on lattice-based metastructure has shown their ability to manipulate wave propagation and producing bandgaps at specific frequency ranges. Enhanced customizability makes them ideal candidates for multifunctional applications. This paper explores a wide range of nonlinear mechanical behavior that can be generated out of the same lattice material by changing the building block into dome shaped structures which improves the functionality of material significantly. We propose a novel hourglass shaped lattice metastructure that takes advantage of the combination of two oppositely oriented coaxial domes, providing an opportunity for higher customizability and the ability to tailor its dynamic response. Six new classes of hourglass shaped lattice metastructures have been developed through combinations of solid shells, regular honeycomb lattices and auxetic lattices. Numerical simulation, analytical modelling, additive layer manufacturing (3D printing) and experimental testing are implemented to justify the evaluation of their mechanics and reveal the underlying physics responsible for their unusual nonlinear behaviour. We further obtained the lattice dependent frequency response and damping offered by the various classes of hourglass metastructures.
	• Research Impact:
	  • Vivek Gupta, Sondipon Adhikari, Bishakh Bhattacharya (2020). Exploring the dynamics of hourglass shaped lattice metastructures. Scientific Reports.
	  • Vivek Gupta, Sondipon Adhikari, Bishakh Bhattacharya (2020). Locally resonant mechanical dome metastructures for bandgap estimation. Active and Passive Smart Structures and Integrated Systems IX.
	  • Vivek Gupta, Anwesha Chattoraj, Arnab Banarjee, Bishakh Bhattacharya (2019). Wave propagation in auxetic mechanical metamaterial: Bloch formalism for various boundary conditions. Active and Passive Smart Structures and Integrated Systems XIII.

2016-2017	9. Dual Functional Metamaterials and Metastructures for Energy Harvesting and Vibration Control
	• Objective: The dynamics of periodic materials and structures have a profound historic background starting from Newton's first effort to find sound propagation in the air to Rayleigh's exploration of continuous periodic structures. This field of interest has received another surge from the early 21st century. Elastic mechanical metamaterials are the exemplars of periodic structures that exhibit interesting frequency-dependent properties like negative Young's modulus and negative mass in a specific frequency band due to additional feature of local resonance. It implies, the spatial periodicity of mechanical unit cells in engineered metamaterials exhibits properties beyond one can expect from conventional naturally occurring materials. Locally resonant units in the designed metamaterial facilitate bandgap formation virtually at any frequency for wavelengths much higher than the lattice length of a unit cell. Whereas at higher frequencies for wavelengths equal to the lattice size of the medium, the Bragg scattering phenomenon occurs, which also helps in the bandgap formation. Due to out of phase motion of multiple resonating units with lattice, there is a change in the dynamic behavior (stiffness or mass) of the material as physical properties become frequency-dependent.
	• Research Impact:
	  • Ankur Dwivedi, Arnab Banerjee, Bishakh Bhattacharya (2020). A novel approach for maximization of attenuation bandwidth of the piezo-embedded negative stiffness metamaterial. Active and Passive Smart Structures and Integrated Systems IX.
	  • Ankur Dwivedi, Arnab Banerjee, Bishakh Bhattacharya (2020). Simultaneous energy harvesting and vibration attenuation in piezo-embedded negative stiffness metamaterial. Journal of Intelligent Material Systems and Structures.
	  • Ankur Dwivedi, Arnab Banerjee, Bishakh Bhattacharya (2019). Study of piezo embedded negative mass metamaterial using generalized Bloch theorem for energy harvesting system. Active and Passive Smart Structures and Integrated Systems XIII.

2015-2016	10. Cabin Pressure Control System (CPCS) • Objective: Cabin pressure control system of an aircraft maintains cabin pressure in all flight modes as per the aircraft cabin pressurization characteristics by controlling the air flow from the cabin through the outflow valve of the cabin pressure control valve. The movement of outflow valve in turn depends on the air flow from the control chamber of cabin pressure control valve, which is controlled by the clapper and the poppet valves. These valves are actuated by absolute pressure and the differential pressure capsules, respectively depending upon the operating flight conditions. Mathematical models have been developed to simulate the air outflow rates from the cabin and the control chamber of cabin pressure control

	valve during steady-state and transient flight conditions. These mathematical models have then been translated into a MATLAB program to obtain plots of cabin pressures as a function of aircraft altitudes. The mathematical models are validated for standard cabin pressurization characteristics of a multirole light fighter/trainer aircraft. The model developed, thus can be used to produce a number of variants of cabin pressure control valve to suit different cabin pressurization characteristics. • Research Impact: • Kanhaiya Lal Chaurasiya, Bishakh Bhattacharya, A K Varma, Sarthak Rastogi (2020). Dynamic modeling of a cabin pressure control system. Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering.

Figure #1: Design and Development of Autonomous Robot for Crop-Monitoring and Localized Pest Neutralization

Figure #2: Design and development of non-magnetic hierarchical actuator powered by shape memory alloy based bipennate muscle.

Figure #3: Design and Development of Aquatic Autonomous Observatory (Niracara Svayamsasita VedhShala - NSVS) for In situ Monitoring, Real Time Data Transmission and Web based Visualization.

Figure #4: 8-inch pipeline test-bed facility with air compressor operational at Department of Mechanical Engineering, IIT Kanpur

Figure #5: Exploring the dynamics of hourglass-shaped lattice Meta structures

Energy Storage Systems Laboratory

Laboratory Coordinator: Dr. Jishnu Bhattacharya

List of Major Equipment:

- Blue wave miniature spectrometer (350-1100 nm)
- Two axis solar trackers
- Water salinity meter
- Compact solar simulator
- Thermal chamber for destructive battery testing
- Sonicator for nano-enhanced PCM
- Pyranometer and Pyrheliometer
- Parallel computing cluster

Brief description of the laboratory:

ESSL (Energy Storage Systems laboratory) focuses on various storage technologies including electrochemical and thermal systems. The Li-battery based systems are analyzed in terms of fundamental material characterization and prediction. Moreover, thermal management techniques are experimented on in terms of applications in the electric vehicles. Thermal storages are linked to the solar heat collection and conversion. Solar conversion and utilization experiments are performed in terms of photovoltaic, beam-concentrator, beam-splitting and desalination applications. Performance enhancement techniques in phase change material based thermal storage systems are analyzed for various applications. Thus, ESSL tries to answer few useful questions in the field of energy conversion and storage.

Laboratory research keywords:

Lithium-ion battery; thermal management; solar conversion; thermal storage; desalination; heliostat field; parabolic trough; nano-enhanced PCM;

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• Formulation of optimal layout for fixed plane solar photovoltaic array • Development of algorithm for shading and blocking loss estimation in a heliostat field • Prototype development of a nano-enhanced membrane-based desalination system
2019-2020	▪ Design and installation of destructive battery test chamber ▪ Experimental evaluation of heat generation by Li-ion cells under pulse discharge condition and testing the validity of Bernardi

	equation ▪ Estimation of spectral factor as function of angle of incidence
2018-2019	• Development of universal non-dimensional number (Runaway Mitigation Number or RMN) for comparing thermal runaway mitigation in large battery packs • Development of layouting algorithm of parabolic trough collector field where inter-trough shading and blocking are included
2017-2018	• Development of real-time spectral factor estimation based on local conditions and weather – case study for Kanpur • A novel stationary concentrator is developed for low concentration, low cost photovoltaic system
2016-2017	• Development of modular sensible heat storage system and demonstration of its thermodynamic advantage
2015-2016	• Building computational facility for large scale parallel computing • Discovery of new ground state structure for vanadium pentoxide through computational structure search

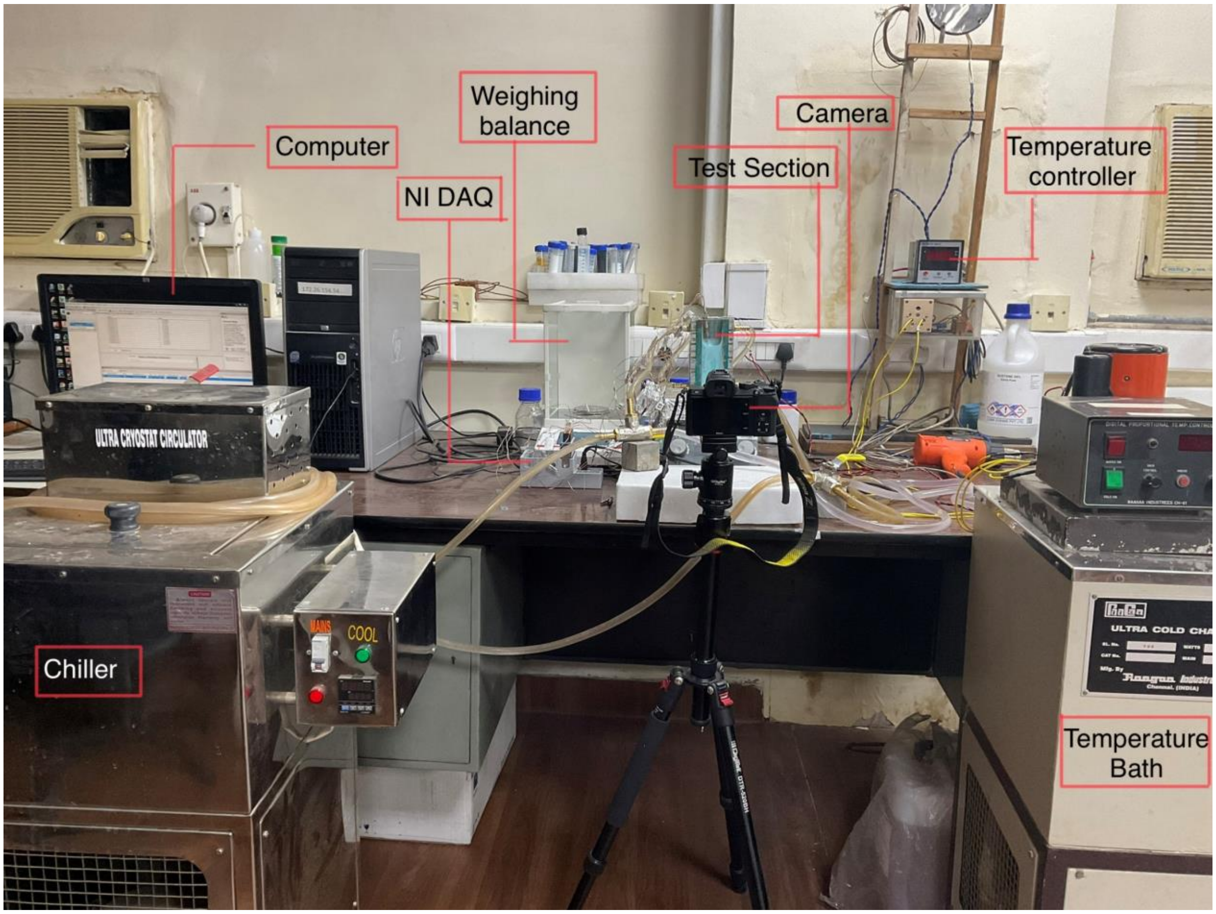


Figure #1: Experimental facility for nano-enhanced PCM based thermal storage systems

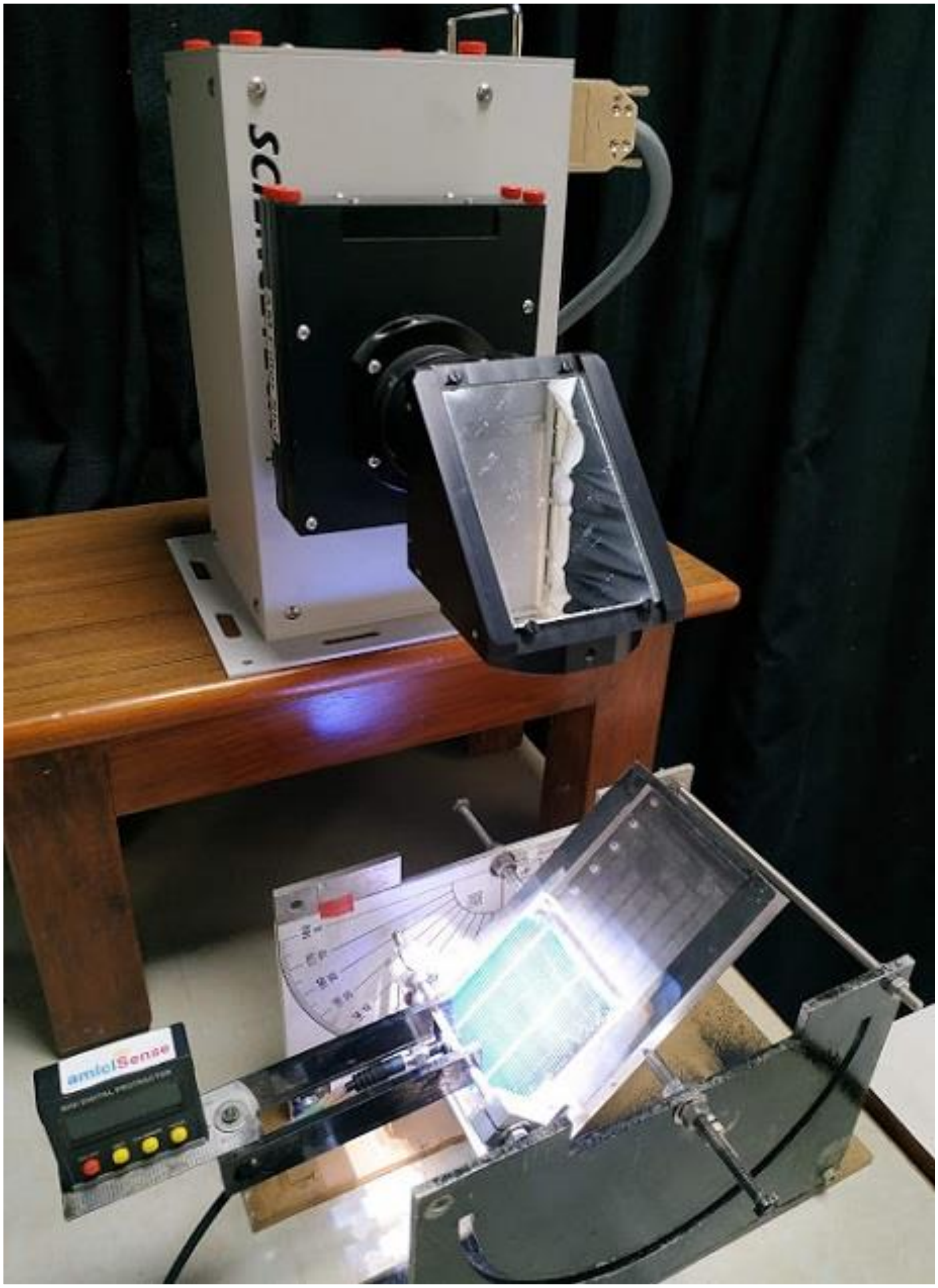


Figure #2: Experimental facility for determining the effect of angle of incidence on solar photovoltaic cells

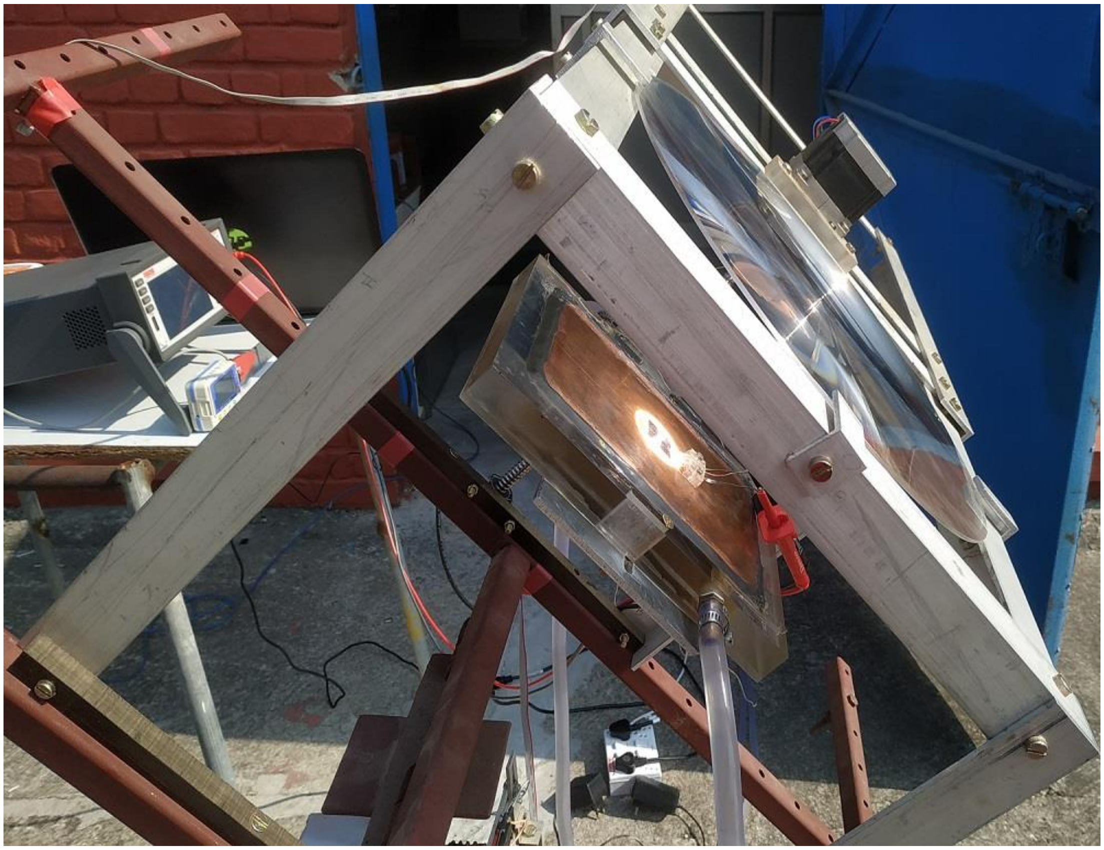


Figure #3: Solar concentrator mounted on two axis solar tracker

Figure #4: Two axis solar tracker for testing large scale panels

Figure #5: Solar desalination system based on Fresnel concentrators and nano-enhanced membrane

Micro systems Fabrication Laboratory

Laboratory Coordinator: Dr. Shantanu Bhattacharya

List of Major Equipment:

- Wire Bonder
- Desk Top Mask Aligner
- DI water system
- Chemical balance
- Fume Hood
- Gravity Convection Oven
- Optical Table
- Spin Coater
- Air cooled Chiller
- Sputtering / PECVD Dual
- Oxidation Furnace
- UV-Vis
- Autoclave
- Silane system
- Nano cal-C
- Fluorescence microscope
- Impedance measurement
- Laminar Tents
- Gas sensing setup

Brief description of the laboratory:

Please provide a brief description of the laboratory in about 8-10 lines, focusing on the main thrust area of the laboratory activities.

The “Microsystems Fabrication Laboratory” is located within the Mechanical Engineering department and caters to the Engineering of micro/nano-systems leading to domain centric applications in healthcare, energy, environment and water. The laboratory has developed key technologies in diagnostic devices, printable supercapacitors, gas sensors, acoustic metamaterials and photocatalytic remediation of textile water. The products and systems developed have resulted in many technology patents, several doctoral degrees, two products (one rapid card for Dengue diagnostics “Test Easy” and one water treatment pilot plant at a medium scale industry at Jaipur textile park), one start-up company incubated @ IIT Kanpur, several awards and accomplishments etc.

Laboratory research keywords:

BioMEMS; Micro/nano systems technology; Paper Microfluidics; Nano-energetic Materials; Acoustic Metamaterials; Photocatalysis; Sensors; Printable Supercapacitors; Product Design; Impedance Spectroscopy

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity (Top Highlights)
2020-2021	**R&D development #1: Fractal Acoustic Metamaterial:** In this work we have developed fractal acoustic meta-structures which are observed to **provide multiple narrow band low frequency adsorption** of acoustic signals. The fractal design consists of a set of interconnected rapidly scaling down side branched Helmholtz resonators with excellent tunability to multiple frequencies. **(Sponsored: Boeing Project)** **R&D development #2: Synthesis and evaluation of novel V2O5-rGO photocatalysts with pH dependent sensitivity:** In this work we have created a pH sensitive photocatalyst using vanadium salts and evaluated its role in colour removal over textile industrial effluents. It is further observed that the catalyst developed has shown reusability and refurbishing abilities. **(Sponsored by Abdul Kalam Technical Innovation Fellowship)** **R&D development #3: Development of an intelligent rotational magneto abrasive flow finish system**: In this work we have carried out the development of a Rotational-Magneto Abrasive Flow Finishing (RMAFF) machine- for finish machining of cylindrical camshafts to a desired 300 nm or lesser surface finish with high finishing rate using an ANN based predictive controller. The ANN is taught using different datasets on parameters like shaft materials, machining conditions, i.e., number of cycles, speed of rotation, abrasive sizes, initial roughness, desired roughness etc. The problem statement addressed is for a loom manufacturer of woven plastics for tape winding operations. **R&D development #4: Development of a vertical electro-chemical micromachining system:** In this work a novel vertical ECMM setup has been designed and developed, which can machine on a workpiece kept in a position perpendicular to the ground. There arise particular situations in avionics and automotive applications when it is difficult to dismantle the whole assembly and carry out the machining. So, the capability of machining on a vertical surface widens the applications of the proposed ECMM setup. This ECMM setup is capable of machining variable orientations of workpieces with machining performance similar to ECMMs with gravity-assisted technology. **R&D development #5: Making data driven quality Management accessible to small scale diary cooperatives of India: T**his work aims at contributing to next generation miniaturised and low-cost sensors systems (with inbuilt data analytics and traceability algorithms) that can be used throughout the supply chain to identify causes of milk quality problems and enable development of strategies to rectify prevalent issues. The various objectives of this study are (1) To undertake field trials to track the quality of milk from the farmgate through the entire supply chain

	to identify critical events that result in deterioration of quality of milk,, (2) To develop POC mid-infrared spectroscopic sensors and enabling algorithms to measure (by proxy) milk quality parameters that can be used to predict the rate at which milk quality may deteriorate and its suitability for pooling or alternate processing options, and (3) to inform actions for supply chain optimization to improve overall provenance and traceability. **(Sponsored by VESKI, Victoria State, Australia)**
2019-2020	**R&D development #1: Impedance spectroscopy biochip for detection of gold labelled DNA:** In this project we have design a microchip platform that carries out specific DNA detection through EIS using nanoparticle labelling approach and also an added selectivity step through the use of dielectrophoresis (DEP), which enhances the detection sensitivity and specificity to match the detection capability of quantitative polymerase chain reaction (qPCR). The detection limit of the proposed biochip is observed to be 3-4 PCR cycles for 582 bp bacterial DNA, where the complete procedure of detection is performed in less than 10 min. **(Sponsored by DST, Bio-Instrumentation)** **R&D development #2: Surface engineering of PEEK surfaces to increase the shelf life in aerospace applications:** In this work, we have reported a combined effect of plasma and PEG Silane treatment for permanent hydrophilic modification and improved adhesion strength of PEEK surfaces. The time-dependent changes in the contact angles, XPS, and ATR-FTIR spectra results have been used to investigate the surface properties of the modified surfaces and the new surfaces are engineered to play a pivotal role in long-term modification of PEEK. **(Boeing project)** **R&D development #3: Parametric behavior of coatings for building large area superhydrophobic substrates:** This work applies the powerful machine learning algorithms (Levenberg Marquardt using Gauss Newton and Gradient methods) to evaluate the various processes affecting the anti-wetting behavior of coated printable paper substrates with the capability to predict the most optimized method of coating and materials that may lead to a desirable surface contact angle. The major application techniques used for this study pertain to dip coating, spray coating, spin coating and inkjet printing and silane and sol–gel base coating materials**. (Sponsored by Boeing)**
2018-2019	**R&D development #1: Ashok Chakra Meta-structure as a broad band low frequency near perfect sound absorbers:** In this work we have designed and developed thin acoustic meta-structures with subwavelength dimensions through which almost perfect sound absorption is achieved in the low-frequency domain. Our overall strategy builds on the fact that the sound absorption capabilities of the meta-structures primarily depend on the geometric dimensions and can easily be reconfigured as per requirements through a change of geometry. To analyze various possibilities, we optimize the geometric structure through hybrid regression analysis using the genetic algorithm approach and finite element-based numerical simulations so that the geometry is tuned for high attenuation of acoustic signals over a broad range of frequencies. Both theoretical

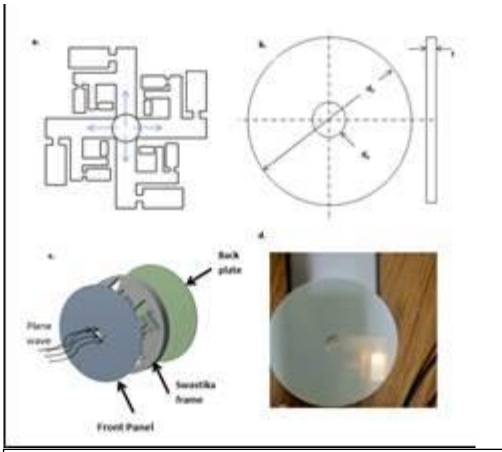
	and experimental data show good parity and are able to establish the meta-structure nature of the assembly with respect to different frequency bands in low frequency domain. **(Sponsored by Boeing)** **R&D development #2: Design and testing of micro-cantilever sensors for detection of trace analytes like cholesterol, chloroform etc.:** In this work we have designed and developed microscale cantilevers for the trace detection of various analytes like chloroform, cholesterol etc. The polymeric cantilever fabrication process was established repeatably using thin films of photoresist and a coating process for rGO-MWCNT (reduced graphene oxide-multiwalled carbon nanotube) nanocomposite material with Poly-L-Lysine functionalization was developed which is used detection of biomolecules with enhanced sensitivity. We have been able to successfully detect 100 femto-molar concentration of Cholesterol from human blood and up to 250 ppb level of chloroform using the cantilever architecture. **(Sponsored by DST Nanomission)**
2017-2018	**R&D development #1: Inkjet Printed Electrodes Of Graphene Oxide-Metal Oxide Hierarchical Nanostructured Nanocomposites For Improved Energy Density And Power Density Thin Flexible Supercapacitors:** In this project we have fabricated fully printed, solid-state, and flexible PμSCs on cellulose paper substrates. The digitally designed interdigitated electrode patterns are first printed on paper with reduced graphene oxide (rGO) ink to construct a conducting matrix. The negative electrode is printed using activated carbon–Bi2O3 ink and the positive electrode is printed with rGO-MnO2 ink, each on one half of the pre-printed conducting patterns to form an asymmetric design using different nozzles of the same printer. A polyvinyl alcohol–KOH electrolyte ink is printed over the electrode patterns and solidifies to complete the device. Notably, geometric parameters such as the width of the electrode finger and the width of the interspaces between the adjacent fingers were also optimized to achieve the optimum electrochemical performance of the device. **(Sponsored by DST, MES, Featured as top success stories of 2021)** **R&D development 2: α-Fe2O3 loaded rGO nanosheets based fast response/recovery CO gas sensor at room temperature** This work illustrates a simple and cost effective methodology to develop nanoparticles of α-Fe2O3 embedded in layered rGO sheets which are found to be a potential material for the sensitive detection of CO gas at room temperature for the first time. The nanocomposite rGO-α-Fe2O3 shows improved CO gas sensing characteristics in comparison with pure α-Fe2O3. rGO sheets provide enhanced sensitivity through their extra-ordinarily high surface area (19.047 m2/gm rGO-α-Fe2O3), low response (21 s at 10 ppm) as well as recovery times (8 s at 10 ppm) etc. Material also shows p-type semicond. behaviour at room temp-erature and has a high selectivity towards CO gas only. **(Sponsored by ISRO)** R&D development #3: **Tapered lateral flow immunoassay-based point-of-care diagnostic device for ultrasensitive colorimetric**

	detection of dengue NS1 In this work we have developed a novel lateral flow immunoassay for detection of dengue leveraging on the benefits of gold decorated graphene oxide sheets as detection labels and a tapered nitrocellulose membrane. The developed assay allows for rapid (10 min) and sensitive detection of dengue NS1 with a detection limit of 4.9 ng mL−1, ~11-fold improvement over the previously reported values. Additionally, the clinical application of the developed assay has been demonstrated by testing it for dengue virus spiked in human serum. The reported lateral flow immunoassay shows significant promise for early and rapid detection of several target diseases. This work received the **GYTI award of 2017** and the proprietor of this work incubated a company at IIT Kanpur which bagged the **BIG, BIRAC grant** successfully. Today the technology has successfully completed clinical trials. **(Sponsored by BIRAC)** **R&D development #4: Highly sensitive V2O5·1.6H2O nanostructures for sensing of helium gas at room temperature** In this work, we report the facile synthesis of hydrated vanadium pentoxide (V2O5·1.6H2O) nanostars using hydrothermal route and their use was demonstrated and compared with nanowire type structure for sensing of helium gas for the first time. The gas sensing properties were attributed to the electron hopping mechanism in V2O5·1.6H2O nanostructures at room temperature. We observed that the change in morphology of V2O5·1.6H2O helps to augment the overall response (to 53% at 300 ppm) with very low response/recovery time (9/10 s). The excellent sensing properties at room temperature, make V2O5·1.6H2O nanostructures a potential material for He gas sensing application. **(Sponsored by ISRO)**
2016-2017	**R&D development #1: Facile synthesis of Au@Ag–hemin decorated reduced graphene oxide sheets: a novel peroxidase mimetic for ultrasensitive colorimetric detection of hydrogen peroxide and glucose** In this work we report the facile synthesis of a quaternary nanocomposite material (hemin–silver coated gold– graphene oxide) and evaluate its efficacy as a novel peroxidase mimetic. A strong synergistic coupling results in an excellent catalytic performance of this nanocomposite. A comparison of the different morphologies of the silver coated gold particles strongly indicates a greater sensitivity of the nanostar morphology over the nanoparticle morphology owing to its high surface-to-volume ratio. Furthermore, the immobilization of hemin and silver coated gold nanostars on a graphene oxide sheet framework imposes a nanoscale confinement, effectively augmenting the overall catalytic performance of the composite. The nanocomposite demonstrates a nanomolar range sensitivity towards hydrogen peroxide and glucose (limit of detection ¼ 1.26 nM and 425 nM). **(Sponsored by DIC, MHRD)** **R&D development #2: Double negative acoustic metastructure for attenuation of acoustic emissions** In this work, we report a double negative acoustic meta-structure

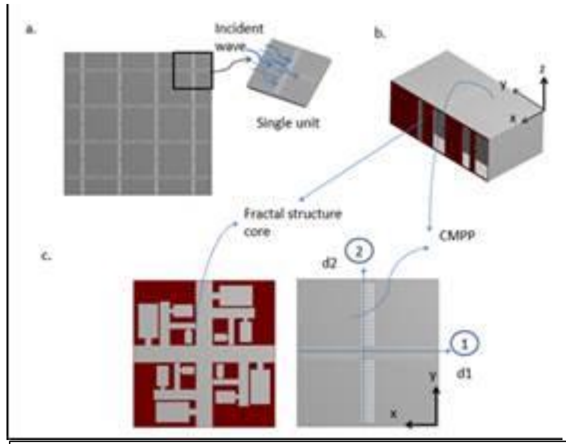
	for absorption of low frequency acoustic emissions in an aircraft. This is achieved by utilizing a periodic array of hexagonal cells interconnected with a neck and mounted with an elastic membrane on both ends. An average transmission loss of 56 dB under 500 Hz and an overall absorption of over 48% have been realized experimentally. The negative mass density is derived from the dipolar resonances created as a result of the in-phase movement of the membranes. Further, the negative bulk modulus is ascribed to the combined effect of out-of-phase acceleration of the membranes and the Helmholtz resonator. The proposed meta-structure enables absorption of low frequency acoustic emissions with improved functionality that is highly desirable for varied applications. **(Sponsored by Boeing)** R&D development #3: **Polyaniline silver nanoparticle coffee waste extracted porous graphene oxide nanocomposite structures as novel electrode material for rechargeable batteries** In this work, we have developed an in-situ hybrid nanocomposite from coffee waste extracted porous graphene oxide (CEPG), polyaniline (PANI) and silver nanoparticles (Ag) and have found this novel composite to serve as an efficient electrode material for batteries. The cyclic-voltammetry (CV) analysis performed on CEPG–PANI–Ag nanocomposite exhibits a purely faradic behaviour using nickel foam as a current collector thus suggests the prepared nanocomposite as a battery electrode material. The nanocomposite reports a maximum specific capacity of 1428 C g−1 and excellent cyclic stability up-to 5000 cycles. **R&D development #4: Digitally controlled portable micropump for transport of live micro-organisms** In this work, we have developed a hybrid strategy where the laser manufactured PMMA samples are smoothened by a chemical etching step and so obtained smooth surface is used to fabricate multilayer micropump which is actuated by a piezo disc. The micropump is operable at lower voltage 5–7.5 V DC. The flow rates of our device can be programmed through a micro-controller interface and trials are able to yield a viable transportation of solutions containing micro-organisms. The optimized design of the microfluidic chamber used in this work is able to discharge the whole containment from within the fluid chambers while retaining the cell viability. **(Sponsored by NPMASS, ADA)**
2015-2016	**R&D development #1: Superhydrophobic poly-methyl-silsesquioxane pinned one dimensional ZnO nanostructures for water remediation through photo-catalysis** In this work we have developed ultra-dense high aspect ratio ZnO nano-forest like structures and explored their potential as photo-catalysts. The films formulated are superhydrophobic (contact

	angle=154d) in nature and have been evaluated as containing a high density of oxygen defects in the crystalline state of the ZnO (as validated through photoluminescence measurements). The samples were found to possess enhanced photo-catalytic properties, as measured through a dye degradation process using an UV-Vis spectrophotometer. These photo-catalytic properties may be due to the high defect density and also the enhanced area of the interactive surface as one goes from nano-particles to nano-rod like structures. The paper gives an insight into highly unique carpeted nano-wire bundles of ZnO and offers immense utility to the realization of high efficiency remediation filters. **(Sponsored by DST WTI)** **R&D development #2: Solar light-based degradation of organic pollutants using ZnO nanobrushes for water filtration** In this work, we report an effective water filtration system based on the photocatalytic performance of semiconducting dense nano-brushes under natural sunlight. During thin-film photocatalysis, which is usually performed by a deposited layer of photocatalyst, a stagnant boundary layer is created near the catalyst which adversely affects the rate of adsorption because of diffusional restrictions. Furthermore, it is useful to fabricate a structured filter element for the passage of water with the use of nanostructures protruding out of the surface. Herein, dye remediation is performed by solar means. This remediation was initially limited to a lower efficiency because of diffusional restrictions but has now become a fast process due to microhole incorporation in the filter materials with protruding dense nanostructures. Theoretical analysis predicts that there is an optimal film thickness that yields the maximum adsorption and also a highly nonlinear behaviour of diffusivity with respect to the fraction adsorbed. The effect of increased surface area due to microholes on the fraction adsorbed is also investigated and it is found that there is an optimum value of hole diameter for maximum adsorption. (Sponsored by DST WTI) **R&D development #3:** In this study, we have synthesized Co3O4 nanobelts via a simple solid-state process and further integrated with nano-aluminum (nAl) to realize novel bulk nanoenergetic systems of Co3O4/nAl .The heat of reaction and combustion performance of these nano-energetic found and the combustion front-wave speed and pressure–time characteristics measurements indicate a nano-energetic system that is able to develop mild peak pressure (12.6~ 20 MPa) and pressurization rate (0.08 to 0.14 MPa ms^{-1}) having a characteristics of low gas generation, which can be harnessed in low intensity pressure-pulse based microporation of soft matters like bacterial cells without any lysis. The material is being utilized to developed a hand-held gene transfector system within bacterial cells at efficiency similar to heat shock method. (DST, SERB)

Acoustics Research:



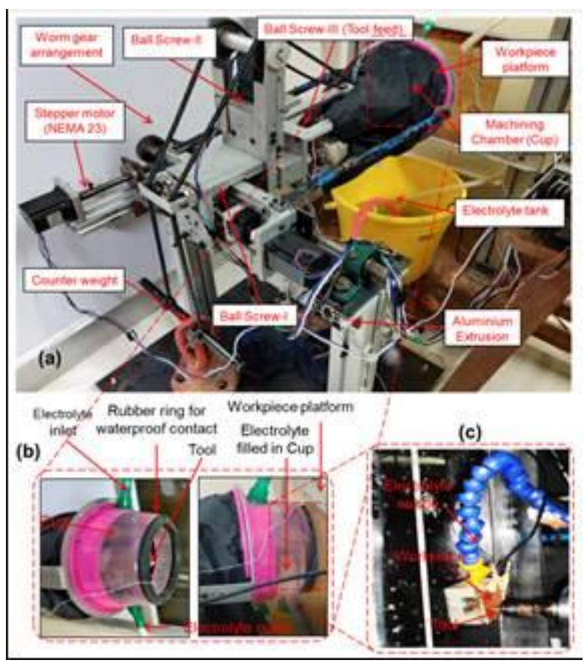
Fractal Acoustic Metamaterial Design[1]



Hybrid fractal acoustic metamaterials[2]

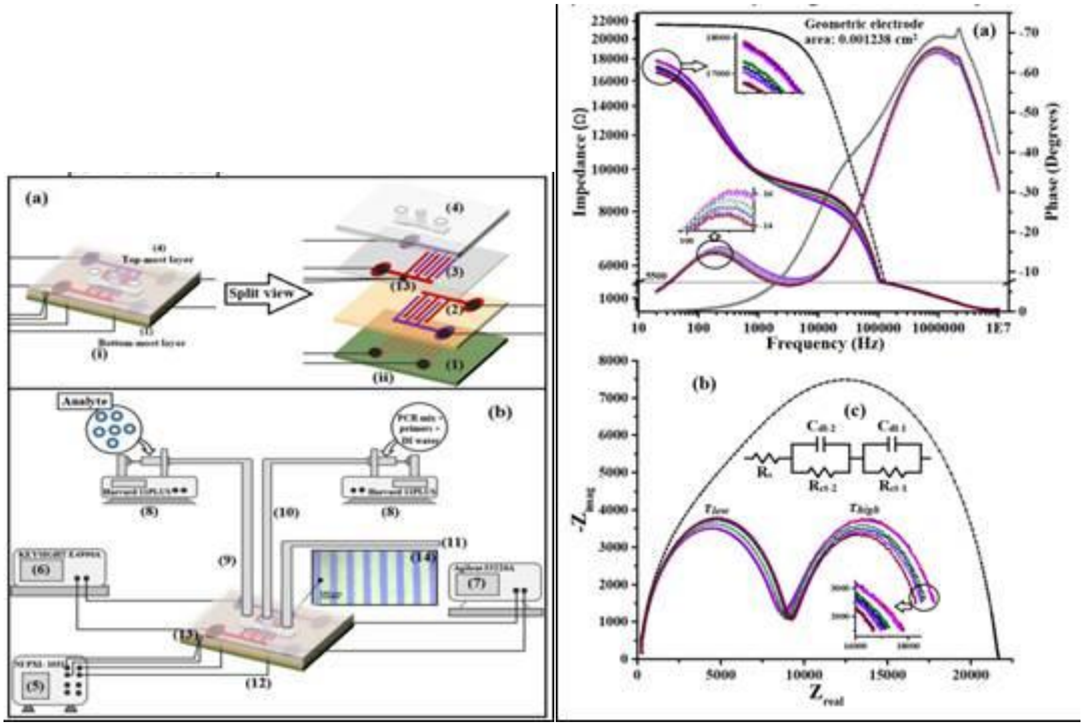
Advanced Fabrication Process Development Research:

Nanofinish through AI based predictive control[3]



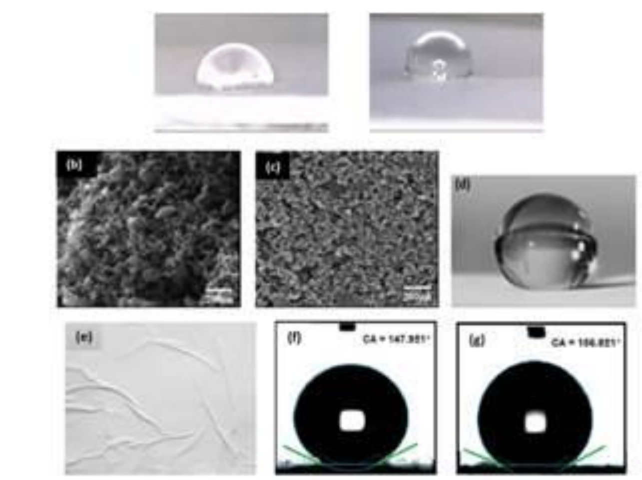
Setup for Electrochemical Micromachining on vertical surfaces[4]

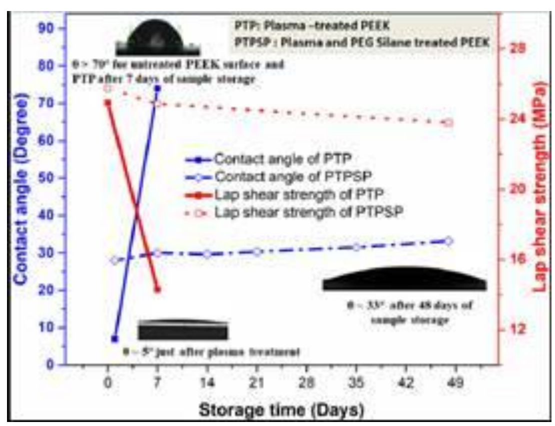
Biosensors Research:



Electrochemical Impedance Spectroscopy on Nucleic acids[5]

Surface and Interface Research:





Printed Hydrophobic

Plasma modified PEEK

Products developed by Microsystems Technology Laboratory:

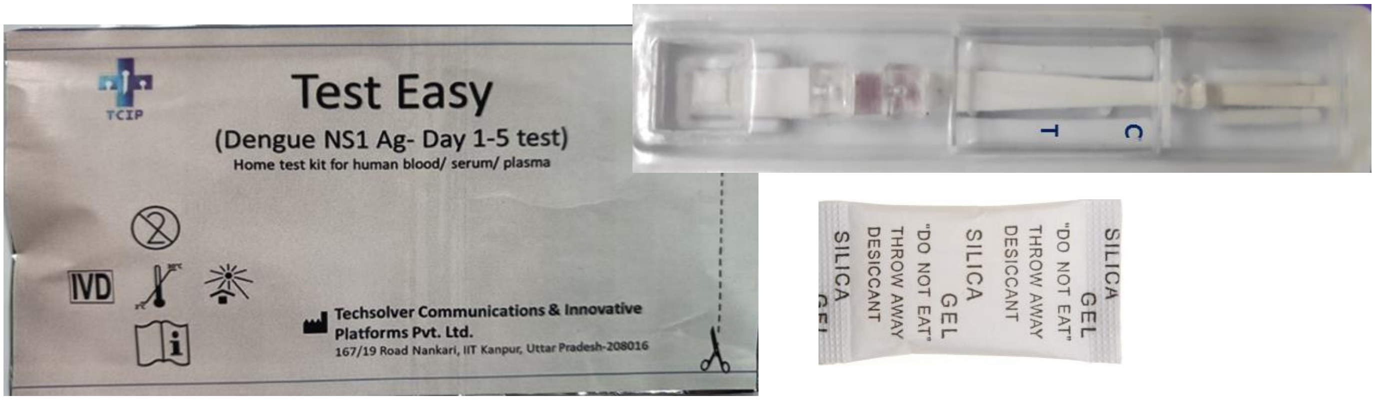
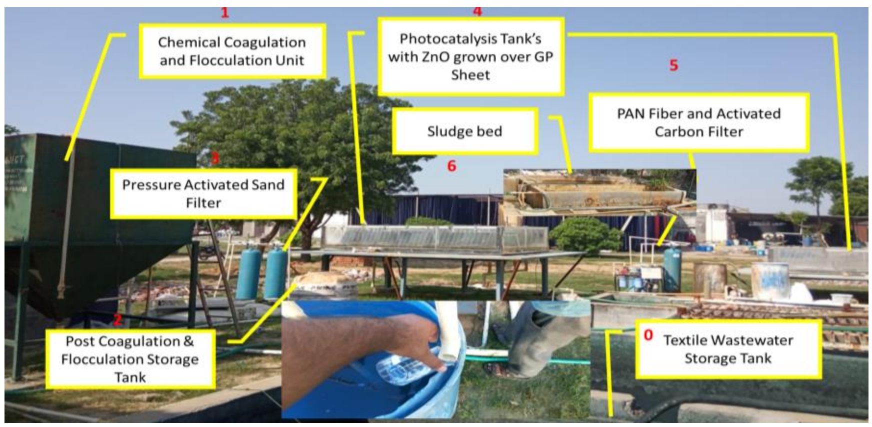
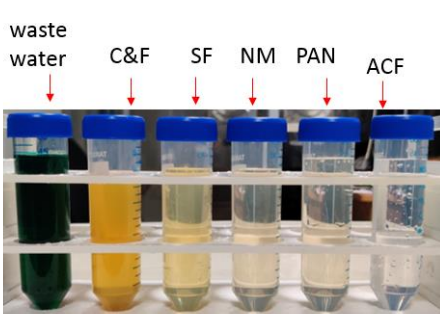


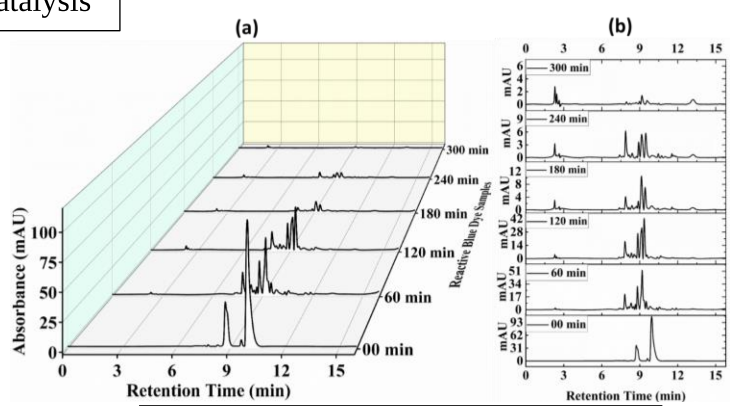
Figure #1: Early Dengue Detection Technology passed clinical validation and is currently awaiting marketing license



Plant layout based on photocatalysis



Decoloring of effluents



HPLC analysis of reaction products

Figure #2: Plant commissioned at Jaipur Textile Park based on photocatalytic treatment of textile effluents

Pictures of Highlighted Laboratory Equipment

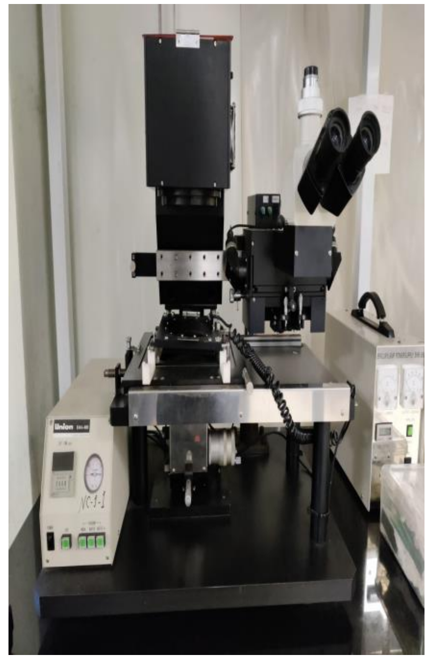
UV Vis Spectrometer

Gas Sensing Setup

Sputtering system

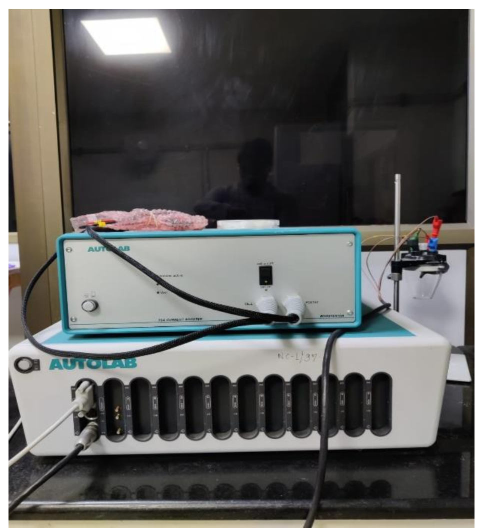
Fluorescence Microscope

3D Printer



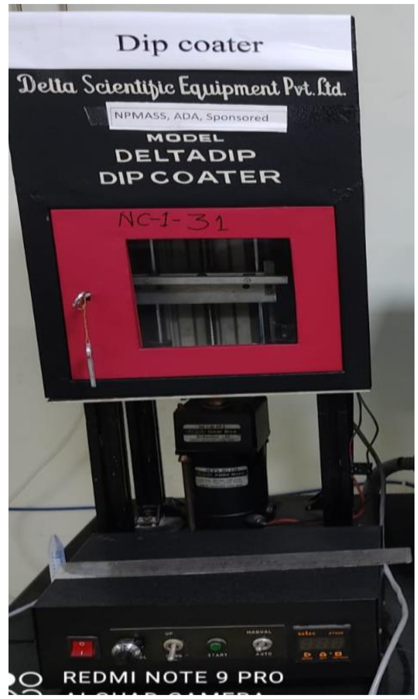
Photolithography System

Impedance Analyzer



Cyclic Voltammeter

Spin Coater



Dip Coater

DI Water System

Wire Bonder

Gas-Hydrate Research Laboratory

Laboratory Coordinator: Dr. M. K. Das

Associated Faculty Members (if any): P. K. Panigrahi

List of Major Equipment:

- High-pressure, Optically Accessible, Gas Hydrate Diagnostic System
- High Performance Computing System

Brief description of the laboratory:

The research work in lab intends to enhance the gas hydrate formation rate for gas storage and transportation application. A high-pressure pilot-scale reactor to simulate the field scale hydrate formation morphology is developed in the lab. The reactor is made of stainless steel (SS 316) with a maximum design pressure of 180 bar. The cylindrical reactor has an internal diameter of 232 mm and a height of 622 mm with a total volumetric capacity of 25 L. There are four circular optical windows (made of sapphire) with a diameter of 50 mm and a thickness of 25 mm for visual observation of hydrate growth inside the reactor. It is the largest reactor in India dedicated to gas hydrates. Since the hydrate formation is a very slow process and gas storage capacity is also very low. So, a chemical promotor to enhance the hydrate formation rate for a possible industrial application is developed. Doing an experiment in such a large reactor is very difficult because it consumes a lot of time and cost. So, for doing cost effective experiment and shorting the experimental time, a new setup is also developed.

Laboratory research keywords:

Gas hydrate formation, gas storage and transportation, CO_2 sequestration, THF hydrate formation, nanofluid synthesis, sea water desalination, cyclopentane hydrate formation.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• Study focuses on the synthesis of a hybrid nanofluid (Cu-Al LDH) and the investigation of its effectiveness as a promoter for CO_2 hydrate formation. • The hydrate formation experiments are conducted in a pilot-scale reactor of 25 L volume with a design pressure of 180 bar. The wall temperature of the reactor is set at 2 ∘C. The charging of the reactor is carried out in both single and dual stage at the maximum pressure of 30 bar. • The presence of LDH nanofluid significantly enhances hydrate kinetics and maximum 176.19% increase in gas consumption compared to pure water.
2019-2020	• Study investigates the influence of surfactant crowding on hydrate growth and detachment of hydrate crystal from the interface in a droplet-based configuration. • Experiments are conducted under a constant subcooling of 5 °C

	using a cyclopentane droplet of volume 5 μL immersed in the water pool. • Hydrate growth without surfactant involves lateral growth followed by radial growth and the present of surfactant crowding encourages the radial hydrate growth and impedes lateral hydrate growth.
2018-2019	• Carbon dioxide hydrate formation is carried out to understand the kinetics of CO_2 hydrate formation in porous media for the application of CO_2 sequestration. • CO_2 hydrate is formed in silica sand with particle size of 90-500 μm having porosity 38%. The operating temperature and pressure are set at 275.35K and 3.5MPa respectively. • The results shows that the final water to hydrate conversion and hydrate saturation are 25.03% and 27.53% respectively at the end of the hydrate formation experiment.
2017-2018	• The objective of this work is to investigate the Tetrahydrofuran(THF) hydrate formation in a cylindrical reactor. • THF hydrate experiments are done at two different THF concentrations 19.06% and 30%. • The hydrate growth rate is mostly controlled by heat transfer phenomena at 19.06% THF concentration and mass transfer effect is eliminated at that concentration.

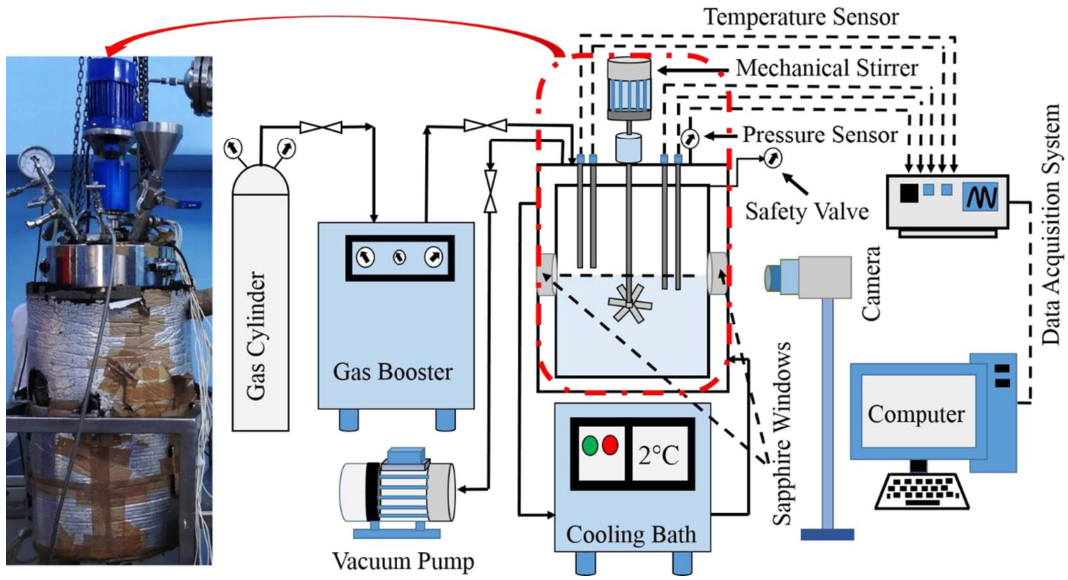


Figure #1. Schematic of the experimental setup for the study of the CO_2 hydrate formation process

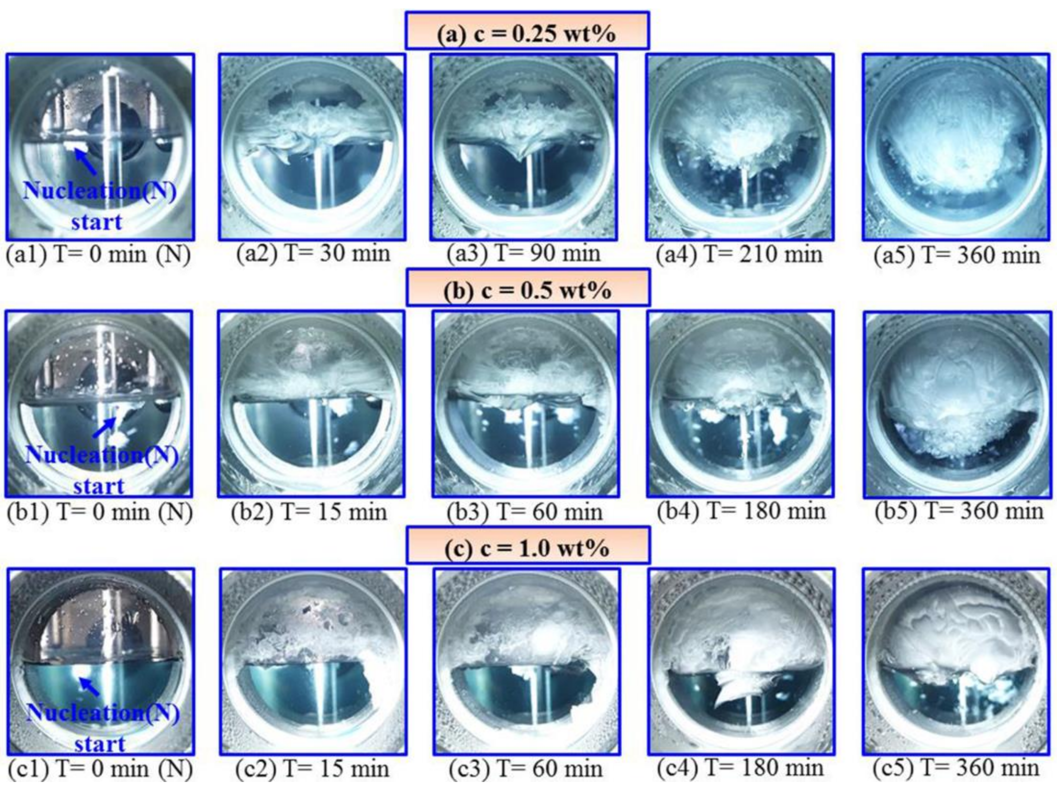
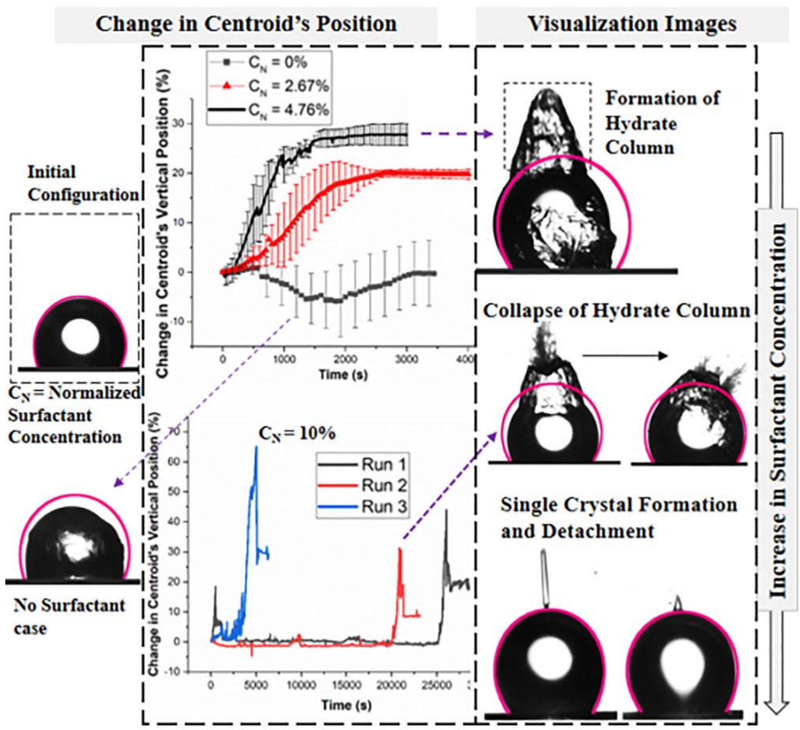


Figure #2: Visualization of CO_2 hydrate growth process at different Cu-Al LDH nanofluid concentrations (c = 0.25, 0.5, and 1.0 wt %) for (Cu^{2+}: Al^{3+}: Na^{+} = 4:1:4) molar ratio.



Figure#3: Sequence of hydrate formation images at different surfactant concentration

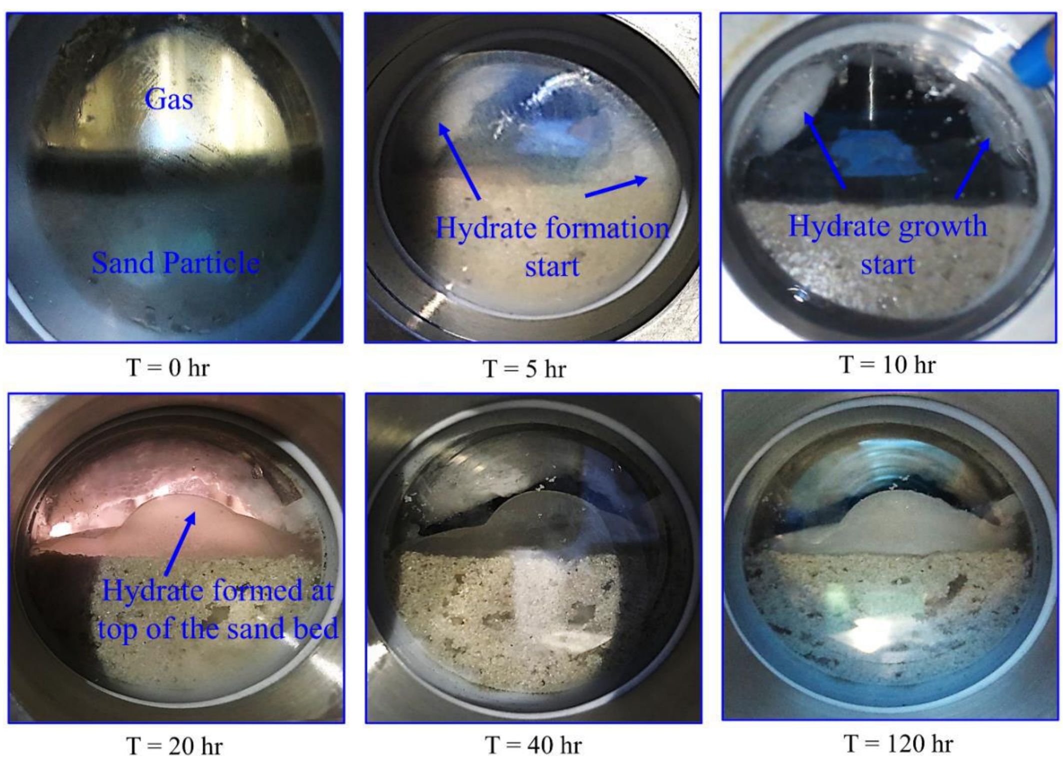


Figure #4: CO_2 hydrate growth visualization during the hydrate formation process

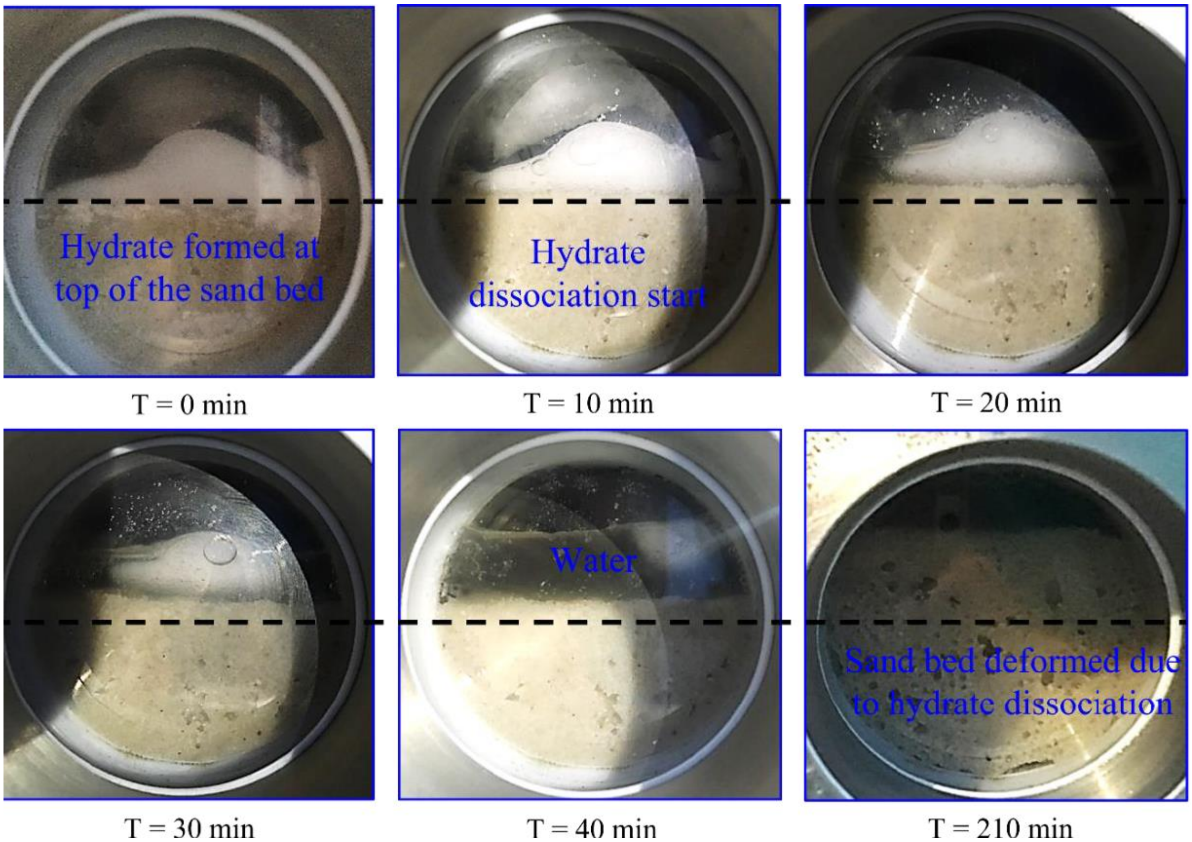


Figure #5: CO_2 hydrate dissociation visualization with time during the hydrate dissociation process

Combustion and Energy Conversion Systems Laboratory

Laboratory Coordinator: Dr. Santanu De

List of Major Equipment:

- Nd:YAG Laser with Chiller (Edgewave IS200)
- Tunable Dye Laser (Sirah Credo)
- CMOS Camera (Phantom VEO640)
- Gen II Image Intensifier (Lambart HiCatt2)
- Mass flow controllers (Alicat, Linetech, Qty: 8)
- Photomultiplier Tube (Thorlab)
- Gas-chromatograph (Nucon)
- Air compressor (Atlas Copco)
- Air dryer (Summit)
- Air dehumidifier (Bryair)
- 36 kW Inline Air Heater
- Electric heater (8 kW)
- Air pre-heater
- Steam boiler with superheater
- Coal pulverizer
- Muffle furnace
- Water Chiller
- Optical table (Newport)
- Peristaltic Pump
- Experimental rig of DFB gasifier
- Lab-Scale Liquid Fuel Combustor
- Lab-Scale Lean Premixed Gas Turbine Combustor

Brief description of the laboratory:

Major research activities of the CECS laboratory can be classified under the following three verticals:

Modelling of turbulent reactive flows: Robust and computationally efficient models for turbulent combustion (flamelet, PDF, MMC methods) based on RANS/LES are being developed and applied to different non-premixed, premixed, and partially-premixed flames of gaseous and liquid fuels.

Application of optical diagnostics tool to turbulent flames: This involves using different line-of-sight and planar measurement techniques for flame visualization. The applications involve chemiluminescence and time-resolved planar laser-induced fluorescence imaging of flames and gas turbine combustors

Coal and biomass gasification: Fluidized bed gasification of high-ash coal and biomass (rice husk, straw, etc.) is being performed to produce syngas. The active research areas include optimizing operating parameters, hot cleaning of syngas, and membrane separation of H_2 and CO_2 capture.

Laboratory research keywords:

Turbulent combustion; Spray combustion; Modeling of turbulent reactive flows; Gas turbine combustion; Laser-based optical diagnostics; Coal and biomass gasification; Fluidization; H_2 separation

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	**Time-resolved planar laser-induced fluorescence (PLIF) facility:** We have developed a state-of-the-art combustion diagnostics facility with a time-resolved planar laser-induced fluorescence (TR-PLIF) facility. The PLIF facility is being used to investigate many complex and transient turbulence-chemistry interaction phenomena in turbulent flames, gas turbine combustors, etc. **Development of lean premixed gas turbine combustor:** A lean-premixed, swirl-stabilized gas turbine combustor is developed with multiple injection ports. The combustor is commissioned and operated with a blend of CNG and H_2. Chemiluminiscence and TR-PLIF experiments are being performed. **Flow-blurring atomizer:** A flow-blurring atomizer is developed, and its spray is visualized based on the Mie-scattering technique. Significant improvement in atomization is found compared to conventional liquid fuel co-axial atomizer. Further characterization of the atomizer is being conducted for macroscopic and microscoping spray characterization. **A fully dynamic mixing timescale model for the sparse Lagrangian multiple mapping conditioning approach**: A novel variant of the minor mixing timescale model in MMC-LES, referred to herein as dyn-aISO, is proposed, and its performance is assessed by simulating the canonical partially premixed, piloted flame series of Sandia exhibiting increasing levels of local extinction. The coefficients for modelling the sub-Lagrangian-filter scale scalar variance and scalar dissipation rates are dynamically modeled using local scalar field values. The new dynamic mixing timescale model could accurately predict the extinction and re-ignition phenomenon, requiring the micro-mixing model to produce the correct compositional fluctuations controlled by the minor mixing timescale model in the MMC method. **Effects of drag and subgrid-scale turbulence modeling on gas–solid hydrodynamics of a pilot-scale circulating fluidized bed:** 3-D, full loop, LES of a circulating fluidized bed are conducted using EE approach. Effects of drag and sgs turbulence models are investigated. Results are validated against measurements from an in-house pilot-scale model. The influence of change in the riser diameter is more pronounced for EMMS models. The hybrid EMMS drag model and sgs-TKE model made the most accurate predictions. **Energy, Exergy and Cost Analysis and Optimization of Hybridized Solar Power Tower Plant:** The performance of a hybridized solar power tower (SPT) plant in real-world scenarios is assessed, which has a north-facing HF that reflects and focuses light on a central cavity receiver. A combined cycle plant based on a close loop Helium Brayton cycle and two R123 organic Rankine cycles is simulated with a thermal energy storage system. An energy and exergy evaluation of the entire model is being conducted to examine the performance of various components.
2019-2020	**Design and development of a pilot-scale bubbling fluidized bed gasifier for high ash coal:** Autothermal gasification of high-ash (>45%) coal is conducted in a fluidized bed. The highest cold gas and carbon conversion efficiencies are 48% and 85%, respectively. A maximum value of syngas HHV of 3 MJ/Nm^3 is obtained during air-steam gasification. An optimum range of steam/coal ratio is found in the range of 0.19–0.28, which maintains bed temperature in the range of 800-900°C. Despite having low alkali content in ash, agglomerates form due to local hotspots. At low fluidization numbers,

	agglomerates are formed due to local hotspots, as the collected ash sample has small alkali content. **Investigation of cold flow hydrodynamics in a dual fluidized bed for gasification of high-ash coal:** A compact DFB model with short riser is proposed for gasification of high-ash coal. The bottom bed of riser is operated in BFB and FFB regimes using primary aeration. Effect of on-bed and in-bed solids discharge from BFB to the riser is investigated. The role of secondary aeration on solids circulation and solids holdup is studied. **Investigation of hydrodynamics and segregation characteristics in a dual fluidized bed using the binary mixture of sand and high-ash coal:** A compact dual fluidized bed with a short riser has been investigated. Effects of unary sand and polydisperse coal/sand binary mixture are investigated. Gas leakage is examined for single chamber pot-seal and double chamber loop-seal. A hydrodynamic model is established to predict axial solids holdup in the riser. **Numerical investigation of cold flow hydrodynamics in an internally circulating dual fluidized bed for coal gasification:** Cold flow hydrodynamic study of a full loop, three-dimensional internally circulating dual fluidized bed (ICDFB) for coal gasification has been carried out using a Eulerian–Eulerian approach. The ICDFB system consists of a central riser and an annular bubbling fluidized bed (BFB) placed concentrically and interconnected by a solids separator and a loop seal. A sensitivity study of various operating parameters that potentially influence solids distribution and recirculation rate has been conducted. The riser gas superficial velocity and loop-seal aeration rate are found to be the major controlling factors of solids recirculation rate. **Large eddy simulation of biomass gasification in a bubbling fluidized bed based on the multiphase particle-in-cell method:** A hybrid EL solver is developed for gas-solids flows based on MP-PIC framework. Gasification of rice husk in a bubbling fluidized bed is performed. The solver could capture transient flow characteristics of gas-solids flows. Product gas compositions show a good agreement with the experimental measurements. Effects of temperature, steam-to-biomass ratio, and equivalence ratio are studied. **LES of a lifted methanol spray flame series using the sparse Lagrangian MMC approach:** Two-phase multiple mapping conditioning / large eddy simulation (MMC-LES) is applied for the first time to lifted spray flames on a vitiated coflow burner. Three flames with different inlet fuel mass loading are investigated. MMC-LES uses a hybrid Eulerian-Lagrangian-Lagrangian approach for the evolution of gas-phase flow, stochastic particles, and liquid fuel droplets, respectively. Two distinct flame base stabilization phenomena are observed, namely a flat flame base spreading across the central region of the jet at low and intermediate fuel loading cases, and an annular flame base in the shear layer that surrounds a cold central jet region, a characteristic of autoignition due to entrainment of hot oxidizer from the co-flow for the highest fuel loading case.
2018-2019	**Numerical investigation of flow and scalar fields of piloted, partially-premixed dimethyl ether/air jet flames:** The computed conditional and unconditional statistics based on the RANS-stochastic MMC approach demonstrate an excellent agreement with the available experimental data, even for flame displaying a large degree of local extinction and re-ignition. For these flames, radical species distribution conditioned on mixture fraction

	confirms the physical separation between the OH and CH_2O species, which was earlier reported using simultaneous laser-induced fluorescence measurements of these radicals. A distinct separation between these radicals becomes evident at downstream locations where the scalar dissipation rate decreases. For the flames investigated here, a strong correlation is noticed between the peak heat release rate and the reaction rate indicator, R_{OH} based on the product of concentrations of OH and CH_2O radicals. **Numerical simulation of lifted DME jet diffusion flames using sparse Lagrangian MMC approach:** A series of simulations are performed for different coflow temperatures (1275 – 1500 K) for pure DME jets issued in a vitiated co-flowing oxidizer stream consisting of products from a lean, premixed H2-air combustion. The variation in the lift-off height (LOH) has been captured adequately and the reported trend agrees with the experimental data. Further, the flame structure has been analyzed in terms of the conditional scatter data of OH and CH_2O radicals. In these flames, OH is formed in the shear layer of the jet and the coflow, whereas CH_2O is found in the fuel-rich region of the jet. Near the flame base, OH and CH_2O are found to significantly overlap with each other, whereas a distinct separation is noticed downstream of the flame base. LES-FPV approach for kerosene-fueled scramjet engine Numerical Investigation of Steady and Unsteady Combustion Phenomena in a 100 kW Micro Gas Turbine Large eddy simulation of biomass gasification in a bubbling fluidized bed based on the multiphase particle-in-cell method
2017-2018	**RANS-based stochastic MMC approach of auto-igniting turbulent lifted CH_4/air jet diffusion flames in a vitiated co-flow:** In MMC, the concept of the mapping function is used, which approximates the cumulative probability distribution of the major scalar, namely mixture fraction for nonpremixed combustion. The corresponding variance of the major scalar is modelled by choosing a standard implementation of the major mixing time scale τ_ϕ modelled in terms of the turbulent time scale as $\tau_\phi = \tau_t / C_\phi$. The same major mixing time constant $C_\phi = 3.0$ is used for all simulations. Additionally, in MMC, a minor mixing timescale $\tau_{\min}$ is introduced, which controls fluctuations of scalars relative to the major fluctuations via the minor mixing time constant, $C_{\min}$. Three different values of $C_{\min} = \tau_{\min}/\tau_\phi = 0.25, 0.35$ and 0.5 are used and the corresponding ratios of minor to turbulent time scales are $\tau_{\min}/\tau_t$ =0.083, 0.116 and 0.166, respectively. The conditional and unconditional reactive scalar fields are highly dependent on the choice of $C_{\min}$ and hence the ratio of the minor and major mixing time scales. The variation in lift-off height is in good agreement with the experimental data for the entire range of coflow temperature for $C_{\min} = 0.25$. Hydrodynamics Study of Fluidized Bed Gasifiers Using an Eulerian-Eulerian Approach Aerodynamic design optimization of a centrifugal compressor impeller for micro gas turbine Numerical Simulations of Turbulent Lifted Jet Diffusion Flames using Stochastic Multiple Mapping Conditioning Approach LES based Σ - Y model for primary atomization using Eulerian stochastic fields approach

2016-2017	**Numerical simulations of turbulent lifted jet diffusion flames in a vitiated co-flow using RANS-based stochastic MMC approach:** Lifted turbulent jet diffusion flames of H2/N2 issued into a hot coflowing stream of combustion products from a lean premixed H_2/air mixture are simulated using RANS-MMC approach. The MMC approach emulates large-scale turbulent fluctuations by using a reference variable, mixture fraction. The modified Curl's model has been adapted to model the micro-mixing term. The computed results from the present simulations are in excellent agreement with the available experimental data. The flame lift-off heights obtained using the minor mixing time constant $C_{\min}$= 0.25 are found to be in close proximity with the experimentally observed values for the entire range of coflow temperatures. **Numerical modeling of turbulent premixed combustion using RANS-MMC approach:** The Sydney piloted premixed jet burner (PPJB) operating in the distributed combustion regime has been considered for model validation. The reaction progress variable is chosen as the reference variable in RANS-MMC of premixed combustion. The stochastic MMC solver has been fully integrated with the RANS flow solver. Computed radial profiles of the mean axial velocity and species mass fractions agree with the available experimental data. In some instances, the RANS-MMC model matches the experimental data better than the results obtained from other state-of-the-art turbulent combustion models.
2015-2016	**Flame stabilization of turbulent lifted H_2 flames in vitiated coflow using RANS-CMC approach:** H_2 flames in vitiated coflow is simulated. RANS-CMC approach is used to study flame stabilization. Effect of jet velocity, coflow velocity, coflow temperature and mixing is studied. **Development of an OpenFOAM-based solver for SCRAMJET combustion:** Large eddy simulations for a hydrogen-fuelled DLR scramjet combustor have been performed using the dynamic Smagorinskey model with the Lagrangian averaging technique. Both non-reacting and reacting cases have been investigated. The physical configuration corresponds to the scramjet combustor experimentally investigated at the Institute for Chemical Propulsion of the German Aerospace Center (DLR). Favre-averaged transport equations for mass, momentum, energy and species concentrations are solved using a finite volume discretization scheme in OpenFoam. The single-step global reaction is used for the partially stirred reactor (PaSR) combustion model. Numerical results for time-averaged pressure, temperature, and axial velocity are compared with experimental data at different cross-sections of the combustor.

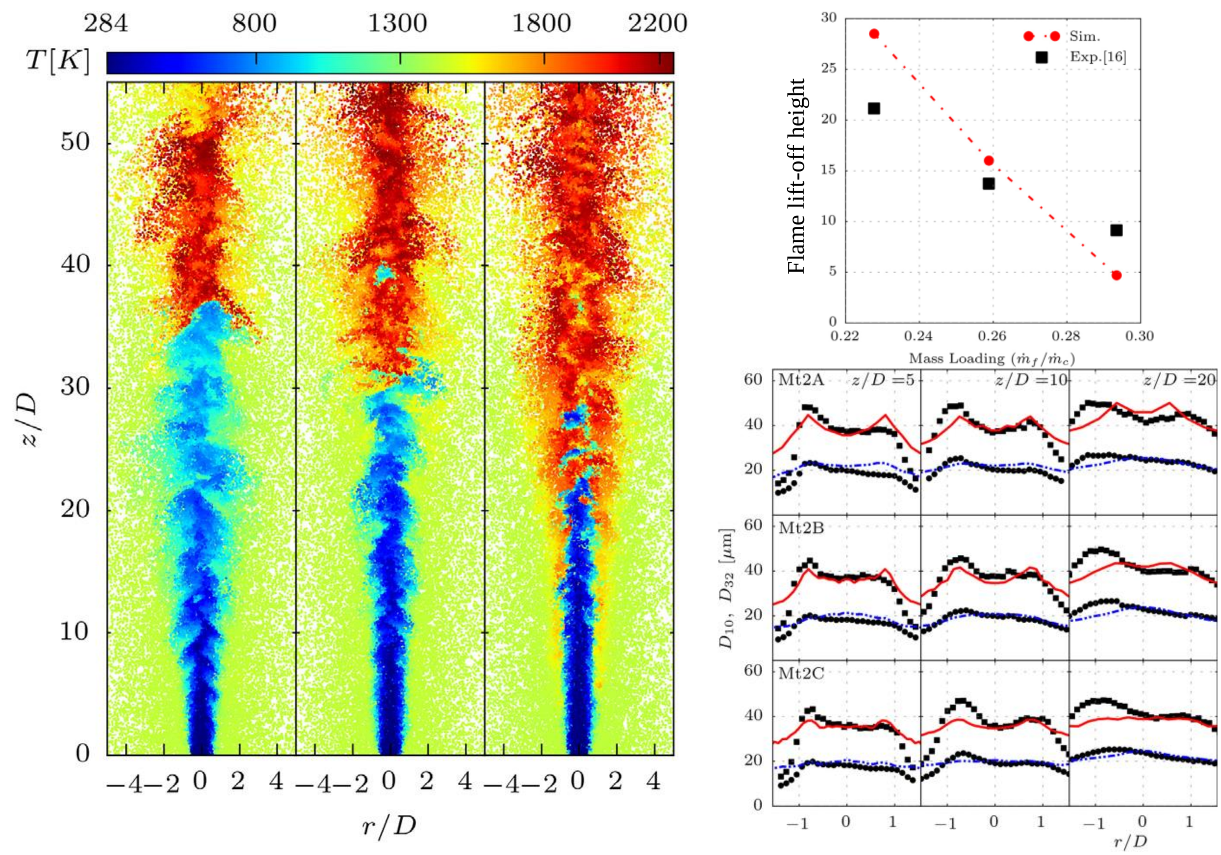


Figure #1: MMC-LES of methanol spray flames: Instantaneous temperature of stochastic particles clipped at the mid-plane (left), flame lift-off height vs. fuel mass loading (right-top), spray AMD and SMD distribution (right-bottom) (Sharma et al., 2021, Proc. Combust. Inst. 38 (2), 3399-3407)

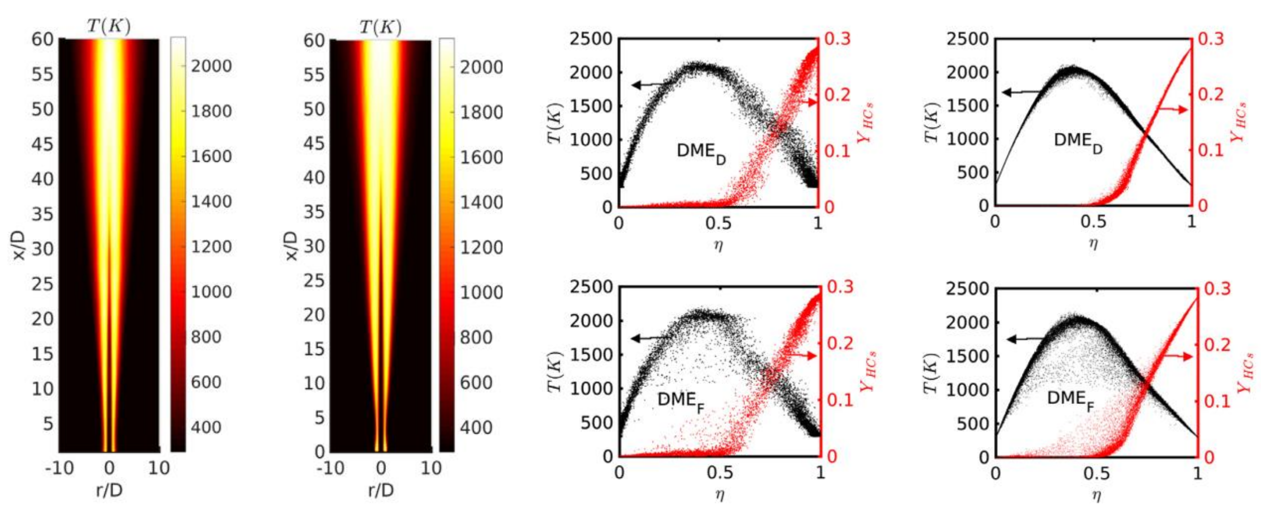


Figure #2: RANS-MMC simulation of DME D and F flames: average temperature (left), conditional temperature (right) (Ghai and De, 2019, Combust. Flame 208, 480-491).

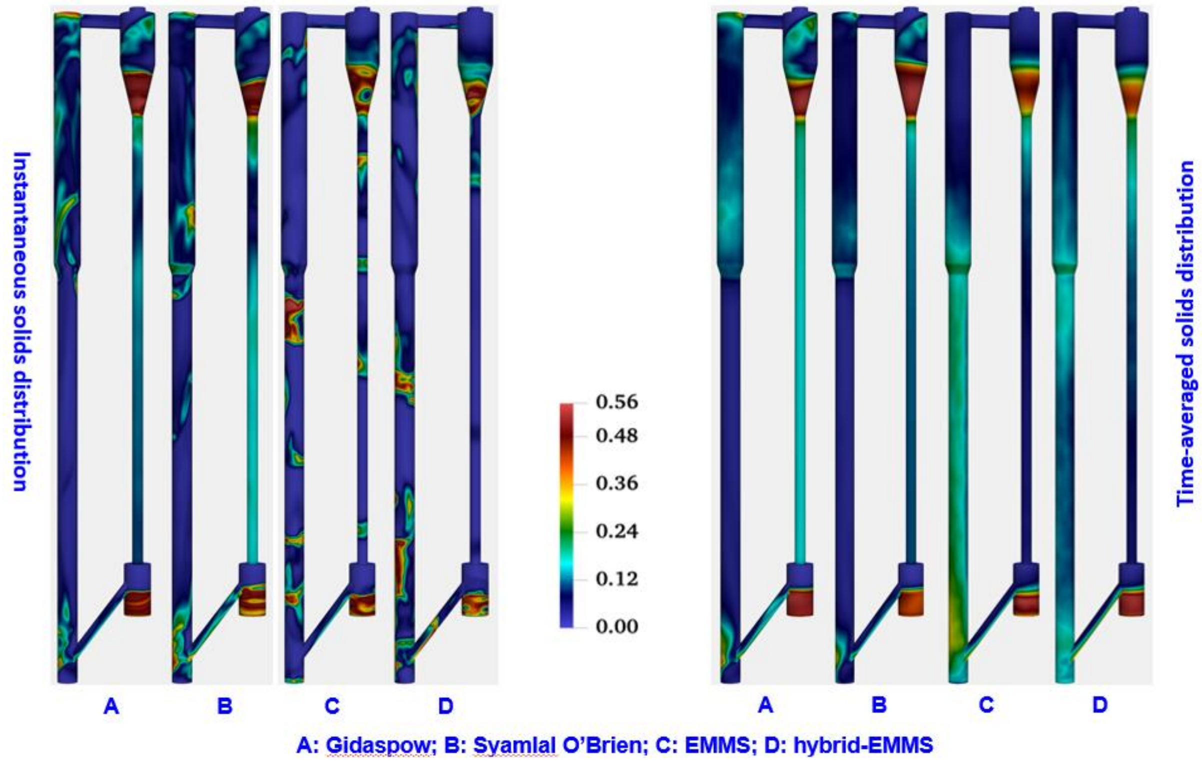


Figure #3: Effect of drag models on numerical simulation of circulating fluidized bed: instantaneous (left) and time-averaged (right) solid distribution (Gupta et al., 2022, Chem. Engg. Sci. 248, 117093)

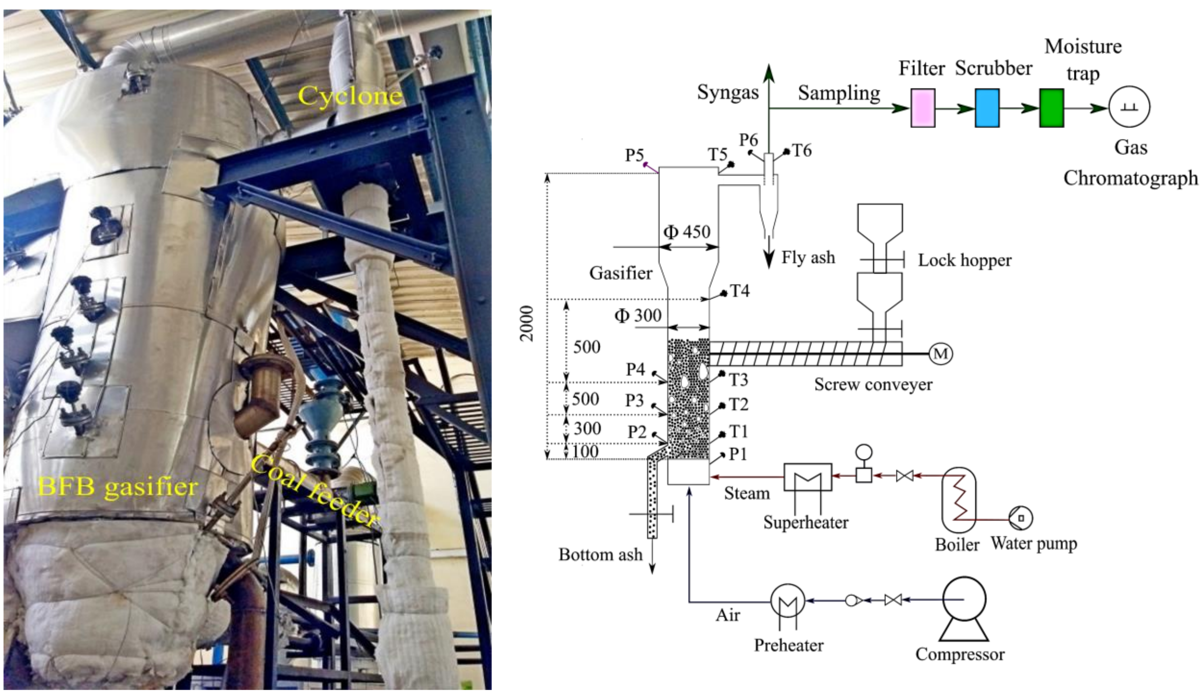


Figure #4: 300 kW_{th} fluidized bed gasifier of high-ash coal: actual photograph (left), schematic diagram (right) (Gupta and De, 2022, Energy 244, 122868)

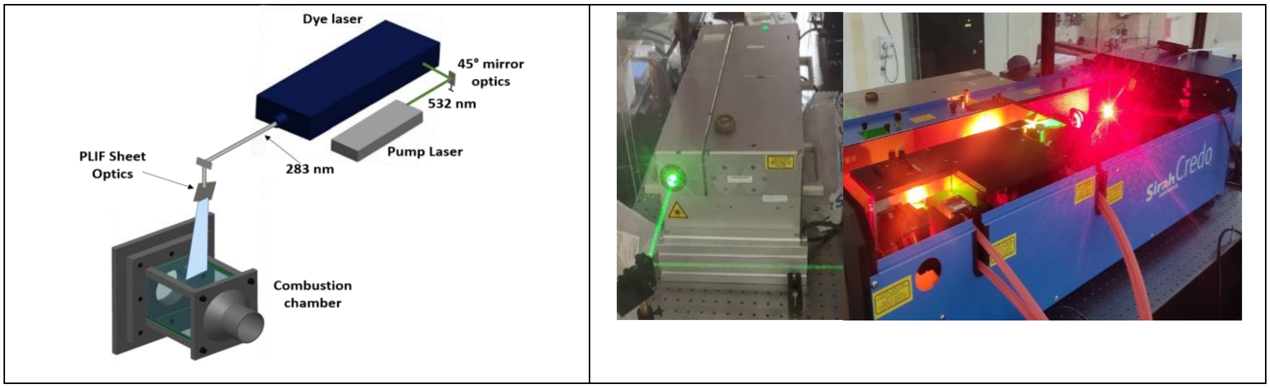


Figure #5: A schematic diagram of time-resolved planar laser-induced fluorescence (PLIF) setup (left), actual images of the pump laser and dye laser (right)

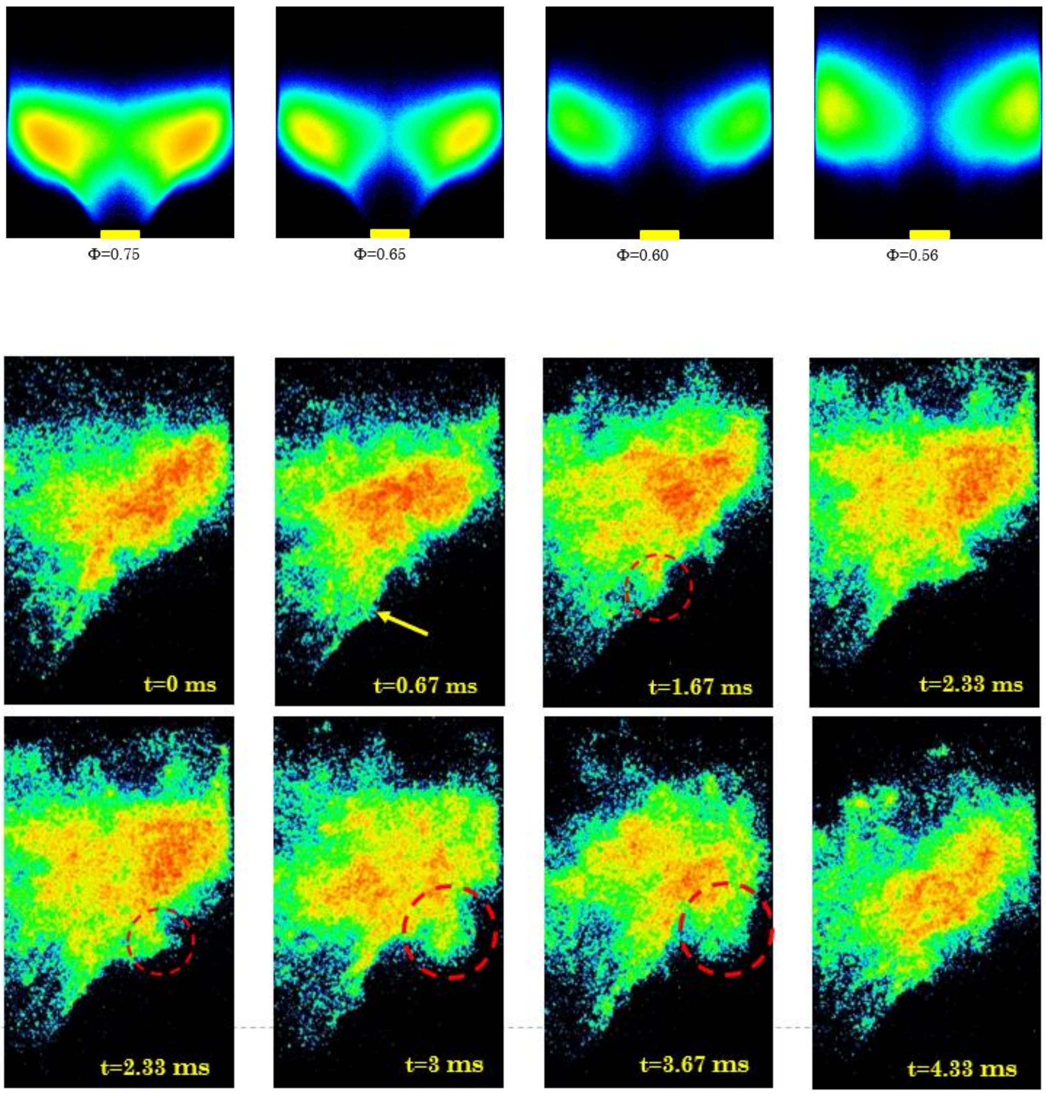


Figure #6: OH chemiluminescence images of a lean premixed combustor: average images at different equivalence ratio (ϕ) (top row), sequence of instantaneous OH images for $\phi = 0.75$ showing unsteady events (bottom row)

Robotics Laboratory (Centre for Mechatronics)

Laboratory Coordinator: Dr. Mangal Kothari (AE Dept)

Associated Faculty members: Dr Anjali Kulkarni, Dr Ashish Dutta, Dr Bishakh Bhattacharya, Dr Bhaskar Dasgupta, Dr K S Venkatesh, Dr Mangal Kothari and others from ME. EE, CSE, and AE Depts.

List of Major Equipment:

- Several manipulators, mobile vehicles etc.

Brief description of the laboratory:

Please provide a brief description of the laboratory in about 8-10 lines, focusing on the main thrust area of the laboratory activities.

Centre for Mechatronics is actually not an exclusive laboratory of the ME Dept, though preponderantly associated with it for several administrative aspects. It is an interdisciplinary center for research in which faculty and students engaged in robotics activities (including PG theses, UG projects and inter-college contests like robocon etc. participate and interact.

Laboratory research keywords (8-10):

Robotics, Mechatronics, Mobile vehicles.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2015-2021	• Analytical Formulation of Algorithms for Analysis and Motion Planning of Redundant Manipulators. • Domain Mapping algorithm with potential applications in solid and surface modelling for motion planning, docking and mesh generation. • Formulations for Enumeration and Synthesis of Robot Manipulators for Optimized Input-Output Motion/Force Transformation. • A Variational Formulation and Optimization-based Solution Procedure for Governing Equations of Physical Systems with Alternative Contact Conditions • A Methodology for Volumetric Modelling of Solid-Solid Infringement for the Planning of Robot Motion or Machine Assembly • A Smoothening Algorithm for the Optimization of Non-differentiable Objective Functions Note: The above indicates the research under the guidance of Dr. Bhaskar Dasgupta (not the entire research of the Centre for Mechatronics). His work has been analytical and algorithmic in nature, and developmental work has been few and far between, Figure #1 highlights one such work.

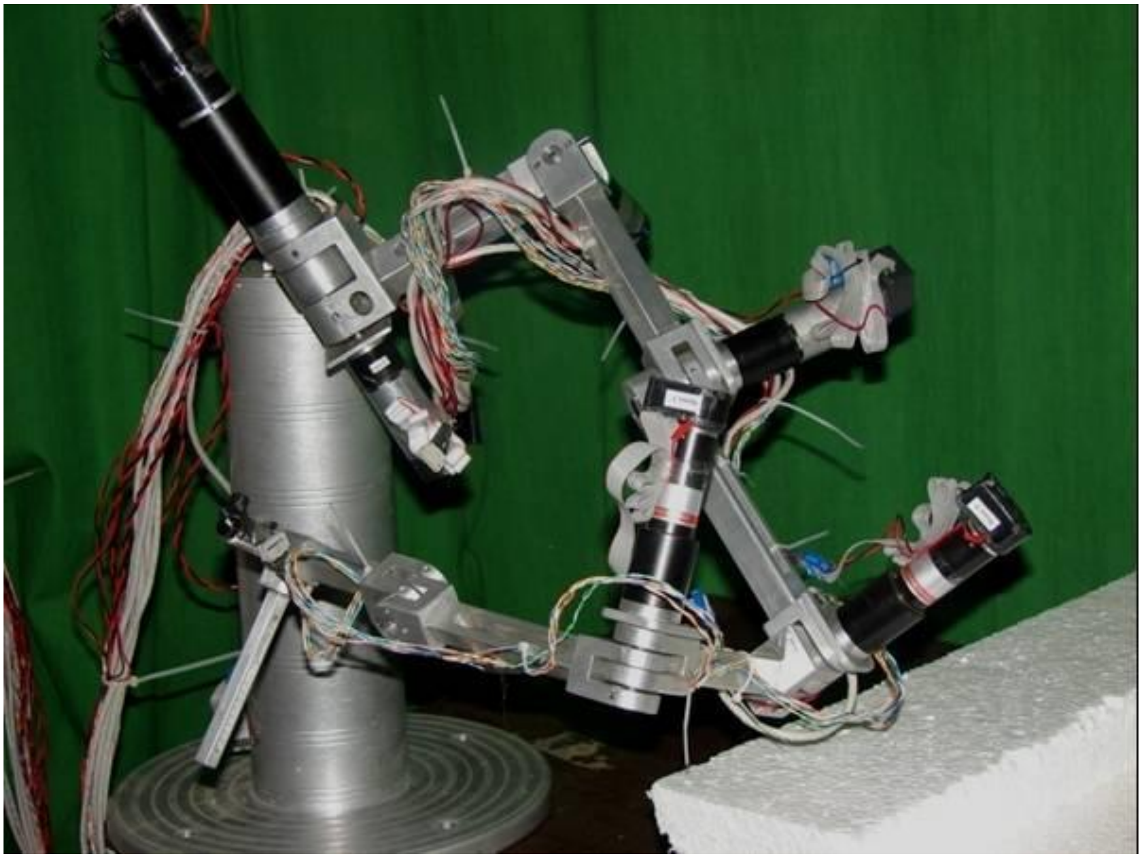


Figure #1: The Snake Robot named VASUKY [**V**ersatile **A**rticulated **S**nake (robot) **U**sing **K**nowledge-domain of *Yantrika*] developed at the Centre for Mechatronics for IGCAR.

A demonstration video can be accessed at: https://youtu.be/-rIsa4dHvIo

Note: My major research has been analytical and algorithmic in nature, and developmental work has been few and far between. The above is one highlight.

Robotics Laboratory (Centre for Mechatronics)

Laboratory Coordinator: Dr. Ashish Dutta (2017 – 2021)

List of Major Equipment:

- Robots – PUMA, CRS for experiments.
- Humanoid robotics platforms – Biloid , Kondo KHR.
- Hand exoskeletons
- 14 DOF mobile manipulator systems for space robotics experiments.
- Mobile robotics kits for teaching and experiments.
- Pneumatic artificial muscles for robotics applications.
- EEG based Brain Computer Interface system.

Brief description of the laboratory:

The laboratory carries our research in the three main areas of:

- Design and control of Brain Computer Interface based hand exoskeletons for rehabilitation of stroke patients.
- Analysis, design and control of biped locomotion of humanoid robots for motion on 3D terrain and for performing complex tasks.
- Motion planning of Mobile manipulators systems like space rovers for space applications on 3D terrain.
- Applications of Machine Learning algorithms for control of robotic systems like hand exoskeleton, space rovers, humanoid robots, etc.

Laboratory research keywords:

Brain computer interface; Hand exoskeletons; biped locomotion; motion planning; machine learning; mobile manipulator systems.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• Brain computer interface-based algorithms for control of hand exoskeletons for rehabilitation of stroke patients. • Motion planning of space rovers using machine learning algorithms • Humanoid robotics gait on deformable terrains.
2019-2020	• Machine learning based control of biped robots for walk on 3D terrain. • Optimal Design of Hand exoskeletons • Design of compliant legged robots for deduced impact while jumping or falling.
2018-2019	• Motion planning of space rover for lunar applications • Design of legged robots for walk on uneven terrain
2017-2018	• BCI based control for robot human cooperation • Clinical trials for recovery of stroke patients.
2016-2017	• Design of hand and leg exoskeletons. • Machine learning based algorithms for control of exoskeletons.
2015-2016	• Design of compliant biped robots and their control. • Machine learning methods for motion planning in 3D.

Figure #1: 14 DOF Lunar rover for space applications.

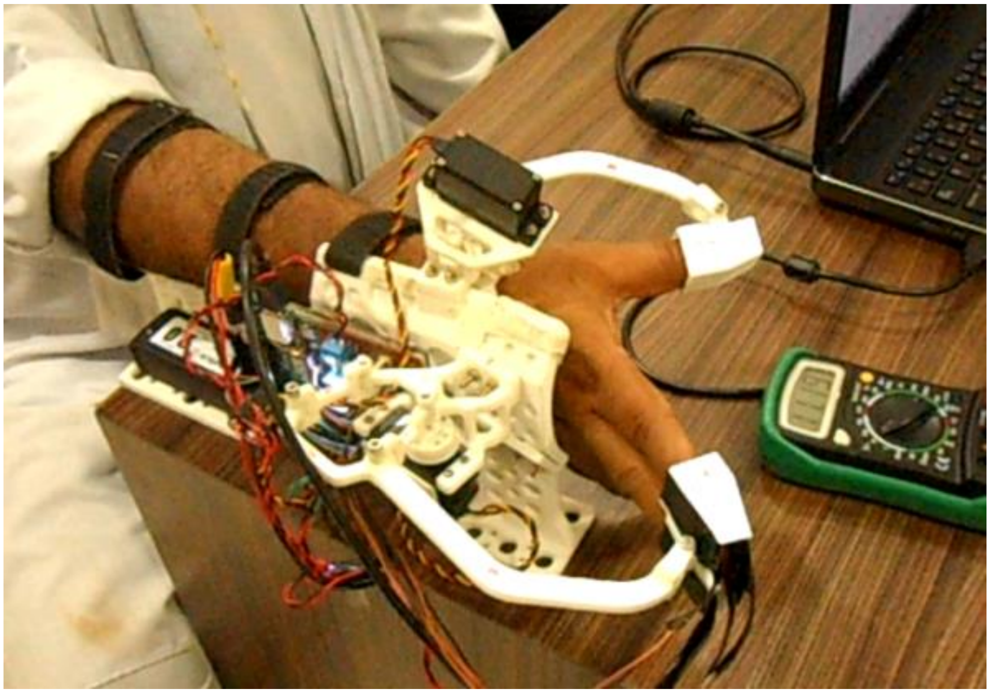


Figure #2: BCI based hand exoskeleton for rehabilitation of stroke patients.

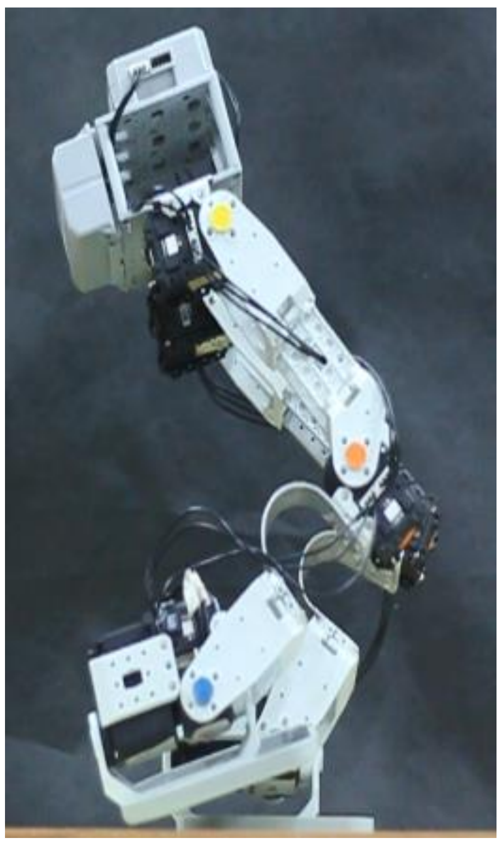


Figure #3: Biped robot with compliance at the shanks.

Computational Heat Transfer

Laboratory Coordinator: Dr. P. S. Ghoshdastidar

List of Major Equipment:

- Dell Vostro 260 ST Desktop Intel Core I-3 3250 T Processor, 4 GB DDR3 RAM, 500 GB SATA II Hard Disk Drive, 16 x Dual Layer DVD Writer, Intel GMA HD 4500 Graphics, 18.5'' LED Monitor, 1000 M LAN Card, USB Keyboard, USB Optical Mouse.

- Dell Vostro 260 ST Business PC Intel Core I-5 3.0 GHz Processor, 4 GB DDR3 RAM, 1 TB SATA II Hard Disk Drive, 16x Dual Layer DVD Writer, Intel GMA HD Graphics, 18.5" HD LED Monitor, 1000 Mbp Gigabit LAN Card, Dell Smart ATX Power Supply, Dell USB Keyboard, Dell Optical Scroll Mouse.

Brief description of the laboratory:

Please provide a brief description of the laboratory in about 8-10 lines, focusing on the main thrust area of the laboratory activities.

Computational Heat Transfer Laboratory is located in the third floor of the Faculty Building (FB354). It has a seating capacity of four students. The thrust areas of the lab are as follows.

- Simulation of heat transfer in rotary kilns with applications to production of important chemicals, and drying of food and non-food products.
- Modelling of pool boiling heat transfer by the coupled map lattice method
- Single phase and two-phase heat transfer in nanofluids
- Electronic and optonic cooling
- Bio-heat transfer
- Phase change materials
- Non-Newtonian fluid flow and heat transfer

Laboratory research keywords (8-10):

Computational heat transfer, rotary kilns, pool boiling, coupled map lattice method, nanofluids, electronic cooling, optonic cooling, bio-heat transfer, phase change materials, non-Newtonian flow and heat transfer

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	▪ Numerical Simulation of Heat Transfer in Laminar Natural Convection of Mixed Newtonian-Non-Newtonian and Pure Non-Newtonian Nanofluids in a Square Enclosure ▪ Computer Simulation of Heat Transfer in Alumina and Cement Rotary Kilns ▪ Numerical Simulation of Room Cooling by Single-Layer and Multi-Layer PCMs in a Hot Climate ▪ Numerical Investigation of Cooling of Photovoltaic Cells by Single-Layer PCMs and Nano-Enhanced PCMs in a Hot Climate ▪ A Computational Study of the Hyperthermia Treatment of A Simulated Tumourous Human Tissue Using Laser, Gold-Nanorods-Assisted Laser and Radio-Frequency Heating ▪ Numerical Simulation of Heat Transfer in a PCM Incorporated PPE Vest in Summer and Winter of Different Countries
2019-2020	▪ Laminar Forced Convection of Nanofluids in a Circular Tube: A New Nonhomogeneous Flow Model ▪ Computer Simulation of Mixed Convection of Alumina-Deionized Water Nanofluid over Four In-Line Electronic Chips Embedded in One Wall of a Vertical Rectangular Channel ▪ A Computational Heat Transfer and Optimization Study of Drying of Peas and Rice Grains in a Rotary Dryer ▪ Three-Dimensional Computer Simulation of Heat-Flux Controlled Pool Boiling of Water-Based Nanofluids by the Coupled Map Lattice Method ▪ A Comparative Numerical Study of Thermal Performance of Three Water-based Nanofluids in the Cooling of a Heated Continuously Moving Horizontal Plate ▪ Effect of Various Thermophysical Property Correlations on Heat Transfer Enhancement in CNT-Water Nanofluid Flow in a Heated Circular Tube: A Numerical Study Using Heterogeneous Flow Model
2018-2019	▪ A Comparative Study of 2-D and 3-D Conjugate Natural Convection from a Vertical Rectangular Fin Array with Multilayered Base Subjected to Distributed High Heat Flux ▪ Simulation of Conjugate Heat Transfer from a Continuously Moving Horizontal Plate to Nanofluid ▪ A Numerical Investigation of Heat Transfer Enhancement in Nanofluids Flow in a Parallel Plate Channel Subjected to Constant Heat Flux

	▪ A Numerical Study of Drying and Preheating of Food in a Rotary Dryer with Superheated Steam and Air as the Drying Media
2017-2018	▪ Heat Transfer Enhancement in Ferrofluids in Micro and Macro Parallel Plate Channels: A Comparative Numerical Study ▪ Computer Simulation of Heat Transfer in a Rotary Lime Kiln ▪ Numerical Simulation of Free Convection Heat Transfer from a Vertical Plate to Non-Newtonian Nanofluids ▪ A Computational Study of the Effect of Magnetic Field on Heat Transfer in Ferrofluid Flow in a Circular Tube ▪ A Computational Study of Synthetic Air Jet Aided Cooling of an LED Street Lighting Luminaire
2016-2017	▪ Numerical Simulation of Heat Transfer during Production of Rutile Titanium Dioxide in a Rotary Kiln ▪ A Computational Study of Mixed Convection Heat Transfer from a Continuously Moving Isothermal Vertical Plate to Alumina-Water Nanofluid as in Hot Extrusion ▪ A Numerical Study of the Effect of Thermal Radiation on the Forced Air Cooling of Low Heat Flux Electronic Chips Mounted on One Side of a Vertical Channel
2015-2016	▪ Heat Flux Controlled Pool Boiling of Zirconia-Water and Silver-Water Nanofluids on a Flat Plate: A Coupled Map Lattice Simulation ▪ A Numerical Study of Heat Transfer and Pressure Drop in Nanofluids Flow between Parallel Plates ▪ Computer Simulation of Mixed Convection Flow of Nanofluids Past a Continuously Moving Vertical Plate ▪ A Comparative Numerical Study of Heat Transfer in Parallel Plate Flow of Alumina-Water Nanofluid Using Homogeneous and Heterogeneous Flow Models

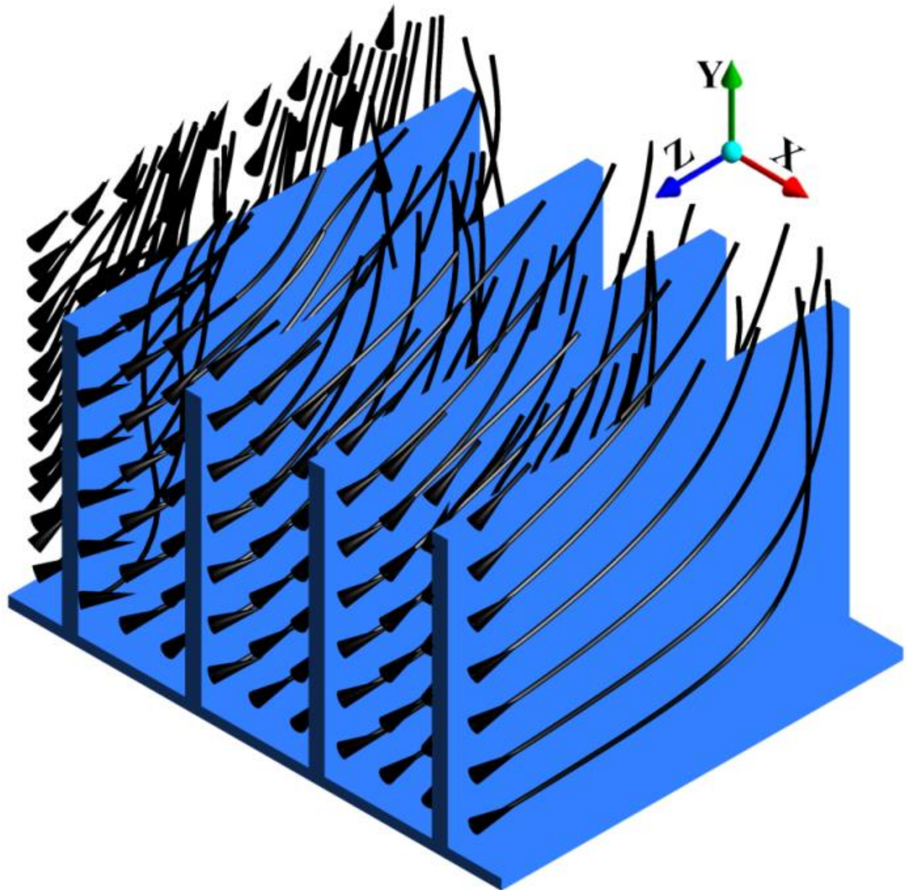


Figure #1: Chimney flow pattern between successive fins in a fin-array subjected to a high heat flux produced at the base of an LED streetlighting luminaire

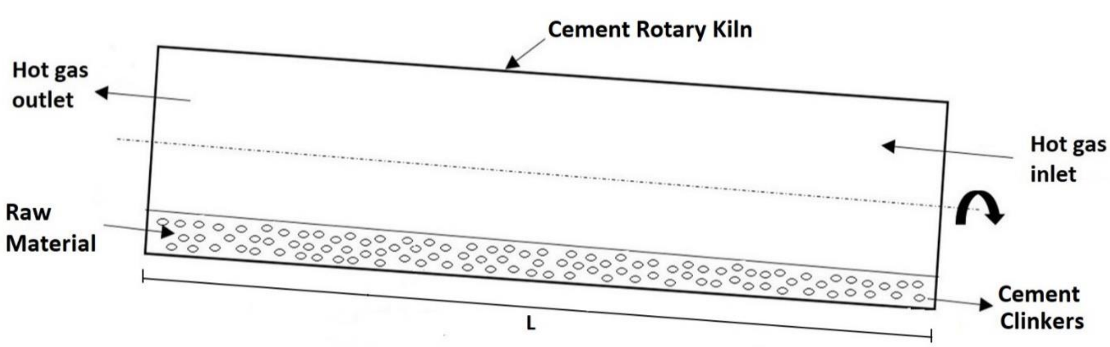


Figure #2: Schematic diagram of a rotary cement kiln

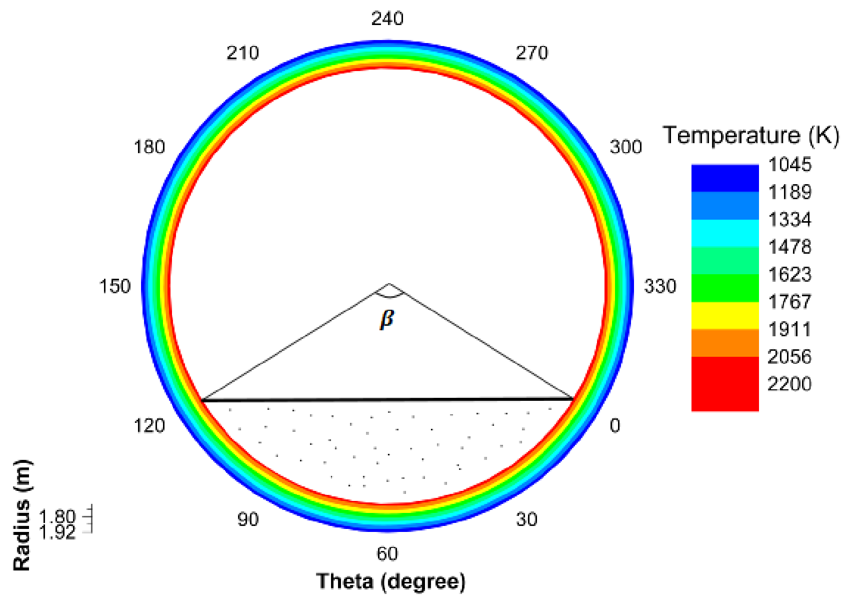


Figure #3: Temperature contours in the transverse section of the rotary cement kiln wall (at the axial position of 84% of the kiln length and at a speed of 3.5 r.p.m.)

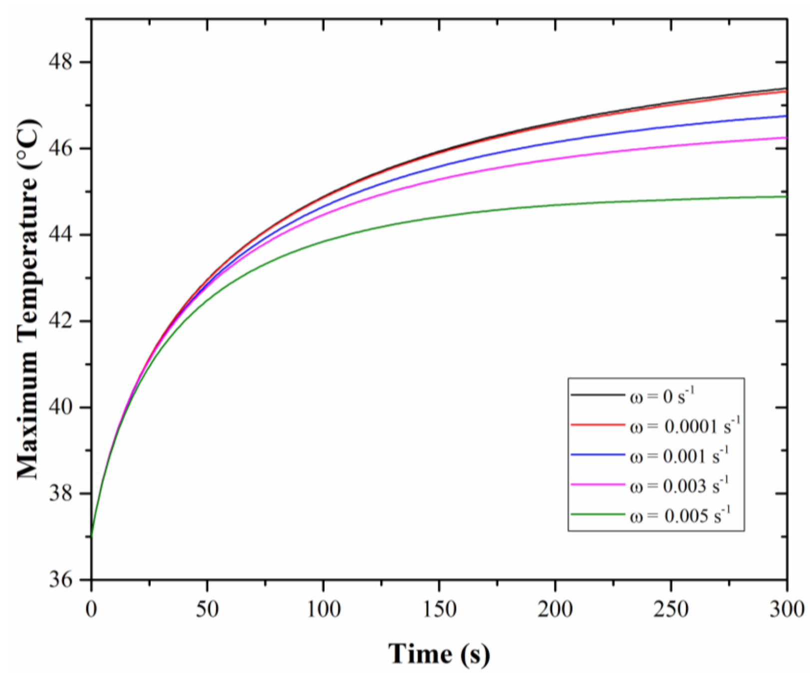


Figure #4: Variation of maximum tissue temperature with time for different blood perfusion rates in a cancerous tissue without any blood vessel under laser irradiation

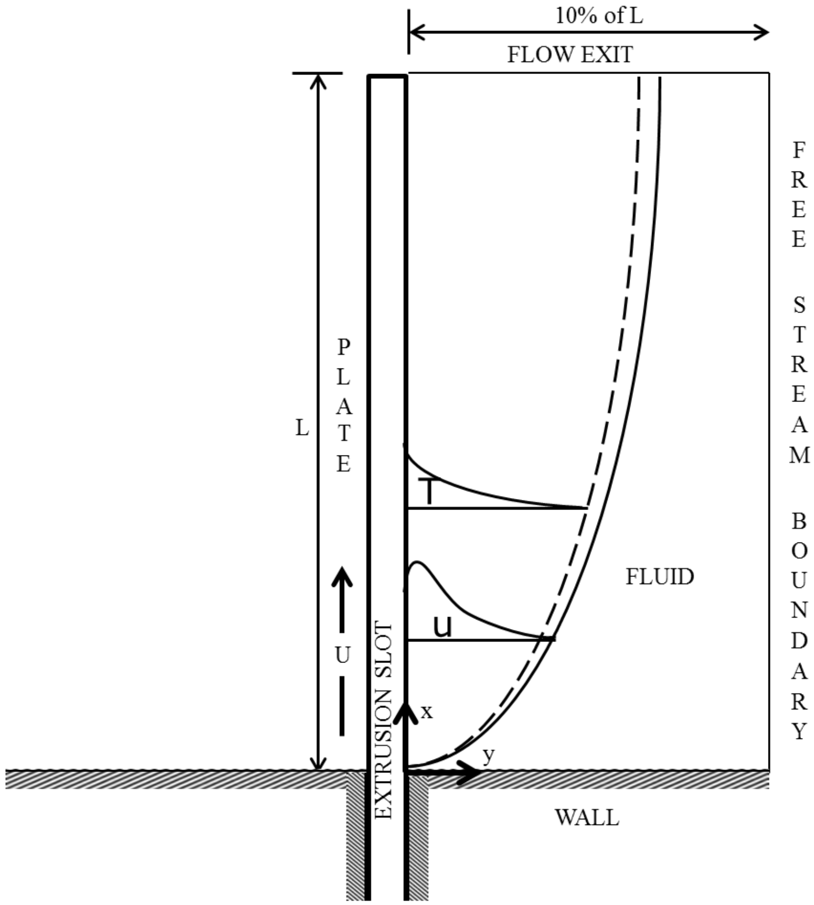
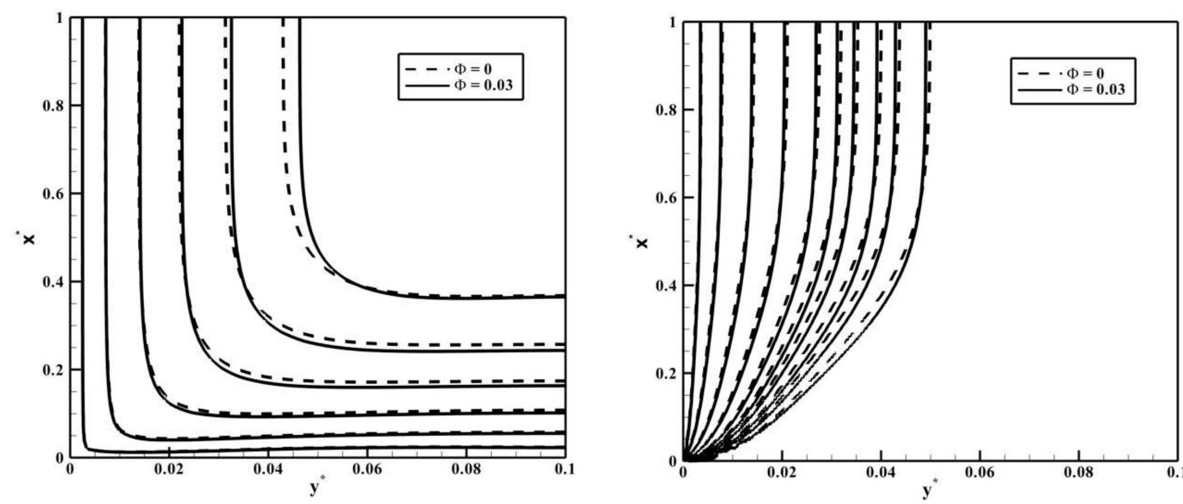


Figure #5: Physical domain of the problem of extrusion of a hot plate cooled by a nanofluid



(a) Streamlines (b) Isotherms

Figure #6**:** Streamlines (a) and Isotherms (b) in the Titania-Water nanofluid at U=0.001 m/s, ϕ =0.03 and Ri=1 during the extrusion process (Ri = Richardson number, ϕ =Volume fraction of nanoparticles, U = Velocity of the plate emerging from the extrusion die)

Continuum Mechanics and Thermodynamics Laboratory

Laboratory Coordinator: Dr. Anurag Gupta

List of Major Equipment:

- Four high performance computer servers
- Several workstations

Brief description of the laboratory:

Our group is primarily engaged in theoretical and numerical research work in the following areas:

- Geometry and mechanics of defects and singular interfaces in thin structures. These include continuous distributions of point defects, dislocations, and disclinations;
- Topological and differential geometric methods in mechanics;
- Finite deformation plasticity (strain-gradient theory, interfaces, stability);
- Interfacial kinetics in solids (grain boundaries, incoherent phase fronts, and junctions);
- Nonlinear elasticity (biological growth mechanics);
- Mechanics of Indian musical instruments (percussion and string instruments).

Laboratory research keywords:

Continuum Mechanics; Solid Mechanics; Elasticity; Thin structures; Mathematical methods in Mechanics.

Major Research and Development Contribution of the Laboratory

The following research papers have appeared in the last seven years:

(2022) Animesh Pandey and Anurag Gupta. Some Consequences of the Distributional Stress Equilibrium Condition, Zeitschrift fuer Angewandte Mathematik und Physik (ZAMP), 73:203, pp. 1-7.

(2022) Animesh Pandey and Anurag Gupta. Singular Points and Singular Curves in von Kármán Elastic Surfaces, Journal of Elasticity, 150, pp. 367–399.

(2022) Manish Singh, Ayan Roychowdhury, and Anurag Gupta. Defects and Metric Anomalies in Föppl-von Kármán Surfaces, Proceedings of the Royal Society A, 478:20210829, pp. 1-23.

(2022) Manish Singh, Animesh Pandey, and Anurag Gupta. Interaction of a defect with the reference curvature of an elastic surface, Soft Matter, 18, 2979-2991.

(2021) Animesh Pandey and Anurag Gupta. Point singularities in incompatible elasticity, Journal of Elasticity, 147, pp. 229–256.

(2021) Animesh Pandey, Manish Singh, and Anurag Gupta. Positive disclination in a thin elastic sheet with boundary, Physical Review E, 104, 065002.

(2021) Animesh Pandey and Anurag Gupta. Conservation laws for defect fields in non-contractible domains, Mechanics Research Communications, 118, 103806.

(2021) Anurag Gupta. Ekatantrī Vīṇā: A Formal Reconstruction Based on Musicological Texts , Kalākalpa, VI (1), pp. 21-30.

(2021) Ankit Biswas, Saptarshi Paul, Vishal Sharma, and Anurag Gupta. Acoustics of Mizhāvu, Journal of the Acoustical Society of India, 48, pp. 127-140.

(2021) Mousumi Mukherjee, Anurag Gupta, and Amit Prashant. A rate-dependent model for sand to predict constitutive response and instability onset, Acta Geotechnica, 16, pp. 93-111.

(2020) Tushar Joshi, Rajat Arora, Anup Basak, and Anurag Gupta. Equilibrium shape of misfitting precipitates with anisotropic elasticity and anisotropic interfacial energy, Modelling and Simulation in Materials Science and Engineering. 28, 075009.

(2020) Ayan Roychowdhury and Anurag Gupta. Growth and non-metricity in Föppl-von Kármán shells, Journal of Elasticity, 140, pp. 337-348.

(2020) Animesh Pandey and Anurag Gupta. Topological defects and metric anomalies as sources of incompatibility for piecewise smooth strain field, Journal of Elasticity, 139, pp. 237-267.

(2019) Roger Sauer, Reza Ghaffari, and Anurag Gupta. The multiplicative deformation split for shells with application to growth, chemical swelling, thermoelasticity, viscoelasticity, and elastoplasticity, International Journal of Solids and Structures, 174, pp. 53-68.

(2019) Digendranath Swain and Anurag Gupta. Mechanochemical aspects of skin wound healing in microgravity, Mechanics Research Communications, 96, pp. 87-93.

(2018) Kevin Jose, Anindya Chatterjee, and Anurag Gupta. Acoustics of Idakka: An Indian snare drum with definite Pitch, Journal of the Acoustical Society of America, 143(5), pp. 3184-3194.

(2018) Rahul Pisharody and Anurag Gupta. Experimental investigations of tānpurā acoustics, Acta Acustica united with Acustica, 104, pp. 542-545.

(2018) Digendranath Swain and Anurag Gupta. Biological growth in bodies with incoherent interfaces, Proceedings of the Royal Society London A, 474, 20170716.

(2018) Ayan Roychowdhury and Anurag Gupta. On structured surfaces with defects: geometry, strain incompatibility, stress field, and natural shapes. Journal of Elasticity, 131, pp. 239–276.

(2017) Ayan Roychowdhury and Anurag Gupta. Material homogeneity and strain compatibility in thin elastic shells. Mathematics and Mechanics of Solids, 22, pp. 1619-1635.

(2017) Sankalp Tiwari and Anurag Gupta. Effects of air loading on the acoustics of an Indian musical drum. Journal of the Acoustical Society of America, 141, pp. 2611-2621.

(2017) Anup Basak and Anurag Gupta. Influence of a mobile incoherent interface on the strain-gradient plasticity of a thin slab. International Journal of Solids and Structures, 108, pp. 126-138.

(2017) Ayan Roychowdhury and Anurag Gupta. Non-metric connection and metric anomalies in materially uniform elastic solids. Journal of Elasticity, 126, pp. 1-26.

(2017) Mousumi Mukherjee, Anurag Gupta, and Amit Prashant. Instability analysis of sand under undrained biaxial loading with rigid and flexible boundary. ASCE Journal of Geomechanics, 17(1), 04016042.

(2016) Digendranath Swain and Anurag Gupta. Mechanics of cutaneous wound rupture. Journal of Biomechanics, 49, pp. 3722-3730.

(2016) Animesh Pandey and Anurag Gupta. Applications of anisotropic slipline theory with non-uniform lattice rotation. Zeitschrift fuer Angewandte Mathematik und Physik (ZAMP), 67:77, pp. 1-9.

(2016) Mousumi Mukherjee, Anurag Gupta, and Amit Prashant. Drained instability analysis of sand under biaxial loading using a 3D material model. Computers and Geotechnics, 79, pp. 130-145.

(2016) Anup Basak and Anurag Gupta. Plasticity in multi-phase solids with incoherent interfaces and junctions. Continuum Mechanics and Thermodynamics, 28, pp. 423-442.

(2015) Digendranath Swain and Anurag Gupta. Interfacial growth during closure of a cutaneous wound: Stress generation and wrinkle formation. Soft Matter, 11, pp. 6499-6508.

(2015) Anup Basak and Anurag Gupta. A three-dimensional study of coupled grain boundary motion with junctions. Proceedings of Royal Society London A, 471: 20150127.

(2015) Anup Basak and Anurag Gupta. Simultaneous grain boundary motion, grain rotation, and sliding in a tricrystal. Mechanics of Materials, 90, pp. 229-242.

Non-linear Mechanics Laboratory

Laboratory Coordinator: Dr. Shakti Singh Gupta and Dr. Pankaj Wahi

Associated Faculty Members: (i) Dr. Manjesh Singh and (ii) Dr. Akhilesh Mimani

List of Major Equipment:

- Shaker platform
- Accelerometers
- Force Transducers
- CCD camera
- Ultra- sound bath
- Balance
- Desiccator
- Hot Plate
- Vacuum pumps
- Freezer
- Spin coater
- Confocal microscope
- Desktop computers
- Fluorescence microscope
- Optical table
- Hot air oven.

Brief description of the laboratory:

The nonlinear mechanics lab used to be jointly shared between Dr. Shakti Singh Gupta, Dr. Sovan Lal Das and Dr. Pankaj Wahi where the primary focus was on understanding nonlinear phenomenon in problems of applied mechanics and biomechanics. However, after Dr. Sovan Lal Das moved to IIT Palakkad, the biomechanics aspect has taken a back seat and the focus has shifted to understanding the mechanics of continuous structures with special relevance to practical systems involving strings, beams, plates etc. One of the main aims of the research activities undertaken in the laboratory is to understand the influence of the nonlinearity on the system response so that this can be utilized to enhance the performance of the system. Also under consideration is the possible exploitation of the nonlinearities into achieving better control strategies. In recent years, the engineering systems of interest being actively pursued include drill-strings for deep borewell drilling used for oil and gas exploration, stability and vibration characteristics of thin-walled shells, energy harvesters including parametric and autoparametric systems with pendulum, vibrations of conveyer belts etc. and the effect of finite-sized pulleys on them. Recently work has also been undertaken to better understand the nonlinearities in traditional independent suspension systems used in automobiles. Optimal synthesis of mechanisms primarily for use in prosthetic devices and finite element-based analysis of various prosthetic devices has been another focus area which is jointly shared with the biomechanics lab under Dr. Niraj Sinha.

Laboratory research keywords:

Nonlinear Vibrations; Stability and Control; Continuous Systems; Drill-string Dynamics, Independent Suspension System, Pendulum based Energy Harvesters, Thin-walled Shells, Unilateral Obstacle and vibrating continua interaction.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	During this period, the focus of the lab came back to understanding the implication of the interaction between continuous structures and boundary obstacles. The effect of the boundary obstacle on the vibrations of axially travelling strings beyond the critical velocity was explored for a large pulley at one end with a small pulley at the other end. Parallel studies on the same analysis with pulleys of comparable sizes at both the ends were initiated. The lab members also resurrected their interest in deep drilling system and started exploring the design of drill bits to ensure better resistance to self-excited vibrations during operation.
2019-2020	During this period, the members of the lab largely carried forward the collaborative effort with the Machining Dynamics Lab to better understand the dynamics of the machining process with a view to control them.
2018-2019	During this period, members of the lab diversified into prosthetic devices along with taking forward the work on instability in cylindrical shell structures. In particular, the buckling of cylindrical shells under torsional loading was considered both using reduced shell equations and using computational models in FEM. On the prosthetic devices front, optimal synthesis of polycentric knees was considered and factors effecting the final optimal design was obtained. This analysis was taken further to develop a prosthetic leg with coordinated motion between the knee and the ankle. Members of the lab also started exploring stability and vibration characteristics of machining tools in collaboration with the Machining Dynamic lab of Dr. Mohit Law.
2017-2018	During this period, the major research activity in the lab was geared towards understanding deep drilling systems and pendulum based energy harvesting devices. We extended our understanding of the conditions affecting appearance of self-excited vibrations in a simplified axial-torsional model of the drill-string and also studied the effect of changing boundary conditions at the ground level on the onset of the instability. In the energy harvesting using pendulum based devices, we worked out control laws to ensure continuous rotation of the pendulum from any arbitrary initial conditions which is a must to utilize this whirling motion for generating power. We also studied the influence of the coupling between the harvester and the vibrating source using an autoparametric pendulum system excited by vortex-induced vibrations. Additionally, in collaboration with Dr. Abhishek from Aerospace engineering, members worked on an initial design and optimization of the main gear-box for a 10-12 tonne class helicopter transmission system. The primary objective was to minimize the weight of the gearbox while ensuring an overall reduction ratio of approximately 25.
2016-2017	During this period, the activities in the lab again continued on analytical and computational approaches to study engineering systems. The computational work focused on understanding the dynamic stresses and the resulting deformations in a shell which is fired from a rifled barrel to provide it directional stability. Another aspect of the computational analysis was to predict the sound pressure levels due to flow in ducted passages with an aim

	to predict the noise level due to HVAC ducts used in buildings and naval ships. On the analytical front, the use of inerters in suspension system of automobiles to enhance its vibration isolation characteristics was explored. We also worked on a new dynamic friction law to better capture the friction force characteristics in the pre-sliding regime. Parallelly we also worked on obtaining a more comprehensive understanding of the parametric instability in thin-walled shell structures, self-excited vibrations in deep drilling systems and the inherent nonlinear instability in reduced order models of nuclear fission reactors.
2015-2016	During this period, the major research of the lab was focused towards obtaining a better understanding of mechanics of continuous structures and ascertaining the validity of some of the simplified theories for the same. Towards this end, a two-pronged approach of analytical studies of simplified theories coupled with computational studies using continuum structures was adopted. Among the simplified theories were the string, beam and shell theories while the computational studies were done on slender and thin-walled structures. The analytical studies using string theories focused mainly on the influence of the presence of a unilateral obstacle at the boundaries on the vibration characteristics. The analytical studies for beams included large amplitude vibrations whose characteristics was compared with a similar response from a computational study using FEM. For shell structures, appropriate equations to study the vibration and stability characteristics were obtained and validated against FEM solutions. Parallelly a computational study on the wrinkling behavior in thin spherical and inflated shell structures was undertaken to ascertain conditions for the appearance of wrinkles on the shell surfaces.

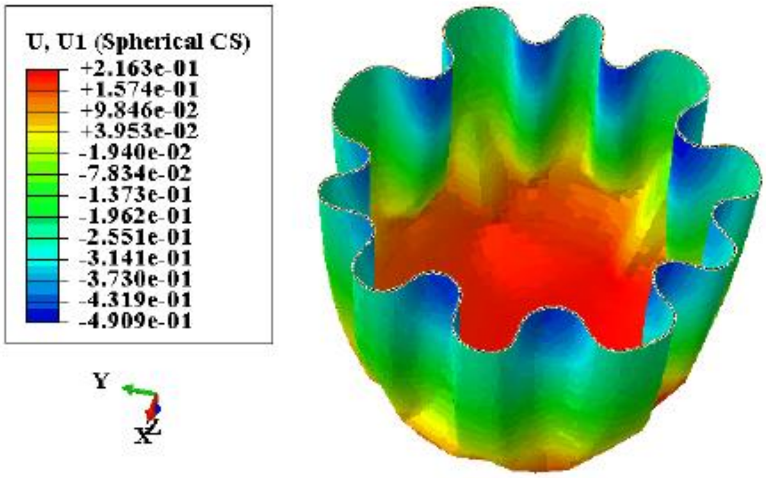


Figure #1: Wrinkling observed in spherical shells under electrostatic forces applied on the outer surface,

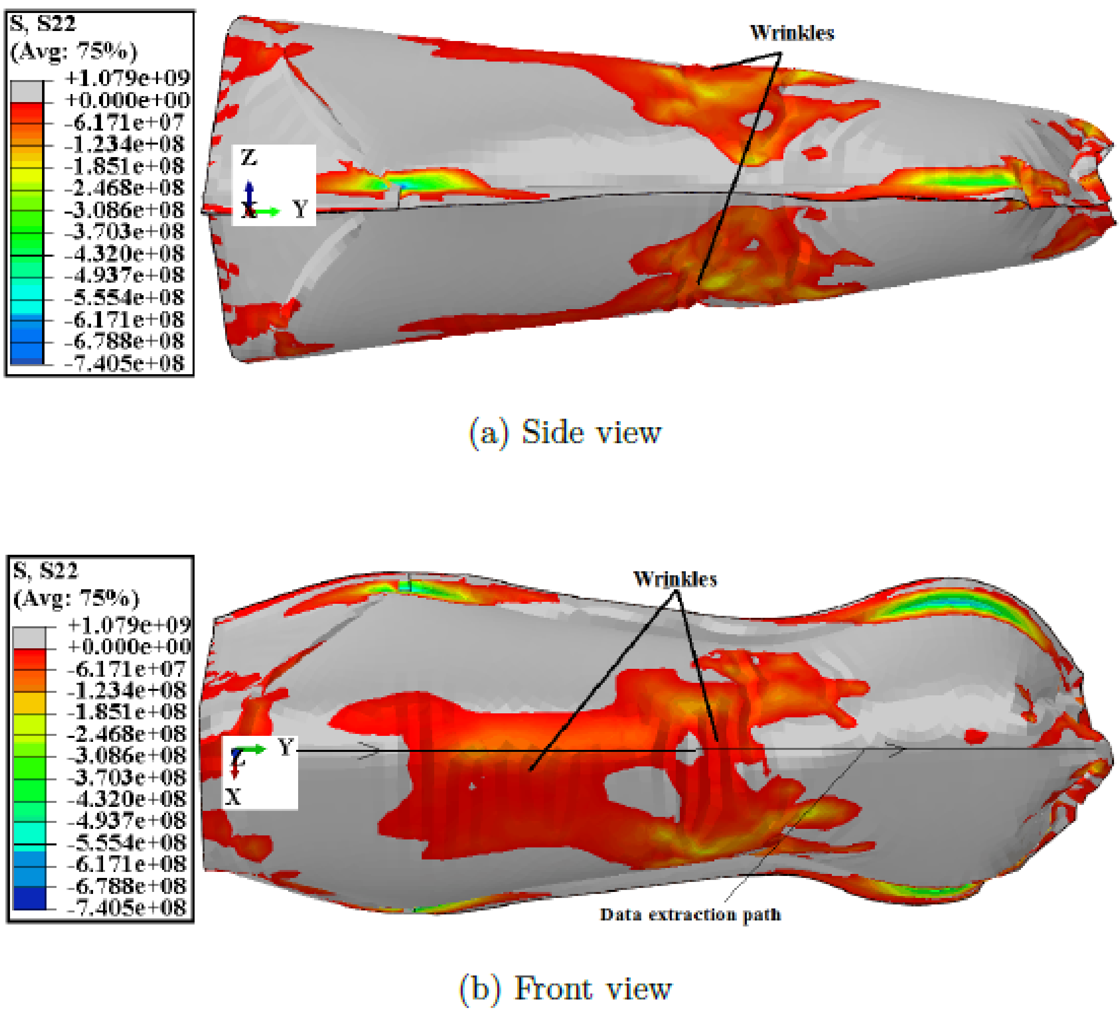


Figure #2: Principal Stress distribution in an inflated pouch under internal pressure with possible wrinkles appearing on the surface.

Advanced Nano-engineering Materials Laboratory

Laboratory Coordinator: Kamal K. Kar

Associated Faculty Members (if any): Malay K. Das, J. Ramkumar,

List of Major Equipment:

- AFM
- SEM
- Raman
- DSC
- TGA
- DMA
- UTM
- PECVD
- Micro-injecting molding
- Thermal conductivity
- Electrical conductivity
- Hall mobility

Brief description of the laboratory:

Please provide a brief description of the laboratory in about 8-10 lines, focusing on the main thrust area of the laboratory activities.

The primary research activities are to design better materials for the technologically essential areas using the fundamental principles of nanomaterials having multifunctional behaviours. Moreover, this laboratory uses the structure-properties-processing-performance concept, a building block of materials science and engineering, to improve the performance of the existing technologies and turn waste into wealth for the larger good of society. In particular, this laboratory has made several contributions through sustained effort using carbon nanotubes, graphene, porous carbon, exfoliated graphite; advanced nanostructured materials including nanopolymers; multifunctional and functionally graded composites; nanocomposites including multiscale composites, -carbon-carbon/silicon composites, etc

Laboratory research keywords:

Fuel cell; Lithium battery; Thermoelectric; Water purification; Supercapacitor; High-performance structural composites; Bio-implants; -Roadwheel of Military Battle Tank Arjuna

Major Research and Development Contribution of the Laboratory

This laboratory has been developing new materials for flexible supercapacitors, IMI shielding, and mechanical heart valves in the last 7 years

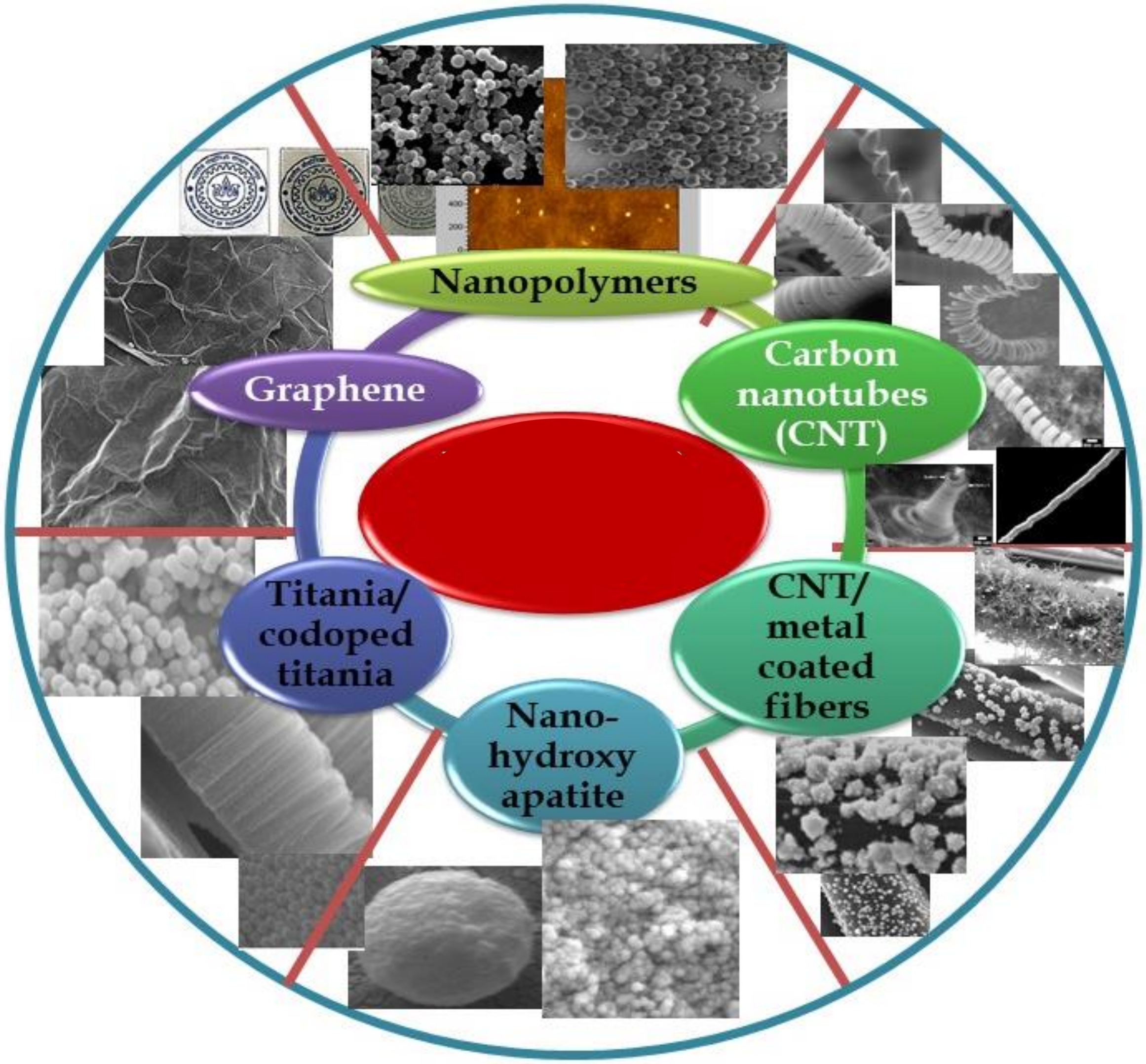


Figure #1: Portfolio of various nanostructured materials made by this laboratory

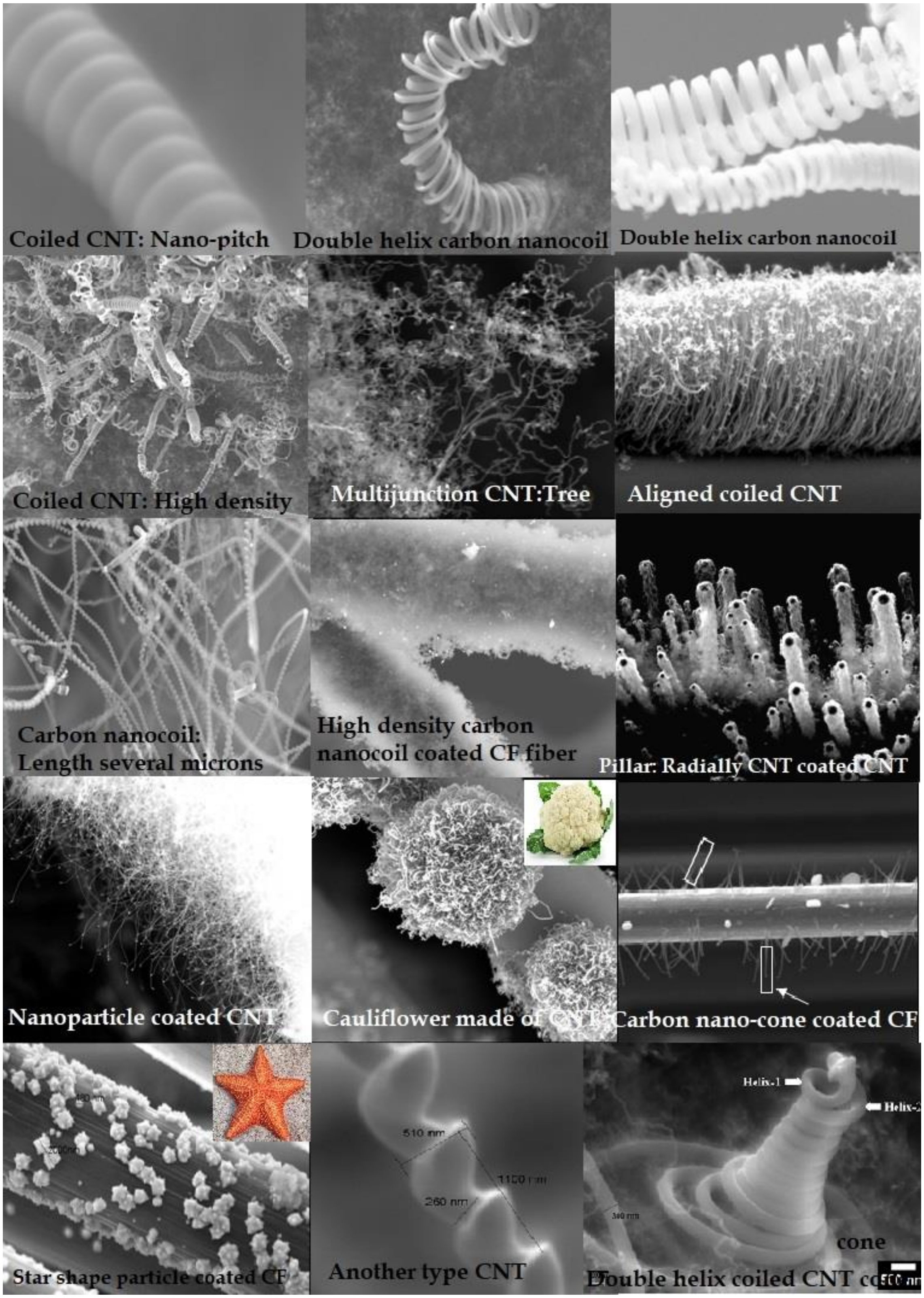


Figure #2: Portfolio of various nanostructured carbon materials made by this laboratory

Phase-Change Thermal Systems Laboratory

Laboratory Coordinator: Dr. Sameer Khandekar

List of Major Equipment:

- FLIR Infra-Red Thermographic Camera
- High Speed Videographic Camera
- Laser-Flash Thermal Diffusivity Measurement System
- Goniometer and Tensiometer
- Mass Spectrometer
- Helium Leak Detector
- Mass Flow Controllers
- Environmental Chamber and Flow Facility
- Lathe, Milling and Drilling Machines
- Pressure/Temperature Transducers and DAQ Systems
- Constant temperature Baths/Circulators (Various Units)
- AC/DC Power supplies (Various Units)

Brief description of the laboratory:

The laboratory is engaged in undertaking and exploring contemporary research problems in the broad domain of phase-change thermal systems. The primary focus is design of experiments, experimental research with controlled boundary conditions, prototype development and to some extent, translational research in system level development. Simulations and mathematical modelling are also simultaneously undertaken to design the experiments, as well as to undertake parametric studies.

Major focus in the recent times has been on understanding nuances of interfacial dynamics of droplets, drop-wise condensation, surface engineering and wettability control and evaporation heat transfer. Several systems have been built and tested in the domain of passive thermal management of electronics, including gravity assisted thermosyphons, conventional heat pipes, pulsating heat pipes and loop heat pipe systems. Large scale systems have also been built to simulate severe accident scenarios in nuclear containments, to specifically study the thermal-hydraulics of steam condensation in the presence of air and hydrogen. Focus has also been directed to provide technology solutions to cater to high heat flux dissipating systems via active spray/jet cooling.

The laboratory is equipped with state-of-the-art equipment as listed above. We have done collaborative research and development within IIT Kanpur, at the national level with other institutes/laboratories and with international laboratories from France, Italy, Brazil, China and Russia.

The laboratory has graduated 12 doctoral students and over 55 master students till date, from its inception in 2004.

Laboratory research keywords:

Design of Experiments; Interfacial physics, Evaporation; Boiling; Condensation; Water Desalination; Fog Harvesting; Nuclear Containment Thermal-hydraulics; Heat Pipes and Thermosyphons; Energy Systems

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	**Solar Water desalination (ongoing):** Determination of Evaporation Rate of Warm Water Placed inside a Partially-filled Top Cooled Enclosure **Thermal Transport in Ferrofluids:** Influence of External Magnetic Manipulation on Thermal Transport Characteristics of the Bubble-Slug Flow of Ferro-Nanocolloids Energy Efficient Thermal Management at Low Reynolds Number with Air-Ferrofluid Taylor Bubble Flows
2019-2020	**Interfacial dynamics and Transport Phenomena:** Drop-on-drop Impact Dynamics on a Superhydrophobic Surface Evaporation Rate of Warm Water Placed inside a Partially-filled Top Cooled Enclosure was determined using non-invasive interferometry and supporting mathematical modeling. **Spray Cooling of high-power LEDs** Thermal Characterization of Spray Impingement Heat Transfer over a High-Power LED Module was carryout and heat flux of the order of 1000 W/cm^2 was demonstrated with this technique.
2018-2019	**Interfacial dynamics and Transport Phenomena:** Coalescence dynamics of sessile and pendant liquid drops placed on a hydrophobic surface was experimentally investigated. Vertical and sidewise (horizontal) coalescence was explored. Evaporation dynamics of liquid bridge formed between two heated hydrophilic and hydrophobic flat surfaces was explored.
2017-2018	**Development of Loop Heat Pipes:** Loop Heat Pipes were indigenously developed with Copper and Nickle bi-porous wicks. The LHPs were successfully deployed for thermal management of high-power LEDs. Miniature Ammonia Loop Heat Pipe for Terrestrial Systems were developed, tested and applied for electronics thermal management. Numerical model to predict the heat transfer characteristics were developed. Dynamic Evolution of an Evaporating Liquid Meniscus from Structured Screen Meshes and other type of porous structures, as applicable to heat pipes was experimentally studied. Effect of externally imposed vibrations on the thermal performance of miniature loop heat pipes for avionics cooling was investigated.
2016-2017	**Understanding Transport Phenomena of Ferrofluids:** Experiments were designed to estimate the heat transfer coefficient for single-phase and two phase (air-ferrofluid) flow of ferrofluids in capillary tubes.

<table>
<tr><td></td><td>On-demand Augmentation in Heat Transfer of Taylor Bubble Flows Using Ferrofluids was demonstrated via dedicated experiments under different boundary conditions. The multi-physics flow and heat transfer of magnetically activated ferrofluids was modeled.

Flexible Heat Pipes for Space Applications:

Flexible wicked heat pipes were designed for space applications and prototypes were supplied to Indian Space Research Organization.

Development of heat flux sensor:

Based on inverse heat transfer techniques, an algorithm was developed to estimate heat flux with the help of one/two thermocouples. This was implemented and a real-time heat flux measurement sensor was developed and tested. This was eventually installed in the Nuclear Containment Facility THYCON.</td></tr>
<tr><td>2015-2016</td><td>Understanding pulsating heat pipes:

Pulsating Laminar Flows in Microchannels were explored to estimate the transport coefficients.

Experiments were conducted on pulsating Taylor bubble flows in micro-channels, in the context of understanding Pulsating Heat Pipes.

Evaporation of a single liquid plug moving inside a capillary tube was studied with the focus on understanding the physics of thin film evaporation near the contact line.

Experiments were conducted to understand the transport phenomena of Thermally induced oscillating two-phase flows in mini-channels.

Steam Condensation in Nuclear Containments:

Experimental setup to decipher the flow of steam-helium-air mixture inside nuclear containment structures were initiated.

A CFD based Modeling Approach for Predicting Steam Condensation in the Presence of Non-condensable Gases was developed and results were validated with supporting experiments.

Effect of surface inclination on film-wise condensation heat transfer during flow of steam-air mixtures was investigated.</td></tr>
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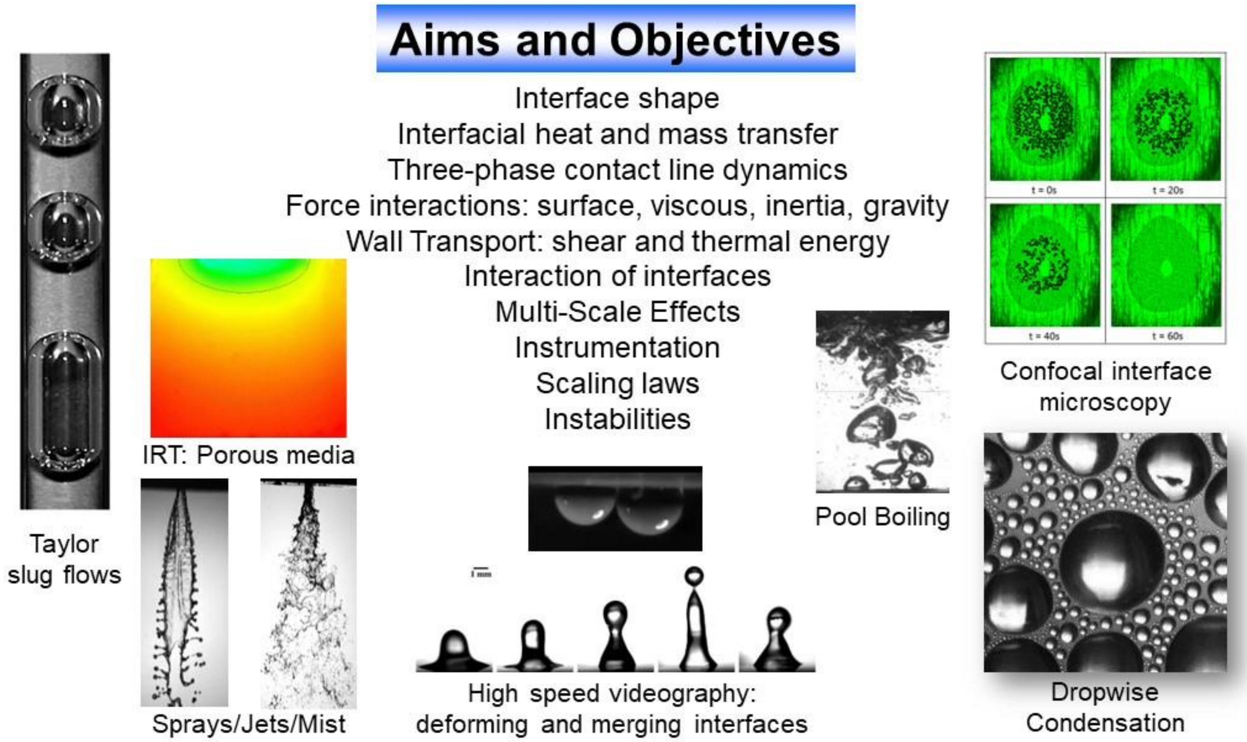


Figure #1: Major aims and objectives, and key words of Phase-change Thermal Systems Laboratory

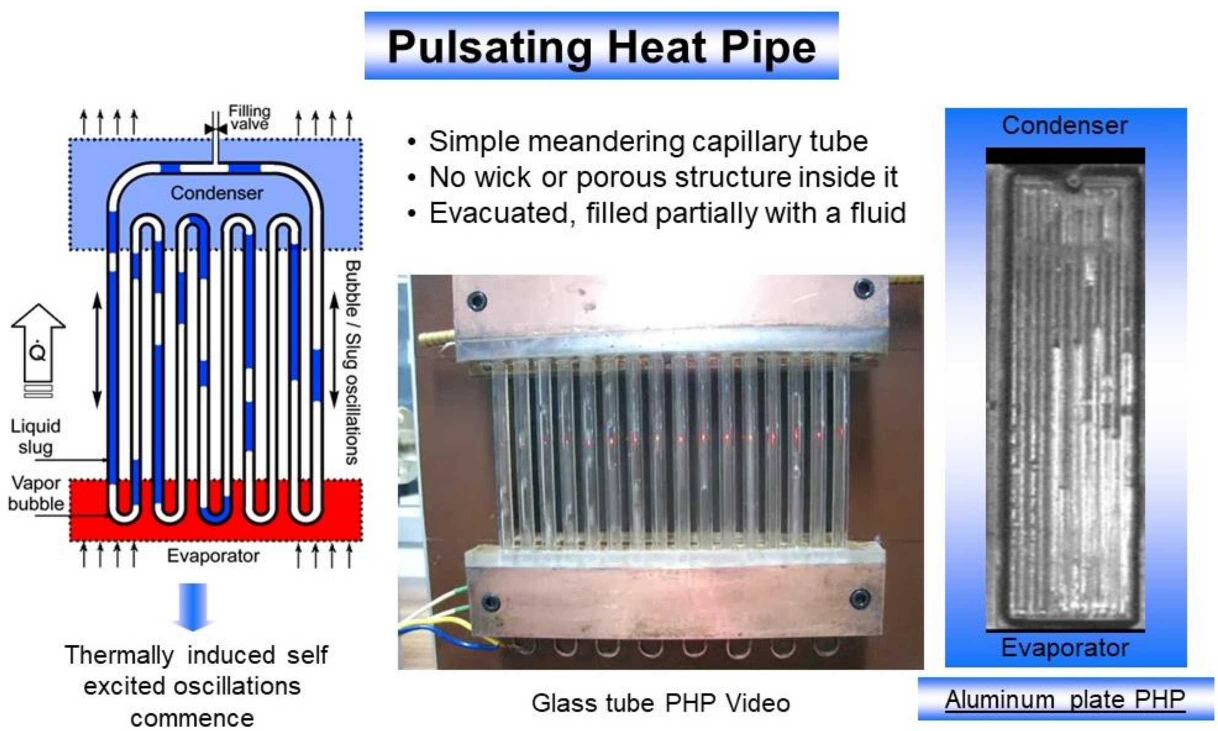


Figure #2: Understanding the physics of pulsating heat pipes

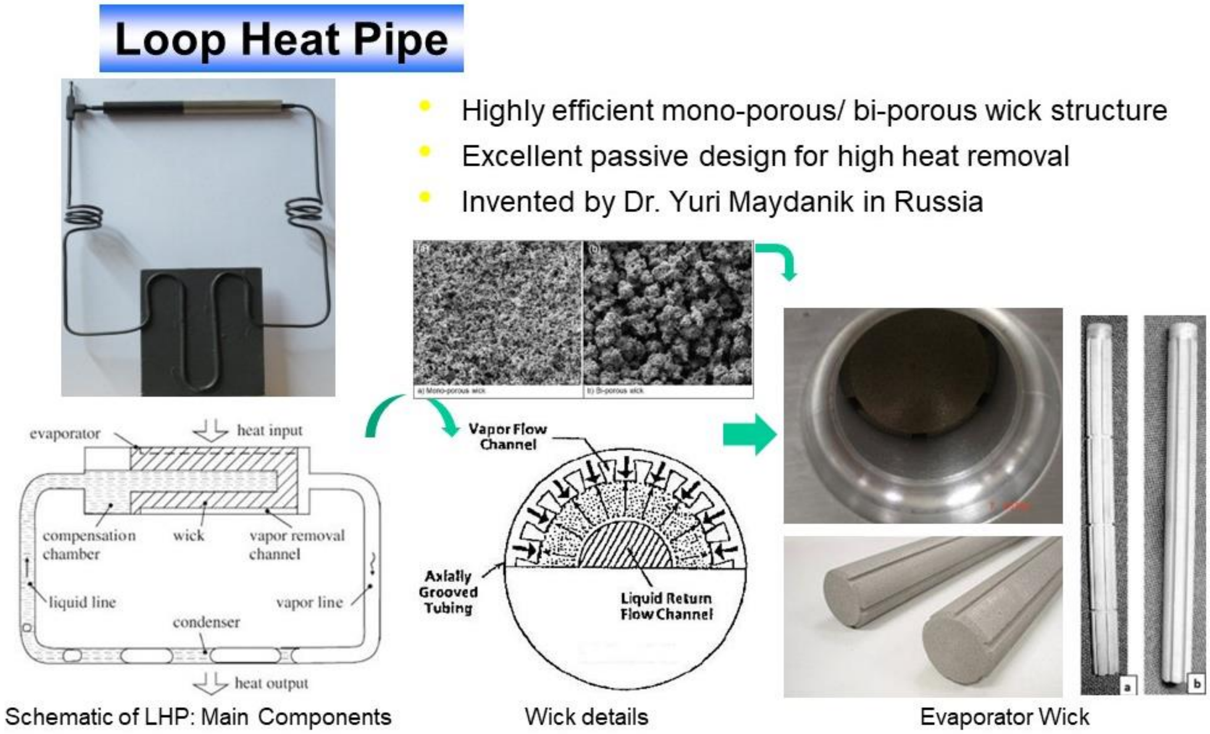


Figure #3: Design and development of loop heat pipes for terrestrial applications

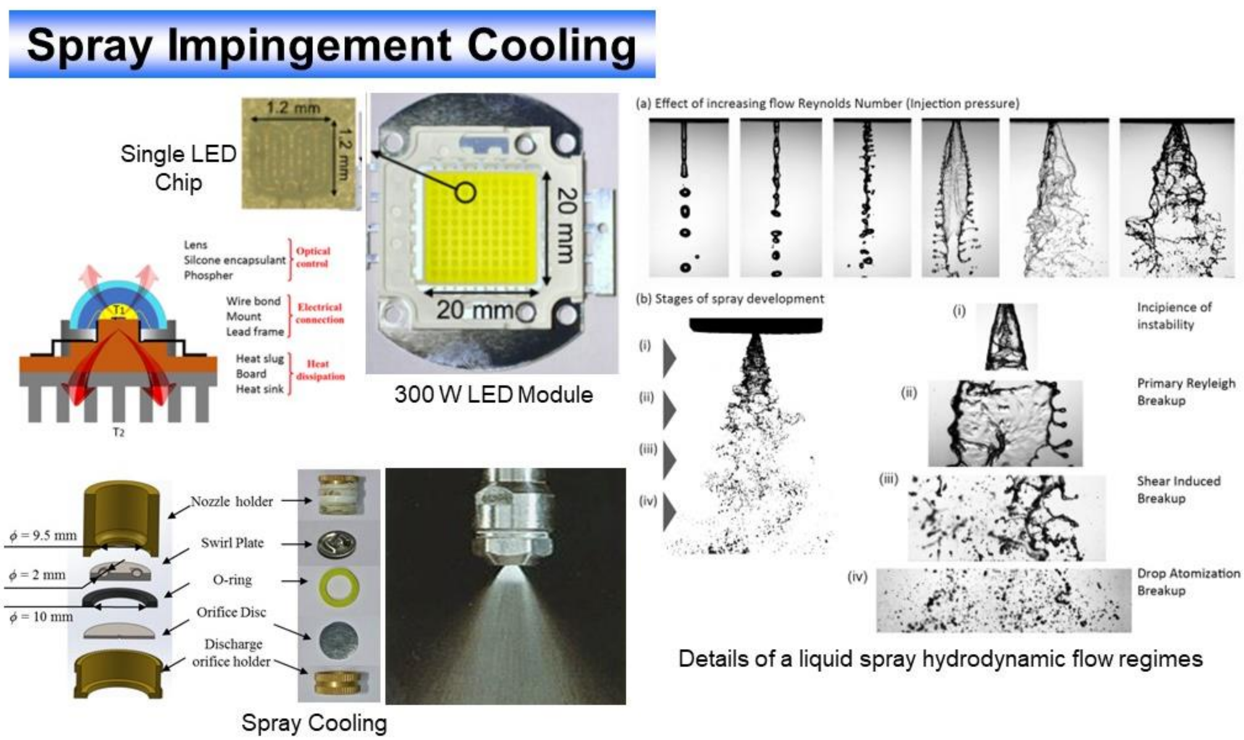


Figure #4: Thermal management of high-power LEDs by spray cooling

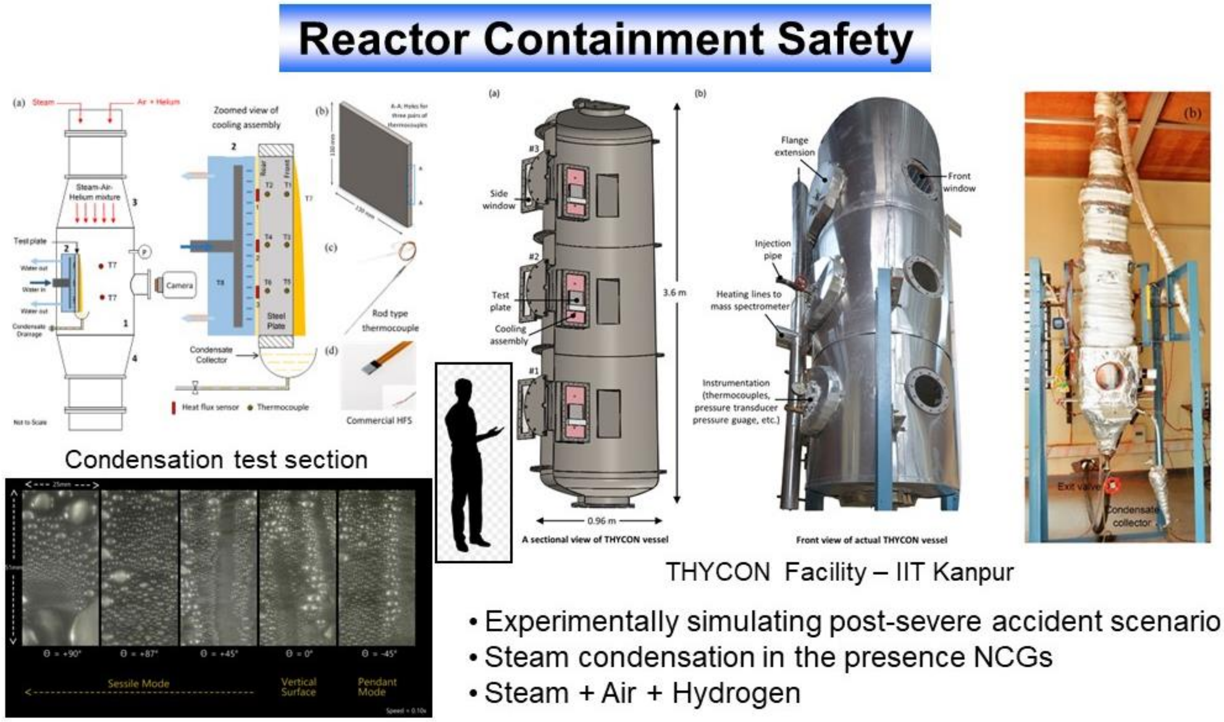


Figure #5: THYCON facility for understanding severe accident thermal-hydraulics in nuclear containments

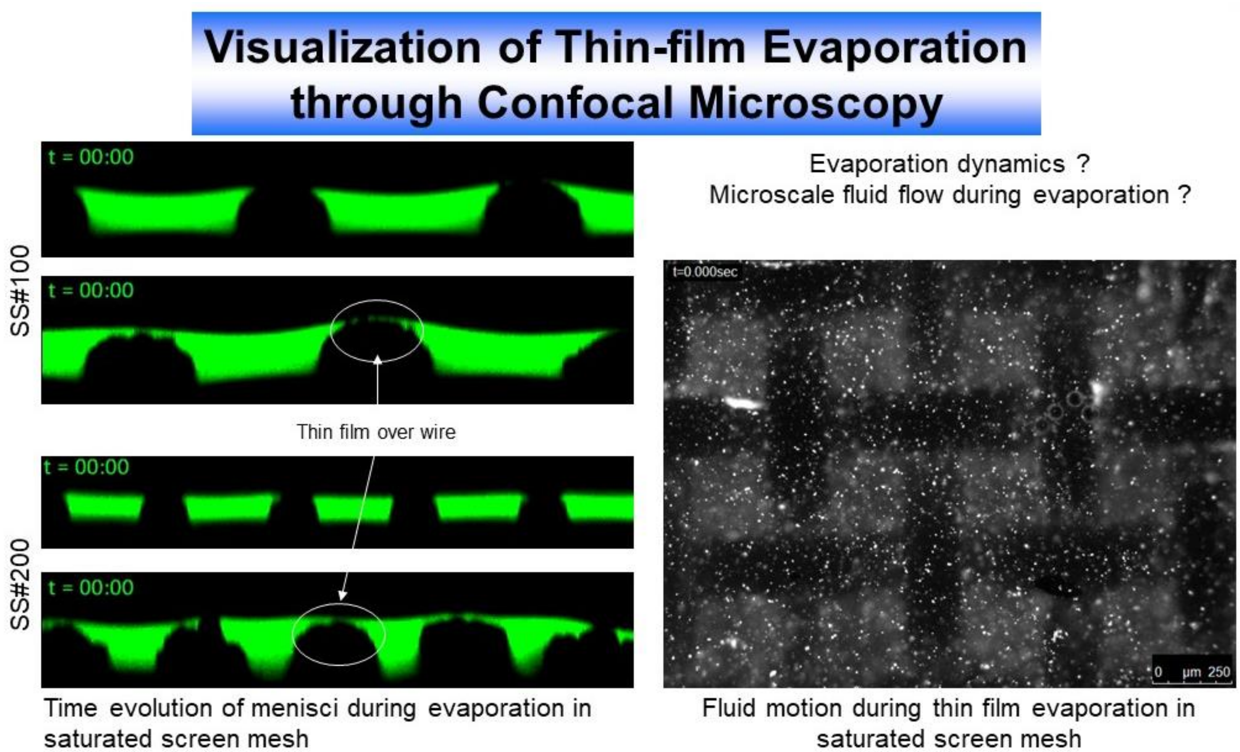


Figure #6: Understanding thin film/ meniscus evaporation in porous wicks/screen meshes

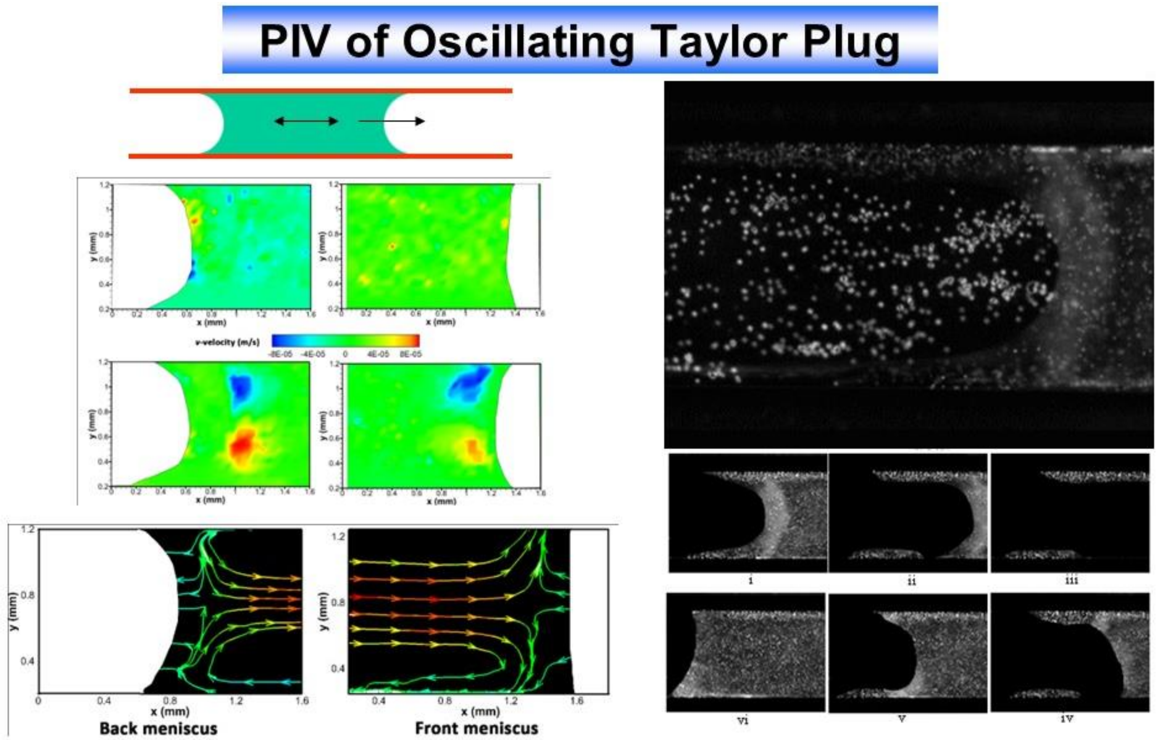


Figure 7: Particle image velocimetry of oscillating Taylor bubbles and menisci

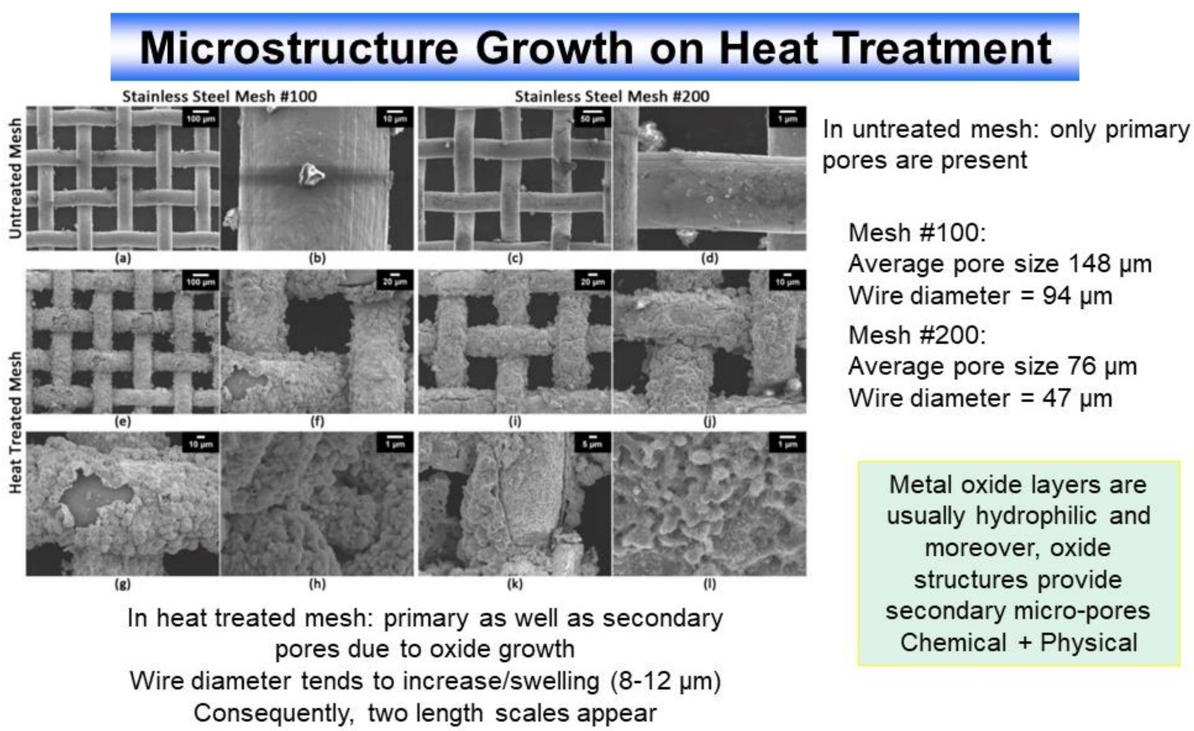


Figure #8: Surface engineering for enhancement of evaporative heat transfer

Solidification Laboratory

Laboratory Coordinator: Dr. Arvind Kumar

List of Major Equipment:

- PIV system for melting/solidification studies for transparent metal analogue
- HS imaging camera
- Desktop computer workstations

Brief description of the laboratory:

Solidification Laboratory is involved in research on melting/solidification-based manufacturing processes. Cutting edge experimental and numerical research is performed in the areas of solidification processing namely casting, welding, metal additive manufacturing and thermal spray surface coating. The focus is on development of state-of-the-art computational models, controlled laboratory experiments as benchmarks and process development. Accurate models by comprehensively integrating the solidification thermodynamics with the attendant multiscale thermo-fluid phenomena have been developed for various solidification processes that can accurately predict and control the physical and metallurgical behaviour of solidification, defects and as-solidified microstructure. The other focus area of the lab is thermal energy storage using phase change material (PCM).

Laboratory research keywords:

Solidification; Casting; Laser welding; Transport phenomena; Segregation; Porosity; Multiscale modelling; Microstructure; Grain morphology; As-solidified material properties.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• Established the role of mushy zone flow instability on the formation of channels segregation during columnar solidification. Channel segregation defects are very critical for casting of structural steels, titanium and nickel-based superalloys used in single-crystal turbine blades, aircrafts and nuclear reactors. • Developed an experimental-numerical framework for additive manufacturing of aerospace component. Mitigated cracking in Laser Powder Bed Fusion (L-PBF) processing of Al7075 alloy powder by employing nanoparticle reinforcement and base plate heating. • Developed a predictive numerical tool for thermal spray surface coating. Also developed HS in-situ imaging facility for droplet impact and solidification on surfaces.
2019-2020	• Developed open-source software for modelling melting/solidification in metal alloys that incorporates the multiscale transport phenomena. • Developed PIV and HS in-situ imaging facility for solidification of transparent metal analogues. Local and whole field imaging and measurement of temperature, flow, concentration, dendrite growth and dendrite fragmentation during solidification are possible. • Developed predictive capability for metal additive manufacturing processes namely Laser Powder Bed Fusion (L-PBF) and Laser Directed

	Energy Deposition (L-DED). The predictive tool incorporates particle-scale modelling by coupling the optical and the thermo-hydrodynamical phenomena. • Developed physics-based predictive capability for laser beam welding. Simulation and prediction of weldpool phenomena including weld composition.
2018-2019	• Established the effect of volumetric laser energy absorption on thermal-fluidic transport in *powder bed fusion (PBF) based metal additive manufacturing* of Ti6Al4V. • Established the pore formation mechanism in thermal spray coating process by investigating dynamics of air entrapment. • Developed numerical tool for thermal energy storage system. Simulation and prediction of cold energy storage (using ice slurry) and heat storage (using phase change material - PCM) parameters. • Developed in-situ experiments to study the discharge stage in PCM.
2017-2018	• Developed predictive macroscopic modelling and simulation of laser spot welding process. • Established discrepancy between numerical and experimental results for PCM based thermal storage and evaluated nano-enhanced composite phase change materials for waste heat recovery. • Developed macroscopic models in OpenFOAM for directed energy deposition (DED) and powder bed fusion (PBF) based metal additive manufacturing. • Understanding of thermal stresses in metal additive manufacturing is developed through track-scale simulations.
2016-2017	• Developed predictive capability of thermal field and weld bead characteristics in submerged arc welding. • For better accuracy in predictions in thermal spray coating application, the rapid solidification and the undercooling effect have been coupled with the model of metal droplet impact and flattening on a substrate.
2015-2016	• Established the role of substrate melting and re-solidification in thermal spray coating process. • For cold thermal storage using ice slurry, a numerical tool is developed to study the transport phenomena of ice slurry in an ice forming unit.

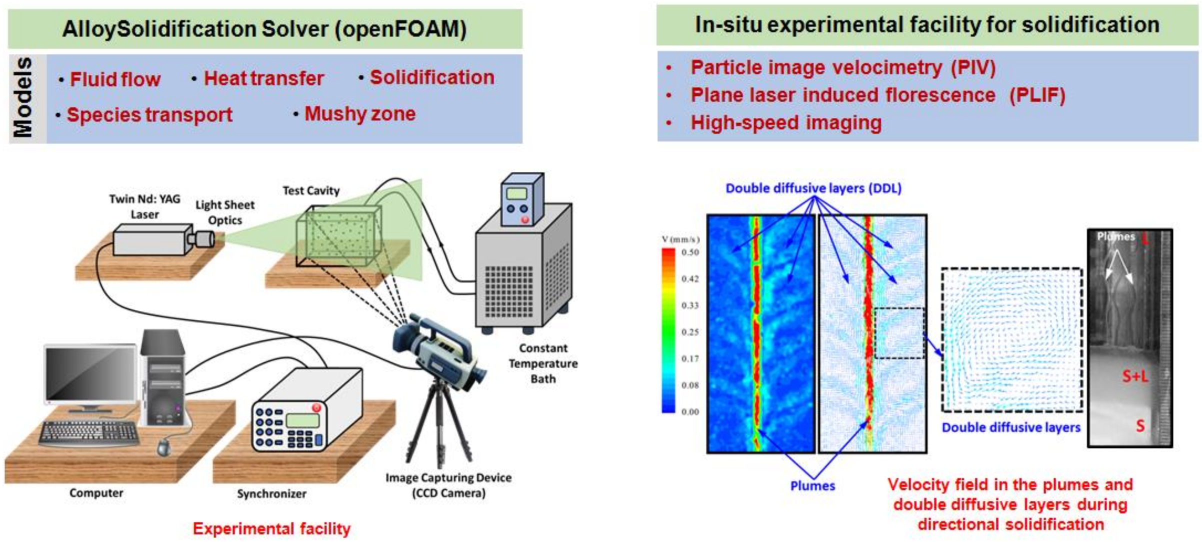


Figure #1: Opensource Alloy Solidification software, and in-situ PIV, PLIF and imaging facility to investigate solidification in transparent analogues.

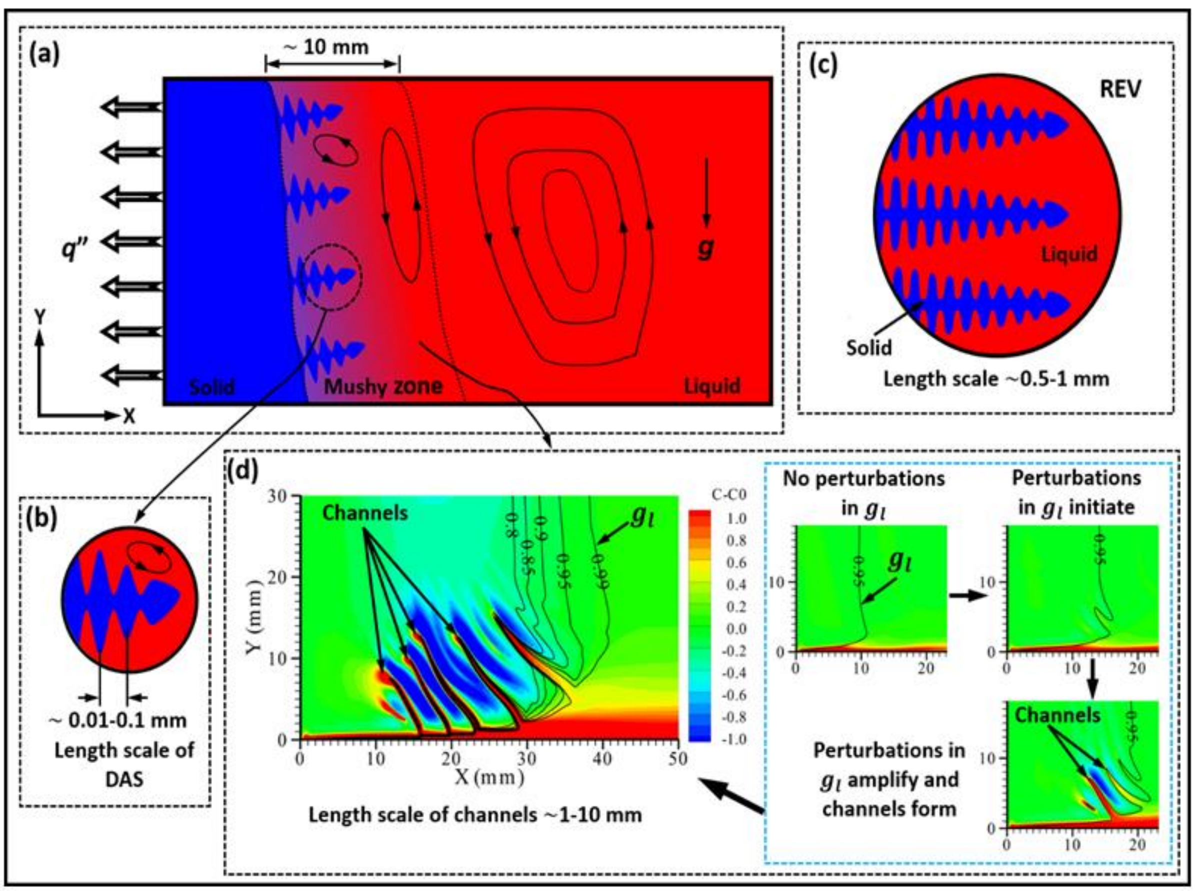


Figure #2: Illustration of the physical scales and the formation of channel segregates phenomenon during columnar solidification (a) system (macroscopic) scale, (b) grain scale, (c) representative elementary volume (REV), (d) formation of channel segregates.

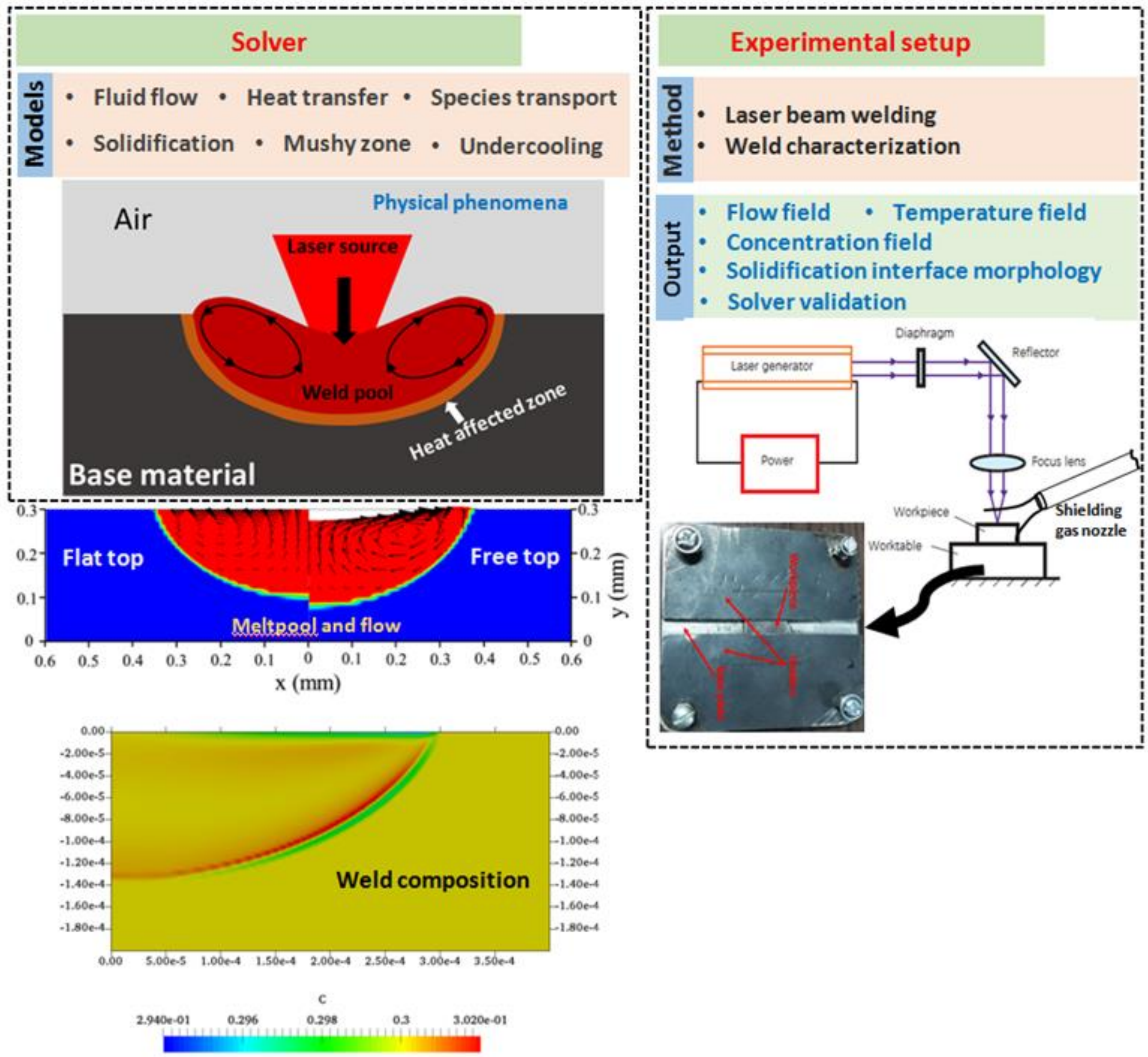


Figure #3: Software tool for laser welding and experimental setup.

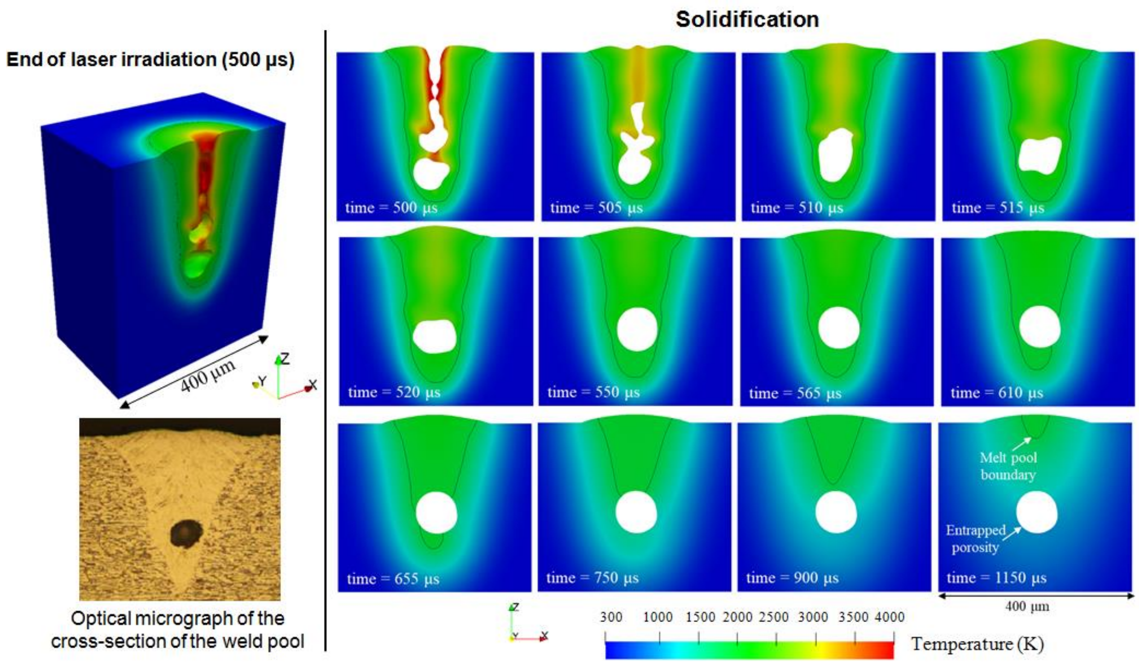


Figure # 4: Trapping of gas cavity and residual porosity formation during stationary laser irradiation of Ti6Al4V. Laser power = 150 W, Beam diameter = 40 μm and Exposure time = 500 μs. Top image at left: at the end of laser exposure. Right images: meltpool and gas cavity dynamics during cooling. Left bottom: as-solidified weld pool. As the gas cavity is very close to the solidification front, it gets captured (610 μs) by the solidifying weld pool front resulting in the formation of a residual porosity (1150 μs). Such porosities degrade the weld quality.

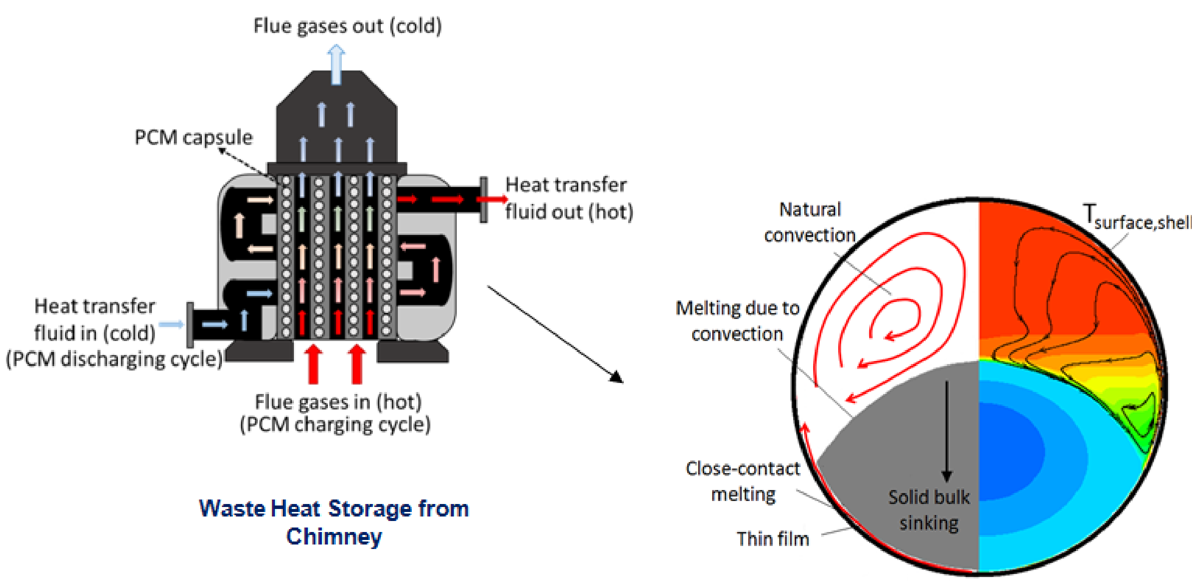


Figure # 5: Fast waste heat recovery from chimney using close-contact charging of nano-enhanced phase change material composite. The physical phenomena of PCM melting during discharging in one of the spherical capsules is shown in the right image.

Experimental Fluid Mechanics Laboratory

Laboratory Coordinator: K. Muralidhar

Associated Faculty Members: Dr(s) Sachin Shinde, P.K. Panigrahi, Pranav Joshi

List of Major Equipment:

- Mach-Zehnder interferometer
- Leica stereomicroscope with computer control
- Ar-Ion laser
- Anton Paar refractometer
- Schlieren and shadowgraph systems
- Stereoscopic PIV
- Micro-PIV with Nd: YAG laser
- Micro-holographic measurement system
- Micro-LIF
- High resolution, color and grey-scale, and high-speed CCD cameras
- Precision digital manometer and selection box
- Several clusters and work stations
- Differential Pressure Transducer and flow meter with data acquisition system
- Syringe pump; Gear pump; Ultra-Sonicator
- Mechanical Stirrer; Centrifuge; Magnetic Particle Separator
- Cardio-flow pumps
- Storagescope, high precision multimeter, spectrum analyzer
- Constant temperature baths; Temperature controllers
- Low speed wind tunnel and a Smoke tunnel

Brief description of the laboratory:

The experimental fluid mechanics laboratory utilizes optical measurement techniques for studying flow and thermal fields in a wide range of multi-physics applications. These include evaporation and condensation, bluff body aerodynamics, jets and wakes, and crystal growth. In recent years, two areas being pursued include biomedical imaging in compliant vasculature and interfacial phenomena including electrowetting. Related applications are in disease modeling and production of potable water from a humid environment. Experimental studies are supplemented with numerical simulation and efforts are on to convert basic understanding into meaningful technologies. Fundamental studies related to droplet coalescence, contact line modeling and blood rheology are jointly in progress. Surfaces of interest are superhydrophobic, hydrophobic with high hysteresis and patterned metallic surfaces. Specific interest is towards resolving three dimensionality in the flow distribution and its consequences.

Laboratory research keywords:

Refractive index-based measurements, PIV imaging of cardiovascular flows, interfacial phenomena and contact line modeling, Effect of substrate curvature on drop spreading, electrowetting and electrically actuated droplets, Evaporative cooling

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	**Contact line dynamics of a water drop spreading over a textured surface in the EWOD configuration -** Modelling the electrowetting process of a liquid droplet placed on a hydrophobic surface in an ambient environment has several challenges over and above those of basic spreading. At an external voltage below the value that causes contact angle saturation, transient spreading is augmented by contact angle reduction defined by the Young-Lippmann equation. In addition, the macroscopic equilibrium contact angle and, therefore, the spreading rate could be altered by the surface hysteresis. Beyond the saturation point, spreading reveals additional features of higher complexity. These details are examined from experiments as well as numerical simulation in the present work. Below the saturation point, the contact angle model developed by the group with the correction related to the electric field is seen to be applicable. Beyond saturation, the experimentally determined instantaneous contact angle distribution shows two distinct functionalities with respect to the contact line velocity. The first prevails from the onset of spreading till the spreading factor attains a peak value. The second trend is initiated with the retraction of the contact line. Except for differences in parametric values, the form of the contact angle model, however, remains unchanged. Simulations in the post-saturation regime are shown to match experimental data in terms of the transient spreading factor, drop shapes, and the instantaneous contact angle. One sponsored project, two doctoral students, four publications, several master's students
2019-2020	**Electrically-driven Continuous Motion of a Liquid Drop on a PDMS-coated Electrode -** Electrically driven continuous motion of a liquid droplet placed on a hydrophobic surface is studied using a single direct current active electrode. While water is mainly the liquid of interest, other liquids such as glycerol, ferrofluids, and a surfactant solution have also been studied. In an experiment, an open electrowetting-on-dielectric (EWOD) configuration is adopted with an active base electrode and a ground wire placed horizontally above but within the drop. Electrohydrodynamic simulations have been carried out in 2D as well as an axisymmetric coordinate system along with a dynamic contact angle model prescribed at the three-phase contact line. Changes in Maxwell's stresses owing to drop deformation and movement are accounted for. With these corrections, experiments and simulations are compared in terms of the interface shapes, contact angles, and instantaneous velocity acquired by the actuated drop and a good match is seen, both, in water and other liquids. Two doctoral students, one post-doctoral fellow, four publications, several Master's students
2018-2019	**Coalescence Characteristics of Liquid Drops on a Hydrophobic Surface with Application to Dropwise Condensation -** Experiments involving two small water drops that are placed adjacent to each other on the hydrophobic surface are of interest in the present work. Pendant and sessile configurations are considered and the resulting coalescence process is imaged using a high-speed camera. The three-phase contact line of the combined drop remains

	unpinned and moves in time, while the liquid bridge relaxes with flow taking place from a region of higher to lower pressure. The digital image sequence is analysed to find the position of the instantaneous centre of mass of the drop, whose movement yields the two velocity components. Instantaneous wall shear rates and stresses are thus estimated and compared for various drop configurations. In the present study, appropriate velocity and timescales associated with coalescence are subsequently incorporated in the mathematical model of dropwise condensation. Coalescence experiments are validated against numerical simulation on a variety of surfaces of distinct texture. Heat transfer rates during coalescence are jointly investigated. Differences arising in the condensation patterns owing to coalescence are seen to significant in terms of the condensation rate and the average heat transfer coefficient. Two sponsored projects, two doctoral students, six publications, several Master's students
2017-2018	**Accelerators for Linear Solvers in 3D CFD with Biomedical Applications –** Acceleration techniques to improve the speedup and performance of the solvers of a linear system of equations generated from an unstructured finite volume formulation have been developed. The goal of the study is to devise strategies that accelerate the solution of the matrix system $A\mathbf{x}=\mathbf{b}$ by understanding the matrix properties from the fluid dynamics and the discretization perspective. Matrix properties of pressure, velocity and temperature reveal that those of velocity and temperature remain well-conditioned with condition number near unity. This important result leads to the development of the proposed $\kappa_{G\sigma}$-BiCGSTAB algorithm. When the condition number of the matrix is close to unity the proposed algorithm facilitates switching of a more expensive preconditioner such as the ILU (0) with SGS leading to an overall reduction in simulation time. For pressure, a modified Poisson's equation is derived where the coefficients of the pressure matrix do not change with the changing non-linear velocity field. The pressure matrix is found to be suitable for computing the expensive but highly parallelizable sparse approximate inverse preconditioner. These improvements have been implemented in the context of biomedical fluid flow including a continuum model for the transport of red blood cells in plasma flow inside micro-scale geometries. Two sponsored projects, one doctoral student, two postdoctoral fellows, four publications, several Master's students
2016-2017	**Determination of mass diffusivity of solutions and sol-gel forming colloidal suspensions using interferometry** - Complex fluids such as colloidal glasses and gels exhibit slow dynamics as they cannot achieve thermodynamic equilibrium over practical timescales. They are known for their hybrid nature, complex electrostatic interactions between particles and time-dependent structural evolution. They have applications as a rheology modifier in paints, petroleum, cement, cosmetics, health care and the pharmaceutical industry. In the present study, an aqueous suspension of Laponite is used a model suspension in which mutual mass diffusion coefficient is experimentally determined. The measurement technique involves the use of interferometry and shadowgraph. Data extraction from optical images forms a part of the study. These techniques have been validated

	from mass transfer experiments involving aqueous solutions of NaCl, KCL, glucose and sucrose. New results have been obtained for mass diffusivity of colloidal suspensions of Laponite RD and Laponite JS in water over a range of concentrations and temperature. These are connected to the microstructural dynamics in the suspension and anisotropy of the oblate shaped nanoparticles. A non-monotonic dependence of binary diffusivity on temperature is explained in terms of competing effects arising from thermal energy of Laponite particles, thermal energy of counterions, and the magnitude of charge on Laponite particles that affect their aggregation rate. Two sponsored projects, two doctoral students, seven publications, several Master's students.
2015-2016	**Pulsatile Flow Hemodynamics in Deformed Vasculatures -** Flow imaging in diseased vascular portions in the physiological range of flow rates is experimentally studied. Dynamic similarity is maintained by matching Reynolds number and Womersley number. A blood mimicking fluid mixture is used as a working medium. Temporal characteristics are explored through tracking a neutrally buoyant tracer particle using Particle Tracking Velocimetry (PTV) technique. Two cameras placed orthogonally obtain three components of velocity traces (u, v and w) within the model. Spatial flow characteristics on the medial plane within diseased vascular models are obtained by the Particle Image Velocimetry (PIV) technique. Pulsatile flow is actuated through a cardio-flow pump which ensures the repeatability of the flow waveform for a large number of cycles. Numerical simulations are performed using a finite volume solver and validate experimental results. Simulations provide an insight of three-dimensionality in flow within the model. The goal of the present study is to determine the distributions of hemodynamic indicators such as wall shear stress, time averaged wall shear stress, and oscillatory shear index and their significance in the progression of arterial disease in the short and the long run. Wall compliance and its impact on weakening the vortex strength have been additionally examined. One sponsored project, two doctoral students, five publications, several Master's students.

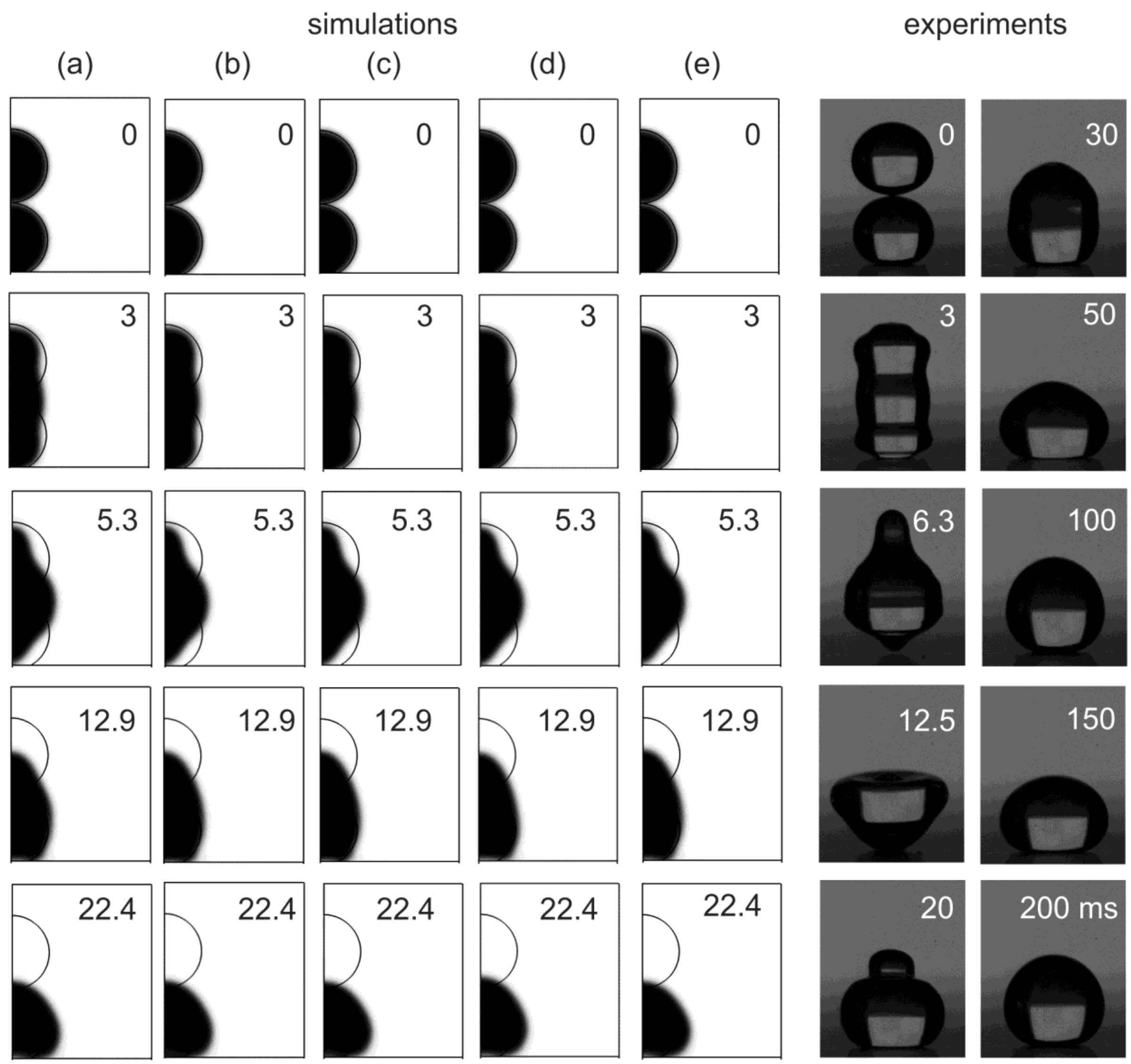
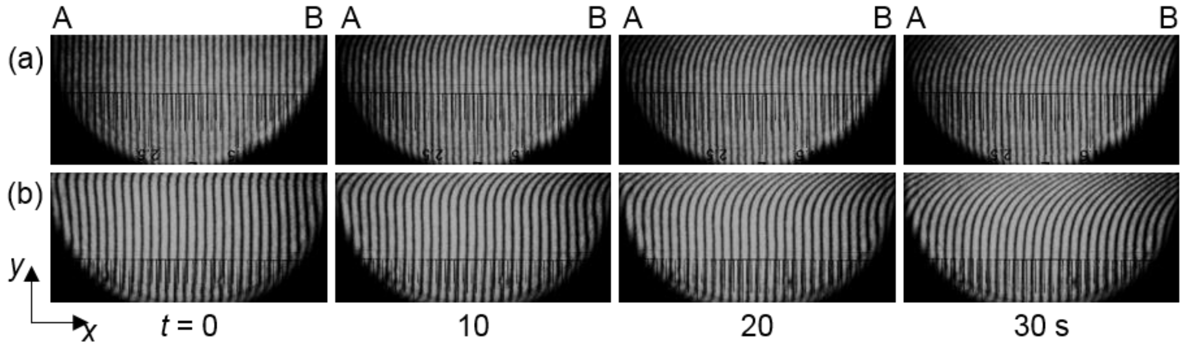


Figure #1: Droplet coalescence Evolution of the simulated interface shapes seen during the coalescence of drops of water using (a) constant contact angle, (b) Bracke et al., (c) Cox (d) Jiang et al., and (e) Kistler models, compared with experiments. Drops are of equal volumes with a combined Bond number of 0.2. The recoil instant is ~ 5.3 ms in simulations and around 6.3 ms in experiments.



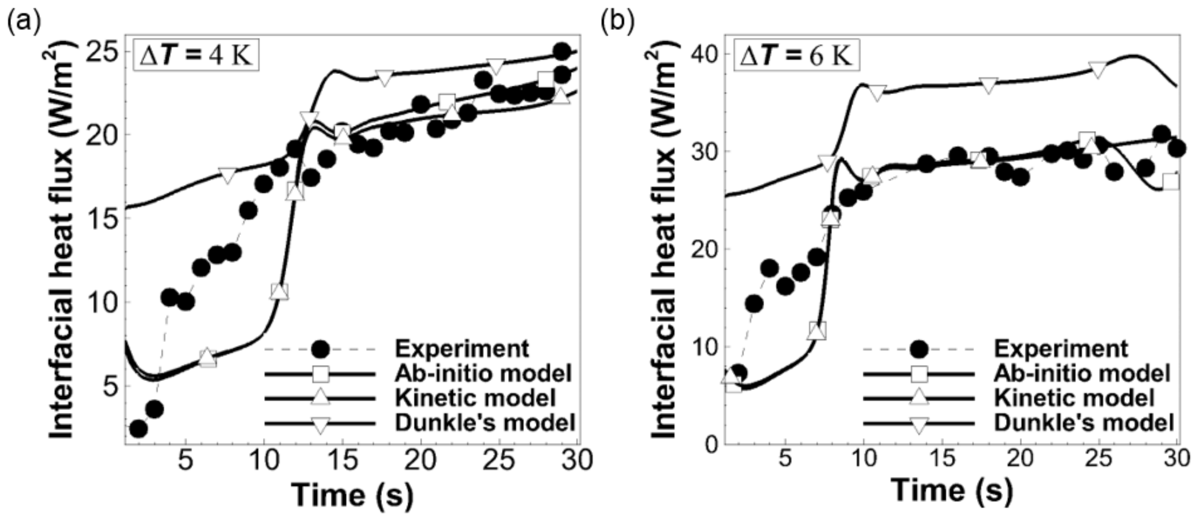


Figure #2: (first row): Evaporative cooling Time-sequence of wedge-fringe interferograms recorded during evaporative cooling of water with the top surface maintained at (a) 294 K (ΔT = 4 K) and (b) 292 K (ΔT = 6 K). The half-filled test cavity and the reference cavity filled with water are initially at 298 K. Both cavities are thermally insulated except the cold surface at the top of the test cavity. Water in the test cavity is filled up to a height of 30 mm while the total cavity height is 60 mm.

Figure #2: (second row): Comparison of the time-dependent average interfacial heat flux obtained from experiments with numerically determined values using three evaporation models. For both experiments and simulations, temperature differences of 4 and 6 K are considered.

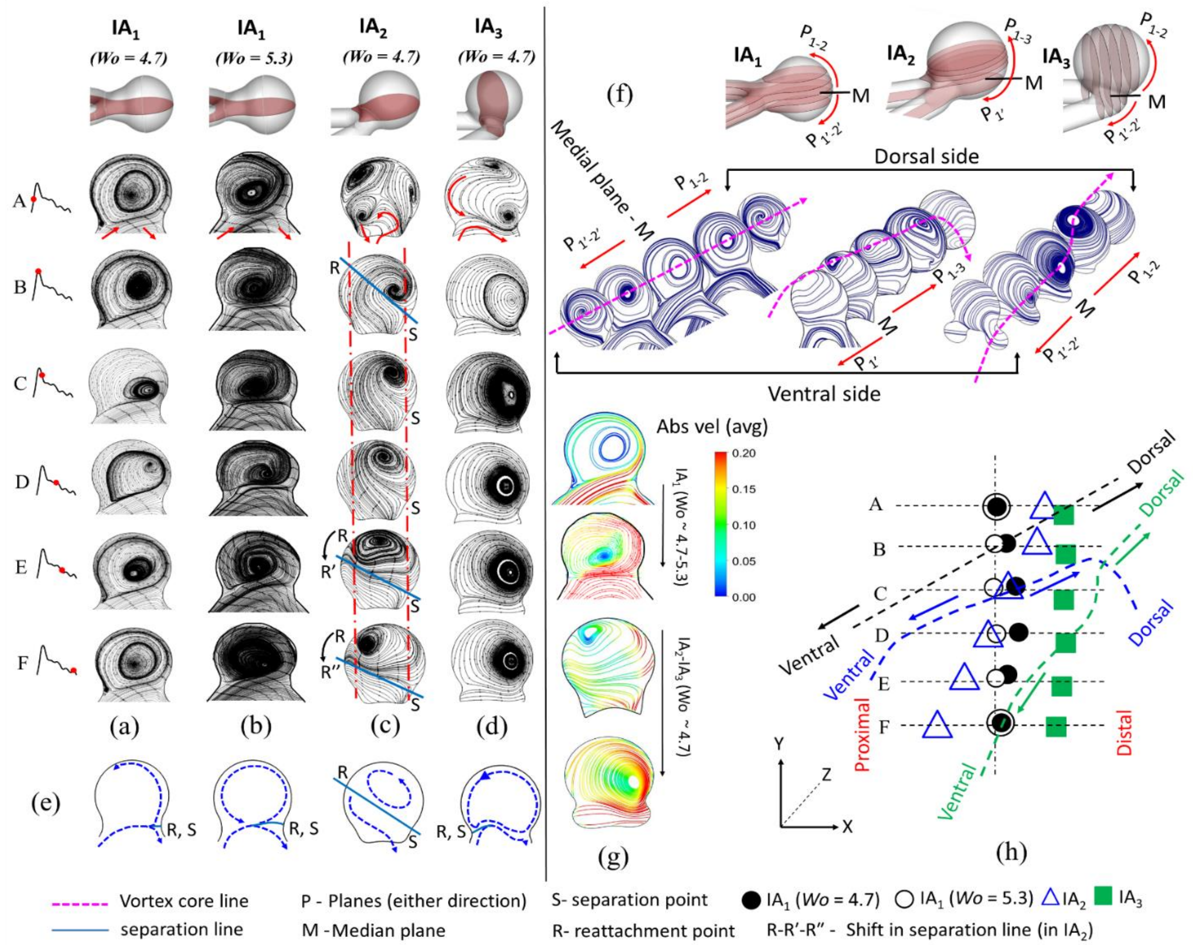
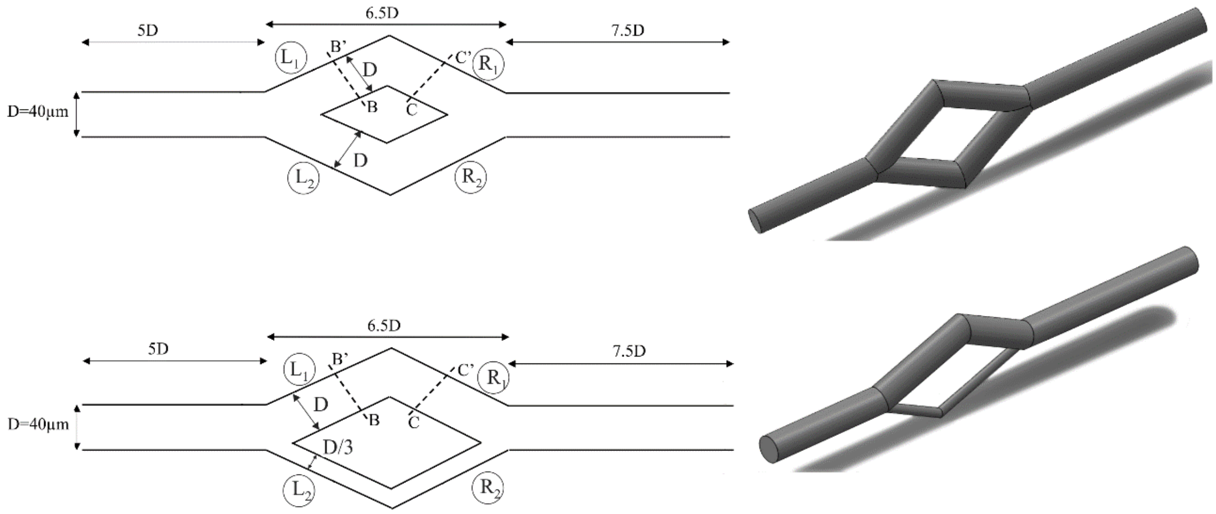


Figure #3: Streamtraces on the medial plane within intracranial models: (a-b) IA_1, (c) IA_2 and (d) IA_3

Figure #3: Biomedical-imaging Streamtraces on the medial plane within intracranial models: (a-b) IA_1, (c) IA_2 and (d) IA_3 at phases A-F of the inflow pulsatile waveform. (a, c, d) are numerical and (b) is from the PIV measurement. Arrows (in red) shown in phase A indicate the directions of inflow and outflow. (e) Schematic drawing of typical streamtraces of the time-averaged flow showing the separation point S, reattachment point R, and the separation line joining them. In (c), the reattachment point is seen to move from R to R' and R'' while the separation point is fixed in all the models and phases. (f) Definitions of planes P_1, P_2, P_3, $P_{1'}$ and $P_{2'}$ parallel to the medial plane M for the three models followed by time-averaged streamtraces within the cycle. (g) Contours of the time-averaged absolute velocity in the three models with the PIV measurement included. (h) Spatio-temporal evolution of vortex cores on parallel planes as in (f), moving from the ventral to the dorsal end.



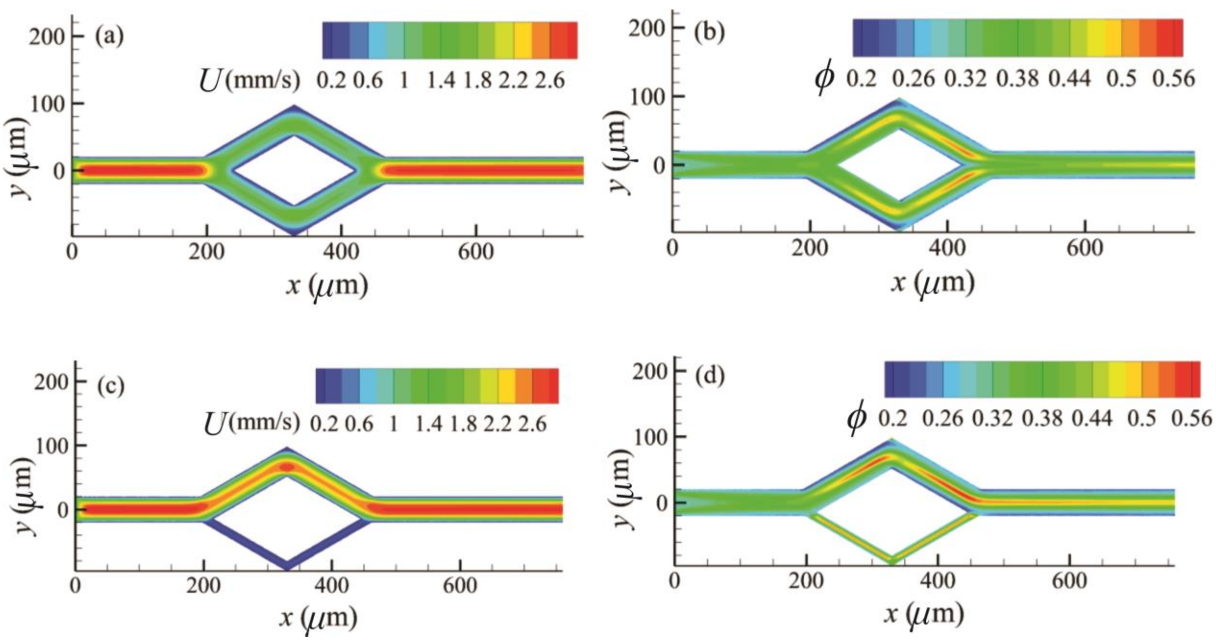


Figure #4: (first row): <u>Blood rheology</u> Layout of tubes with branching selected to demonstrate the Zweifach-Fung bifurcation law. The branching tubes have aspect ratios of 1 and 3 in the geometries above and below respectively.

Figure #4: (second row): Magnitude of the velocity vectors over the mid-plane for aspect ratio (a) *AR*=1 and (c) *AR*=3. RBC concentration over the mid-plane for aspect ratio (b) *AR*=1 and (d) *AR*=3. The average RBC concentration at the inlet is 0.3 while the characteristic shear rate $\bar{\dot{\gamma}} = 40.3\, s^{-1}$ The second row is a confirmation of the Zweifach-Fung bifurcation law which shows that higher concentration of the hematocrit will be realized in the artery of larger diameter.

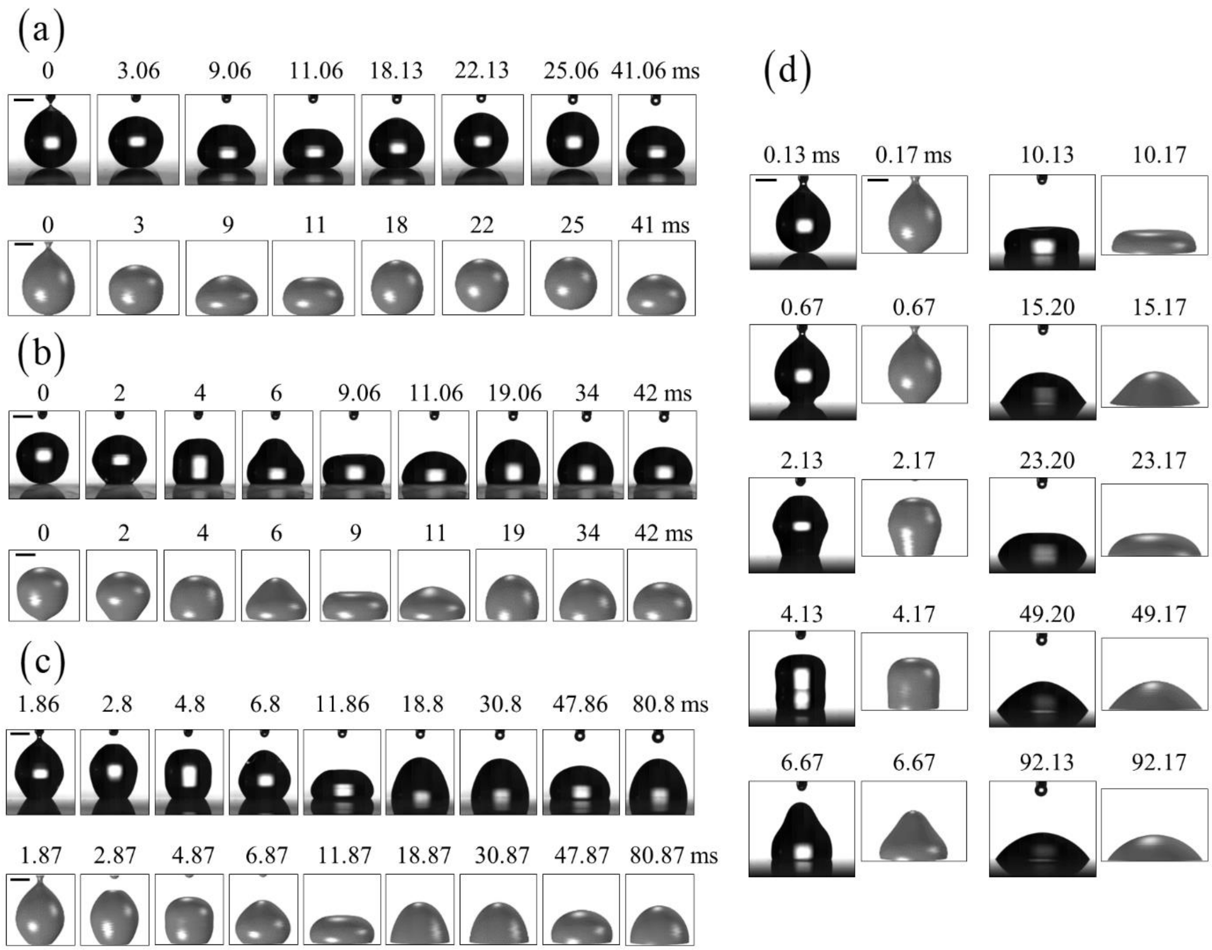


Figure #5: Contact line motion Experiment (black shade) and numerical simulation (grey) of the droplet shape evolution on surfaces of (a) Glaco, (b) FluoroPel, (c) PDMS, and (d) glass. In the numerical simulation, the dynamic contact angle model developed by the group is used as a wetted wall condition. The bars shown in the first image represent a length of 1 mm. The match in terms of the instantaneous drop shapes is seen to be quite good.

Micro-scale Transport Laboratory

Laboratory Coordinator: Dr. P. K. Panigrahi

List of Major Equipment:

- Digital holographic interferometry (DHI)
- Digital holographic microscopy (DHM)
- Micro Particle image velocimetry (μPIV)
- Infrared Thermography (IRT)

Brief description of the laboratory:

In this laboratory, works related to the understanding of processes at microscale are carried out. Evaporation from reservoirs/wells has several applications such as microfluidic cell culture, protein/DNA microarray, micro reactors for chemical synthesis, point of care diagnostics and biological lab on chip devices, protein crystallization etc. Internal hydrodynamics as well as vapor phase transport of an evaporating body are studied using various optical techniques. Micro particle image velocimetry technique is utilized for velocity measurement inside the droplet, microchannel etc. Techniques such as Digital holography which is capable of providing instantaneous three-components of fluid flow velocity (3D-3C) using a single camera is utilized for the velocity measurement. Digital holographic interferometry is used for the non-intrusive measurement of temperature. The work on development of high heat flux electronic cooling system using electrohydrodynamic based atomization (Electrospray) and propulsion (Ionic wind) is another focus of our laboratory.

Laboratory research keywords:

Holography, Micro PIV; Micro fluidics, Protein crystallization, Interferometry, High Heat flux cooling, Corona wind, Electrospray, Magneto-hydrodynamics, Electro-hydrodynamics

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	*A hybrid cooling system using combined electrospray and corona wind has been designed, fabricated and tested in our lab. The cooling system is light weight, cheap and requires less coolant flow compared to the other existing technologies. The system can be used in several applications i.e., high heat flux electronics, data center and other manufacturing industries.* **Patent**: 1, **Journals**: 4 (i) Digvijay Shukla, M. K. Sharma and P. K. Panigrahi, " Hybrid electrospray and ionic wind-based thin-film evaporative cooling system for thermal management applications ", **Indian Patent Filed** (ii) Digvijay Shukla. Bal Krishan Mishra and P K Panigrahi "Digital holographic study of corona wind assisted evaporation of hydrocarbon from a microliter well", **Applied Physics B,** 128, 123 (2022)

	(iii) Digvijay Shukla and P K Panigrahi, "Interaction of vapor cloud and its effect on evaporation from microliter coaxial well", **Colloids and Surfaces A: Physicochemical and Engineering Aspects,** Vol. 629, 20, 127391(2021) (iv) Sunil K. Saroj, Pradipta Kumar Panigrahi, "Magnetophoretic control of diamagnetic particles inside an evaporating droplet", **Langmuir,** 37, 51, 14950–14967 (2021) (v) Tapan K. Pradhan, and Pradipta Kumar Panigrahi, "Vapor mediated interaction of two condensing droplets", **Colloids and Surfaces A: Physicochemical and Engineering Aspects,** Vol 608, 125555, (2021)
2019-2020	*The data analysis tool for estimation of vapor cloud concentration over an evaporating liquid pool using holographic measurements has been developed. The detailed microscale characterization carried out in our laboratory has proposed several designs for fabrication of superior quality protein crystal.* **Journals**: 3 (i) Digvijay Shukla, Pradipta Kumar Panigrahi, "Digital Holographic Interferometry Investigation of Liquid Hydrocarbons Vapor Cloud Above a Circular Well", **Applied Optics,** Vol 59, No. 19, 5851 (2020) (ii) Tapan K. Pradhan, and Pradipta Kumar Panigrahi, "Suppressing internal convection of a droplet using confinement during protein crystallization", **Journal of Applied Physics,** Vol 128, 084701, (2020) (iii) Sunil K. Saroj, Pradipta Kumar Panigrahi, "Magnetic suppression of the coffee ring effect", **Journal of Magnetism and Magnetic Materials,** Vol 513, 167199 (2020)
2018-2019	*The laboratory has proposed and demonstrated several designs using magnetic field for controlled deposition pattern of particle on surfaces. The magnetophoretic based deposition pattern control proposed in the manuscript can find application in several interdisciplinary subjects i.e., micropatterning, inkjet printing, fabrication of micro or nanostructures, DNA/RNA micro-arrays deposition, forming templates on solid surfaces, biochemical assays etc.* **Journals**: 2 (i) Sunil K. Saroj, Pradipta Kumar Panigrahi, "Drying pattern and evaporation dynamics of sessile ferrofluid droplet on a PDMS substrate", **Colloids and Surfaces A,** Vol. 580, pp. 1-13 (2019) (ii) Sunil K. Saroj, Pradipta Kumar Panigrahi, "Effect of salt concentration (NaCl) on drying pattern of ferrofluid droplets", **Journal of Flow Visualization and Image Processing,** Vol. 25, pp. 245-258 (2018)
2017-2018	**Journals**: 3 (i) Tapan Kumar Pradhan and Pradipta Kumar Panigrahi "Convection inside a condensing and evaporating droplet of aqueous solution", **Soft Matter,** Vol. 14, pp. 4335-4343 (2018)

	(ii) Tapan Kumar Pradhan and Pradipta Kumar Panigrahi "Hydrodynamics of two interacting liquid droplets of aqueous solution inside a micro-channel", **Langmuir,** Vol. 34, pp. 4626-4633 (2018) (iii) Tapan Kumar Pradhan and Pradipta Kumar Panigrahi "Evaporation induced natural convection inside a droplet of aqueous solution placed on a superhydrophobic surface", **Colloids and Surfaces A: Physicochemical and Engineering Aspects,** Vol. 530, pp. 1-12 (2017)
2016-2017	**Journals**: 3 (i) Tapan Kumar Pradhan, Pradipta Kumar Panigrahi "Evaporation-induced natural convection of a liquid slug of binary mixture inside a microchannel: effect of confinement", **Microfluidics and Nanofluidics,** Vol. 20, pp. 115 (2016) (ii) Sunil Kumar Saroj, Mohammed Asfer, Aman Sunderka, Pradipta Kumar Panigrahi "Two-fluid mixing inside a sessile micro droplet using magnetic beads actuation" **Sensors and Actuators A: Physical,** Vol. 244, pp. 112-120 (2016) (iii) Tapan Kumar Pradhan, Pradipta Kumar Panigrahi "Influence of an adjacent droplet on fluid convection inside an evaporating droplet of binary mixture" **Colloids and Surfaces A: Physicochemical and Engineering Aspects,** Vol. 500, pp. 154-165 (2016).
2015-2016	**Journals**: 3 (i) Tapan K Pradhan and P K Panigrahi "Thermo-capillary convection inside a stationary sessile water droplet on a horizontal surface with an imposed temperature gradient", **Experiments in Fluids,** Vol. 56, 178 (2015). (ii) Tapan K Pradhan and P K Panigrahi "Deposition pattern of interacting droplets", **Colloids & Surfaces A: Physicochemical & Engineering Aspects,** Vol. 482, pp. 562-567 (2015). (iii) Singh Dhananjay Kumar and Panigrahi P. K." Three-Dimensional Investigation of Liquid Slug Taylor Flow Inside a Micro Capillary Using Holographic Velocimetry", **Experiments in Fluids,** Vol. 56:6, pp. 1-15 (2015).

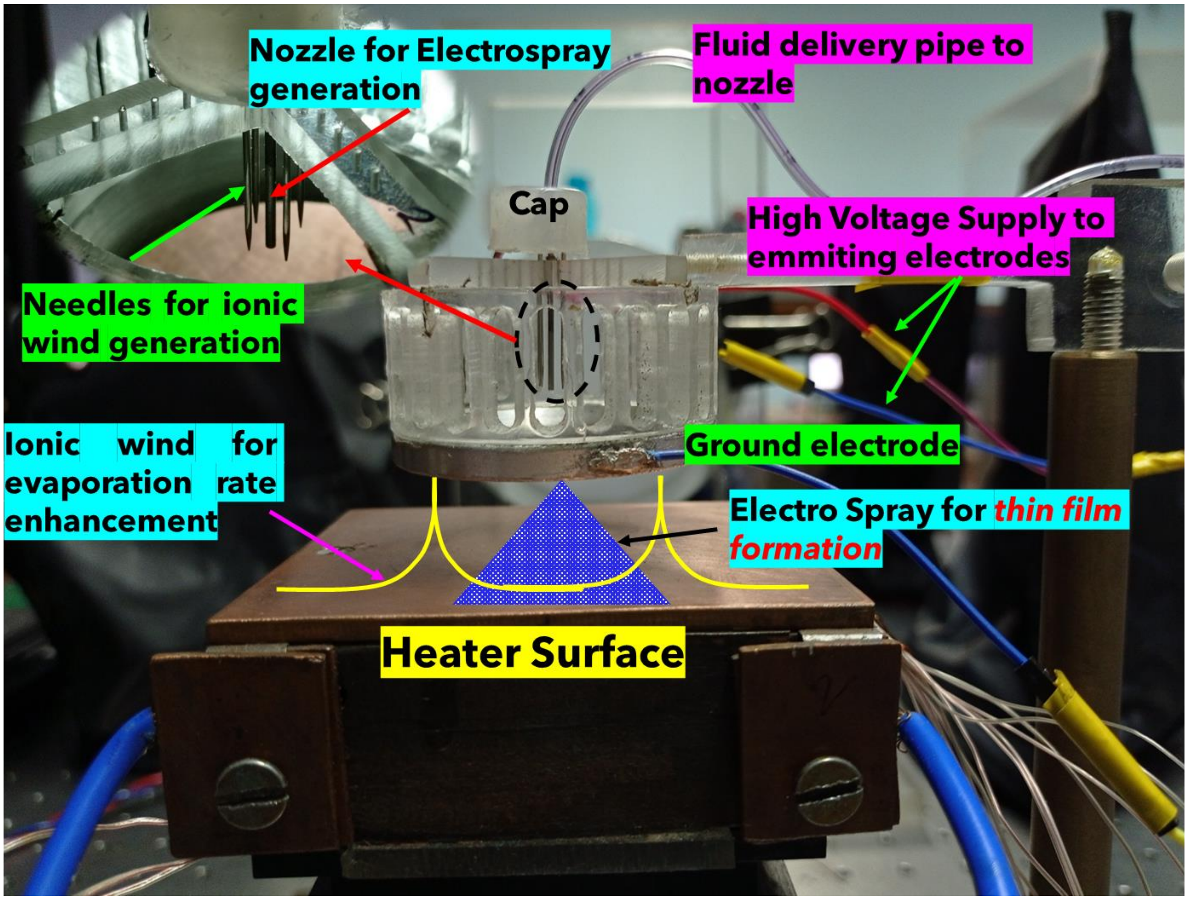


Figure #1: Snapshot of the hybrid electrospray (ES) and ionic wind (IW) based thin film evaporative cooling system for the thermal management of electronic components. Results indicates the effectiveness of hybrid mode where superior heat transfer performance is observed compared to existing techniques. This can be attributed to the utilization of **thin film-based evaporation mechanism**, where thin film of liquid is created using **Electrosparying** and **Ionic wind** jet enhances the evaporation from thin film due to two phase heat transfer technique.

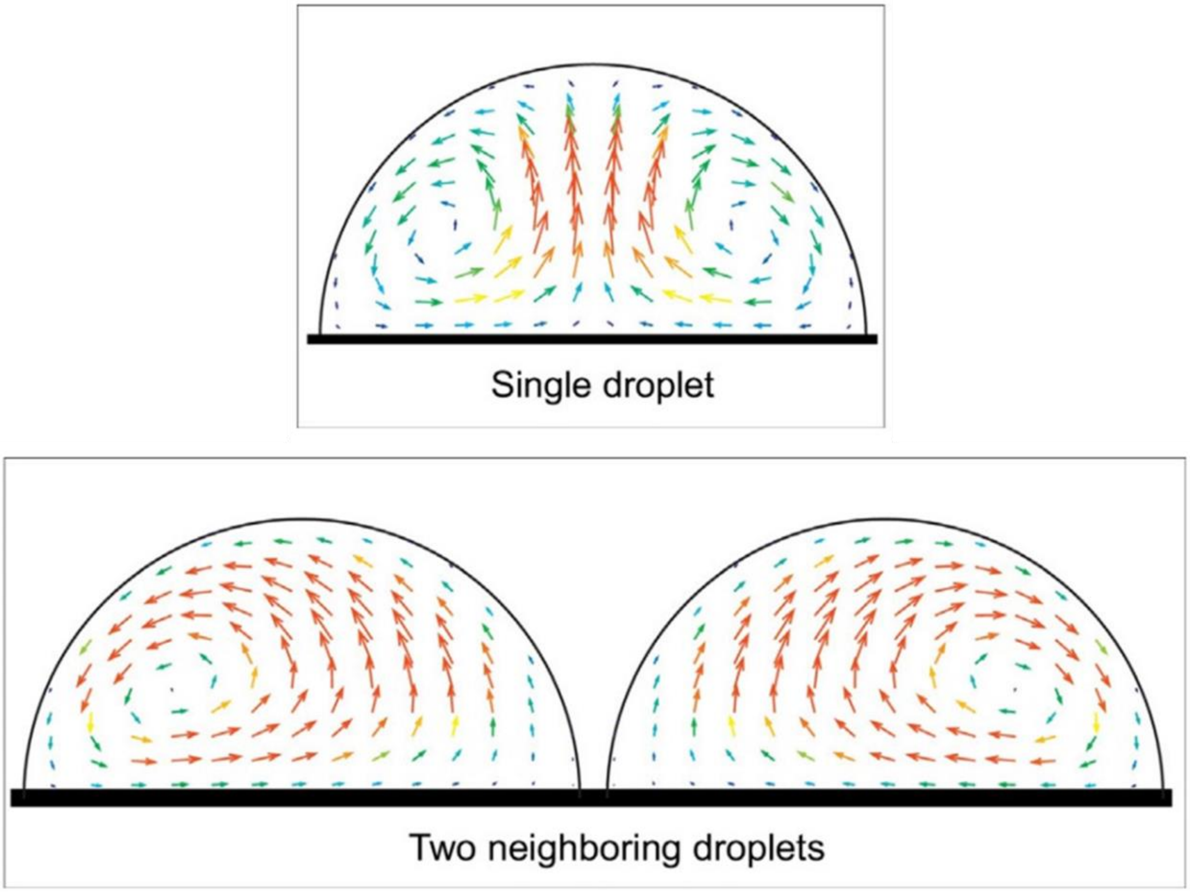


Figure #2: Interaction between droplets plays crucial role in several applications i.e., droplet coalescence, digital microfluidics, dropwise condensation, protein crystal growth by vapor diffusion method and surface coating etc. where droplets are surrounded by other droplets. Velocity filed inside the evaporating droplets is captured using **Micro PIV technique**. Single droplet shows a symmetrical flow pattern with two recirculating bubbles. This behaviour is attributed to the symmetric evaporative flux distribution on the droplet surface. Presence of another droplet changes the evaporative flux distribution and results in asymmetric concentration field inside the droplet.

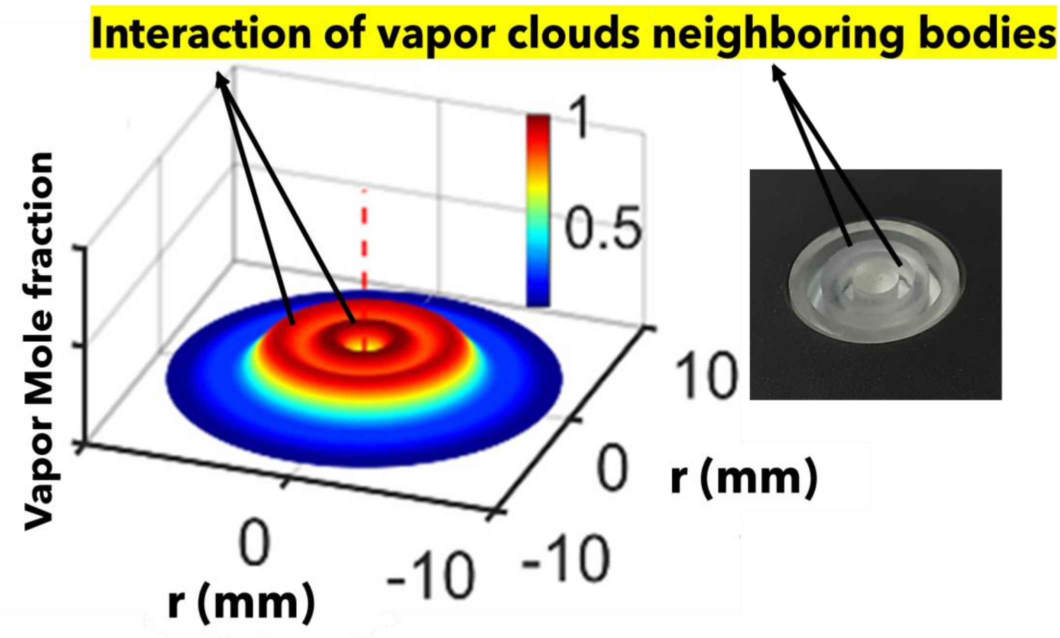


Figure #3: Presence of an adjacent evaporating body (i.e., droplet/ well cavity) leads to asymmetric evaporative flux distribution on the droplet surface **due to the influence of the neighbouring droplet on the free stream mass fraction**. The vapor phase transport from evaporating co-axial microliter wells is presented. **Digital holographic Interferometry** is used to decipher the vapor mole fraction field above the coaxial well. Normalized Vapor cloud mole fraction distribution at liquid vapor interface of hexane evaporating from coaxial cavity at the initial time period (t = 0 + (s)) is shown in the figure. Vapor cloud interactions of microliter volume coaxial cavities can influence the evaporation rate of individual coaxial cavity and the convection inside the liquid phase. The present study demonstrates the capability to precisely control the evaporation process by appropriate design of coaxial well.

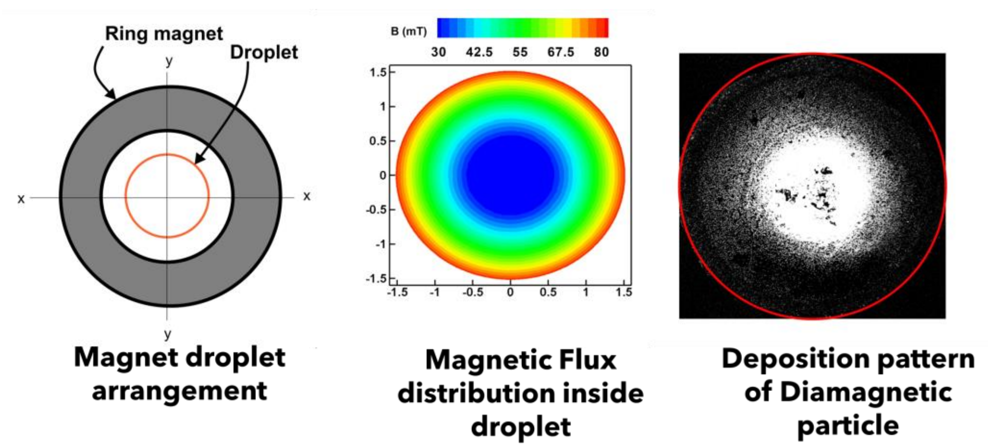


Figure #4: Negative magnetophoretic effect on nonmagnetic particles in the ferrofluid droplet during evaporation is presented. The selective deposition of the diamagnetic particles at the contact line and center of the droplet is obtained by controlling the particle motion inside the droplet. In the absence of the magnetic field, there is a coffee-ring formation and the diamagnetic particles. Magnetic particles travel toward the higher magnetic field zone and diamagnetic particles move toward the smaller magnetic field zone when a magnetic field is applied by a solid magnet placed over the droplet. The deposition behavior can be reversed or suppressed using a ring magnet. In this case, the negative magnetic force is stronger at the contact line region of the droplet and decreases as it approaches the center region of the droplet. Therefore, deposition pattern can be controlled with the help of the magnetic field, which can be useful in many applications i.e., manufacturing and biotechnology.

Fabrication/Manufacturing Graduate Research Laboratory

Laboratory Coordinator: Dr. J. Ramkumar

List of Major Equipment:

- Micro fabrication using electrochemical spark
- Abrasive Jet Machining (AJM)
- Electrochemical Machining(ECM)
- Abrasive Flow Finishing Machine (AFM)
- Universal Rotational Abrasive Flow Finishing (UR-AFF)
- Magnetic Abrasive Flow Finishing (MAF)
- Magneto Rheological abrasive flow finishing (MRAFF)
- Rotational Magneto Rheological abrasive flow finishing (RMRAFF)
- Magneto Rheological Fluid based Nano finishing of Flat and Free form Surface (RMRAFF).

Brief description of the laboratory:

Micro manufacturing Lab is a part of Manufacturing Science Lab situated in the Northern Labs in the Department of Mechanical Engineering. In this lab, research is conducted on different advanced manufacturing processes with a special focus on developing new and industrially viable manufacturing and finishing techniques for micro-fabrication. Ongoing research in the lab is focused primarily on processes such as: Laser Beam Machining, Abrasive Flow Finishing, Electrochemical Machining, Electric Discharge Machining, and Electrochemical Polishing. At present, we are working on addressing problems such as: internal finishing and selective boring of thin-walled tubes, developing cost-effective, quick, and industrially viable technique for large surface area texturing, productivity enhancement in Electric Discharge Machining process, incremental metal forming techniques for thin sheets, and porosity estimation and removal of parts printed using selective laser sintering process.

Laboratory research keywords:

Micro fabrication; Electrochemical machining; Texturing; Sintering; Forming; Finishing; Hybrid Machines; Design and Fabrication.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	Designed and developed an experimental setup for large surface area texturing using Wire Electrochemical Micromachining. A methodology is proposed for generating micro-pillars on a flat metallic surface using wire as a tool. **Funding agency:** Department of Science and Technology, Govt. of India.
2019-2020	Designed and developed an experimental setup for generating texture on flat, cylindrical, spherical, and freeform surface using electrochemical micromachining. For this, a flexible tool is also developed (patented) which adapts to any shape / contour of the surface to be processed. **Funding agency:** Indian Space Research Organization (ISRO), Govt. of India.
2018-2019	Designed and developed an experimental setup of wire electrochemical machining for generating macro and micro threads on conducting materials. **Funding agency:** Department of Science and Technology, Govt. of India.
2017-2018	Developed an experimental setup of wire electric discharge machining for micromachining operations such as slitting, profiling, grooving, and texturing. **Funding agency:** Deptt. of Science and Technology, Govt. of India.
2016-2017	Developed an experimental facility for Laser Beam Machining. SPI fiber laser (CW Fiber Laser – 200w – redPOWER® R4) was installed. Study was performed to understand the melt-pool hydrodynamics in case of deep hole drilling using pulsed laser beam. **Funding agency:** Deptt. of Science and Technology, Govt. of India.
2015-2016	Designed and developed an experimental setup for Rotational Magneto Rheological abrasive flow finishing process. This process is capable of finishing a freeform surface and roughness in few nanometers can be obtained. A replica of knee joint was fabricated and was polished using this process. **Funding agency:** Defense Research and Development Organization, Govt. of India.

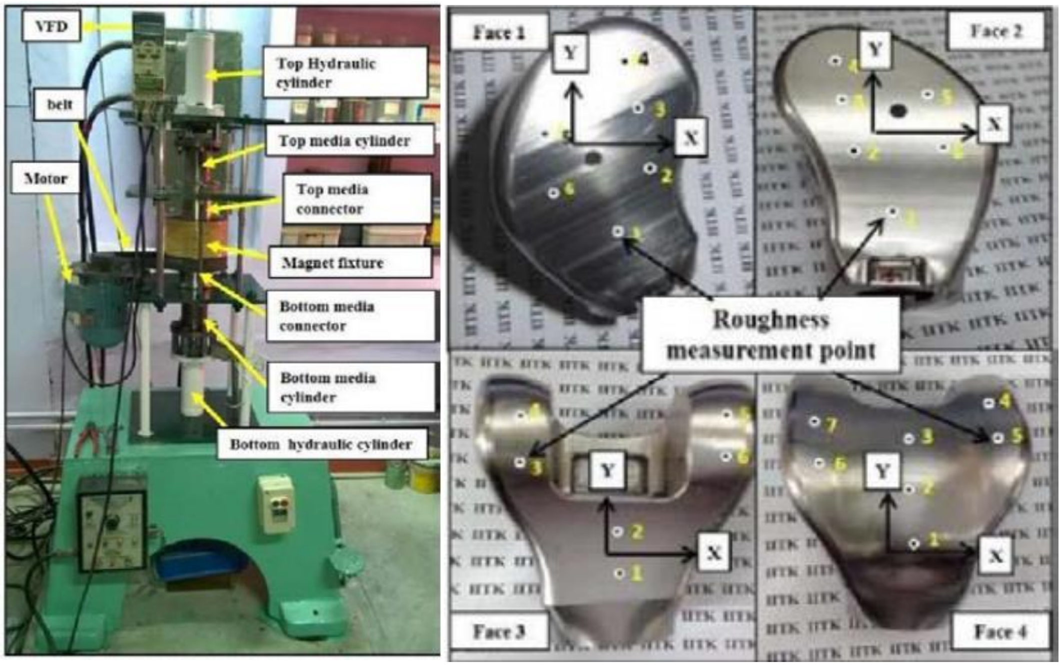


Figure #1: (a) Rotational Magneto Rheological abrasive flow finishing set up and points on four different faces of the component.

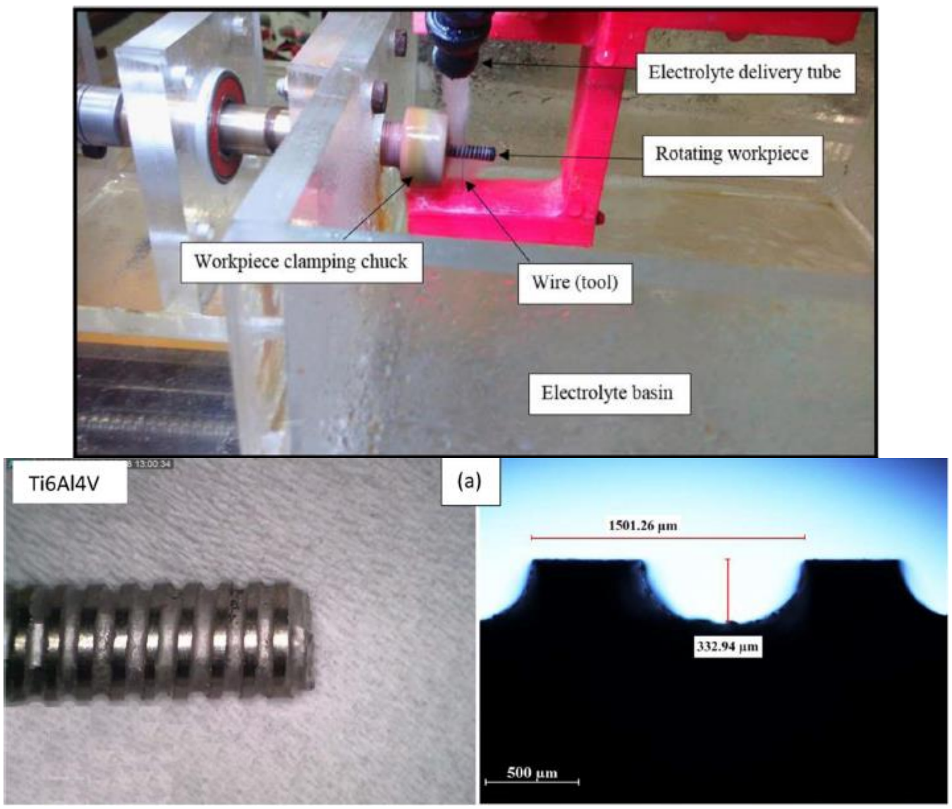


Figure #2: Experimental setup developed for electrochemical micro threading and generated threads.

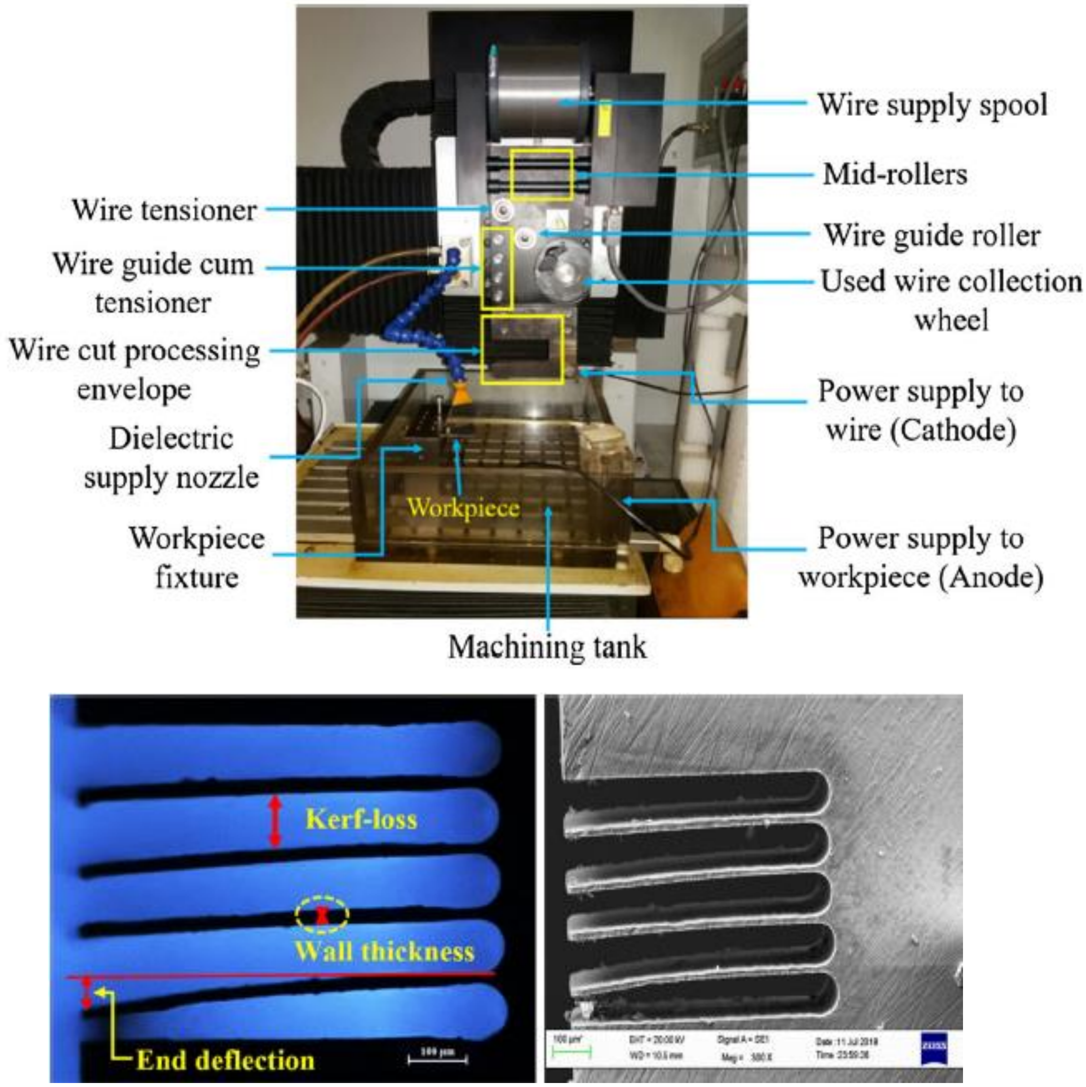


Figure #3: Experimental setup for wire electric discharge machining and generated slits.

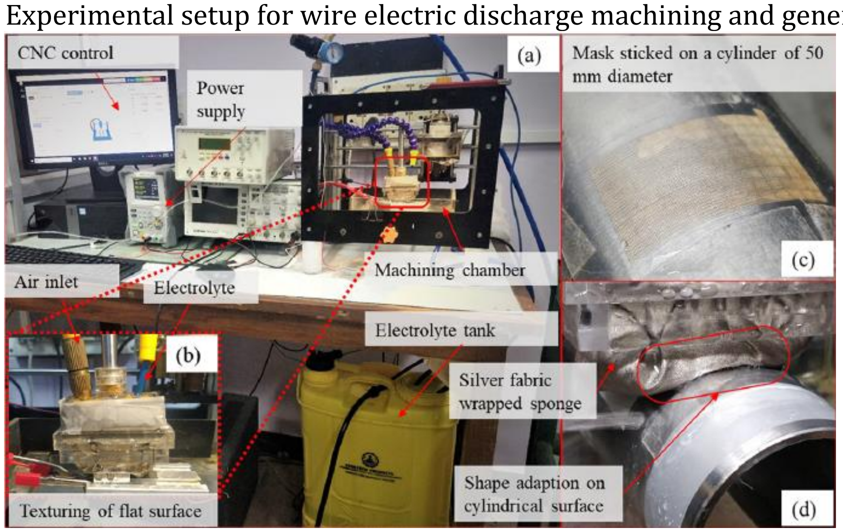


Figure #4: Experimental setup of electrochemical machining for texturing on a curved surface using a flexible electrode.

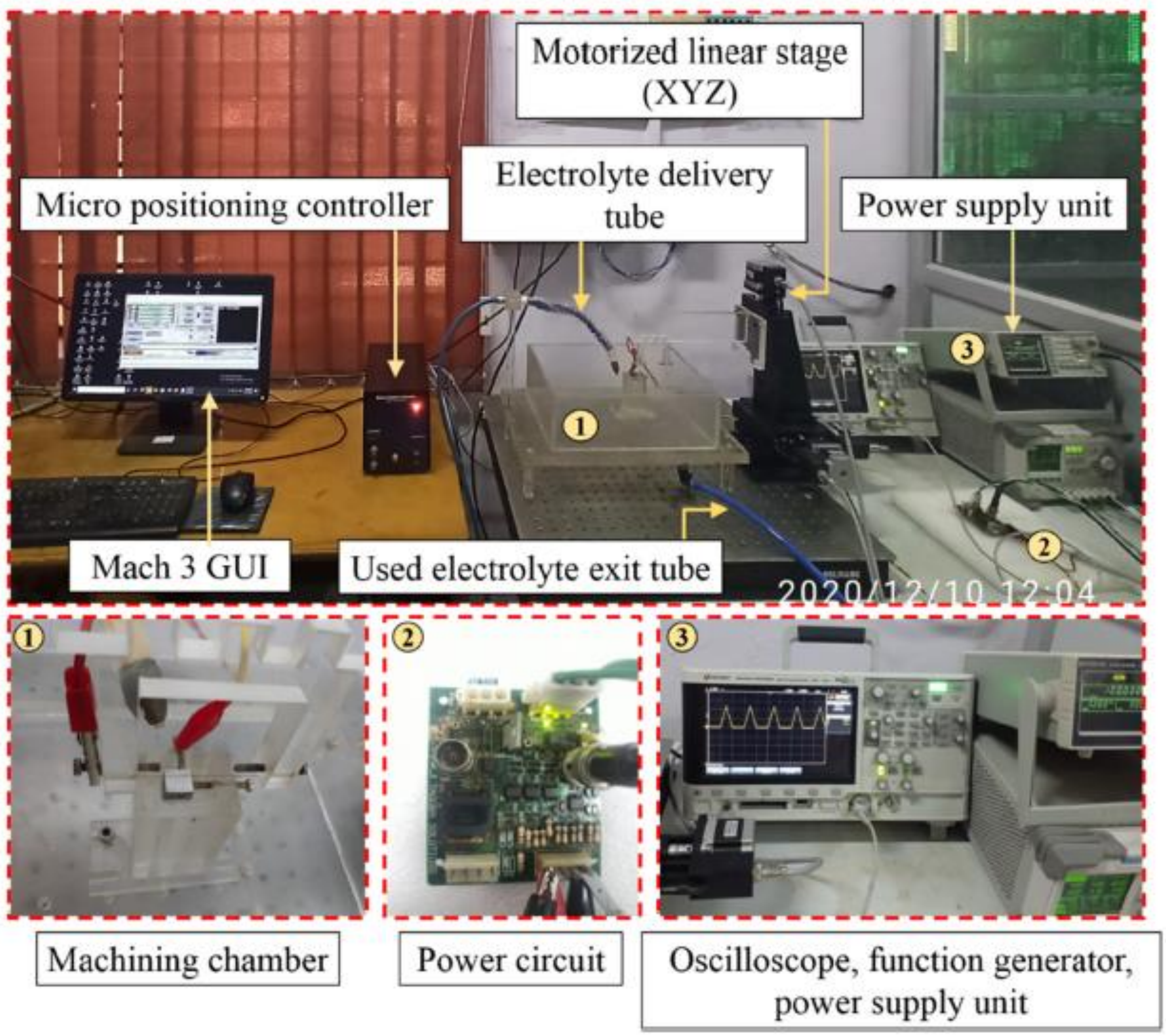


Figure #5: Experimental setup for large surface area texturing using wire electrochemical micro-machining process.

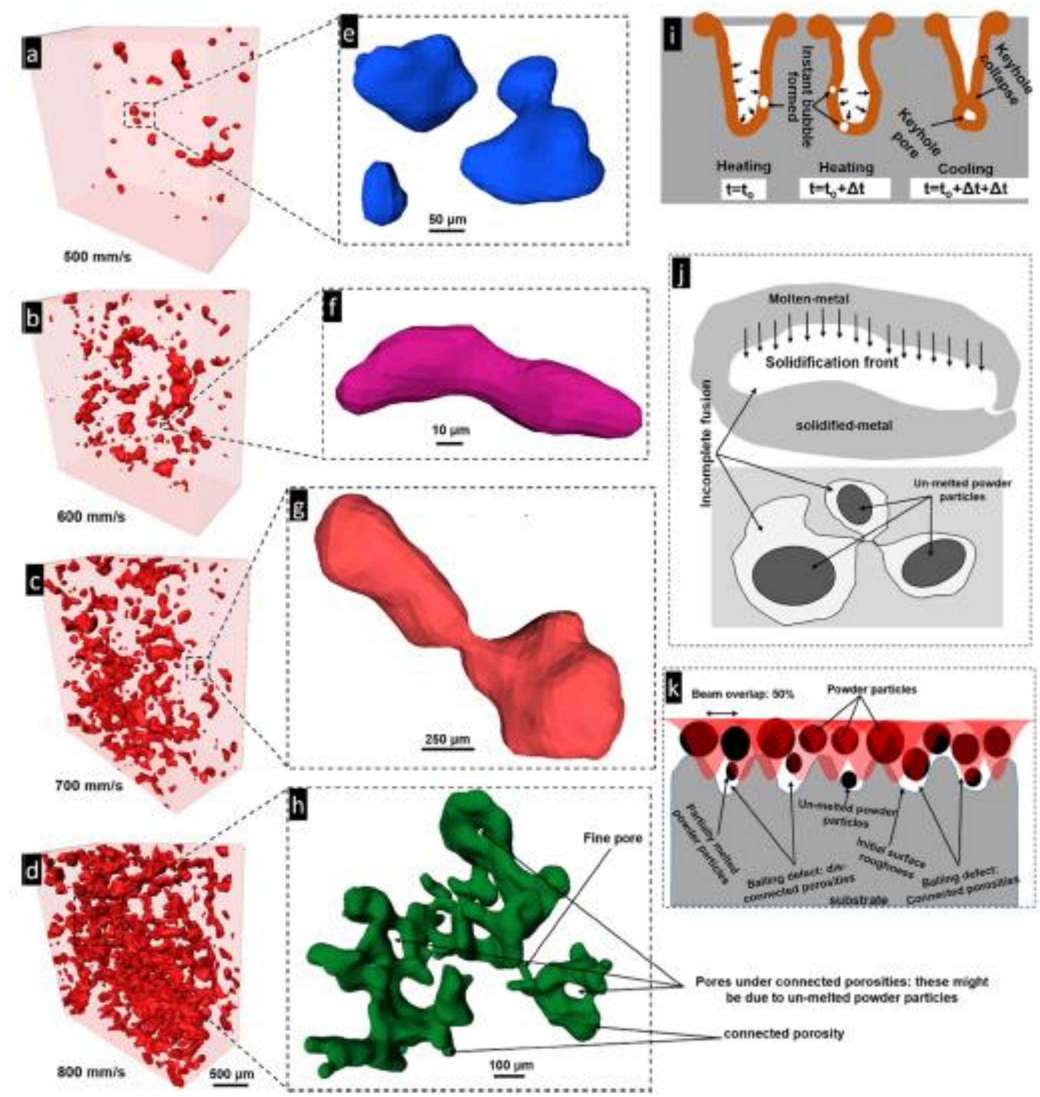


Figure #6: 3D rendering of porosities, obtained from XRT, in the fabricated samples with varying scanning speed of (a) 500 mm/s, (b) 600 mm/s, (c) 700 mm/s, and (d) 800 mm/s. Illustration of different types of porosities, such as (e) key hole, (f) incomplete fusion, (g) dis-connected porosity, and (h) connected porosity. Schematics illustrating the mechanisms of formation of porosities: (i) key hole, (j) incomplete fusion and (k) dis-connected and connected porosity.

Gas Turbine Heat Transfer Laboratory

Laboratory Coordinator: Dr. A. K. Saha

List of Major Equipment:

- IR Camera
- High Speed Blower
- High Speed Camera
- Shadowgraph/Schlieren Setup
- Multiple Cameras, Laser as light-source, Optical quality mirror.
- Laser Doppler Velocimetry (LDV)
- Laser Induced Fluorescence (LIF)
- Hot-wire Anemometry, Load-Cell
- Constant Temperature Water Bath
- Rotating Test Rig

Brief description of the laboratory:

Heat transfer laboratory caters for the research in gas turbine application, fundamentals of heat transfer and flow physics. The IR thermography and Schlieren systems are the two most important equipment that help in getting spatial distribution of heat transfer unlike the thermos-couple which provides point measurements. The rotating test rig is another facility that helps in getting the convective heat transfer co-efficient under rotating conditions.

Vayu, a parallel cluster machine used in our laboratory for high-fidelity simulations of flow and heat transfer over an array of bluff bodies.

Laboratory research keywords:

IR thermography; Schlieren system; Rotating test rig

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	The enhancement of heat transfer from a rib-roughened surface under rotating conditions has been carried out at various Reb and Rotation numbers. The effect of rib geometry and duct aspect ratio is also studied. Fluid flow measurement in a convectively cooled plate using a synthetic jet with the help PIV is being carried out. Computation of heat transfer enhancement from an array of heated bodies mounted on a wall is carried out at high Reynolds number using the parallel cluster machine. Three-dimensional simulation of head-on and off-center collision of two miscible liquid drops is performed to see the effect of drop inertia and impact parameters on flow characteristics, energy budget and mixing index using a parallel clustered machine.
2019-2020	The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken at various Reynolds number

	and Rotation numbers. Fluid flow measurement in a convectively cooled plate using a synthetic jet with the help PIV is being carried out. Computation of heat transfer enhancement from an array of heated bodies mounted on a wall is carried out at high Reynolds number using the parallel cluster machine. Computation of coalescence of two drops of different liquid properties is conducted to investigate the influence of surface tension gradients on partial coalescence process.
2018-2019	The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various rib geometries and duct aspect ratio. Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re using the parallel cluster machine. Simulations are performed to examine the behavior of physical properties of surrounding liquid as well as the drop liquids in various pinch-off regimes during coalescence of two unequal-sized drops.
2017-2018	The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various rib geometries and duct aspect ratio. Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re using the parallel cluster machine. The mechanism of heat transfer between solid and liquid surfaces has been analysed using oblique high-speed cold micro-sized drop impact on a hot liquid film with variations in impact velocity, impact angle and liquid film thickness.
2016-2017	The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various flow velocities. Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re using the parallel cluster machine. The mechanism of heat transfer between solid and liquid surfaces has been analysed using normal high-speed cold micro-sized drop impact on a hot liquid film with variations in impact velocity and liquid film thickness.
2015-2016	The enhancement of heat transfer from a rib-roughened surface under stationary conditions has been undertaken for various rib geometries and duct aspect ratio. Computation of heat transfer enhancement from a heated body mounted on a wall is carried out at high Re number using parallel cluster machine. The mechanism of heat transfer between solid and liquid surfaces has been analysed using normal high-speed cold micro-sized drop impact on a hot liquid film with variations in impact velocity and liquid film thickness.

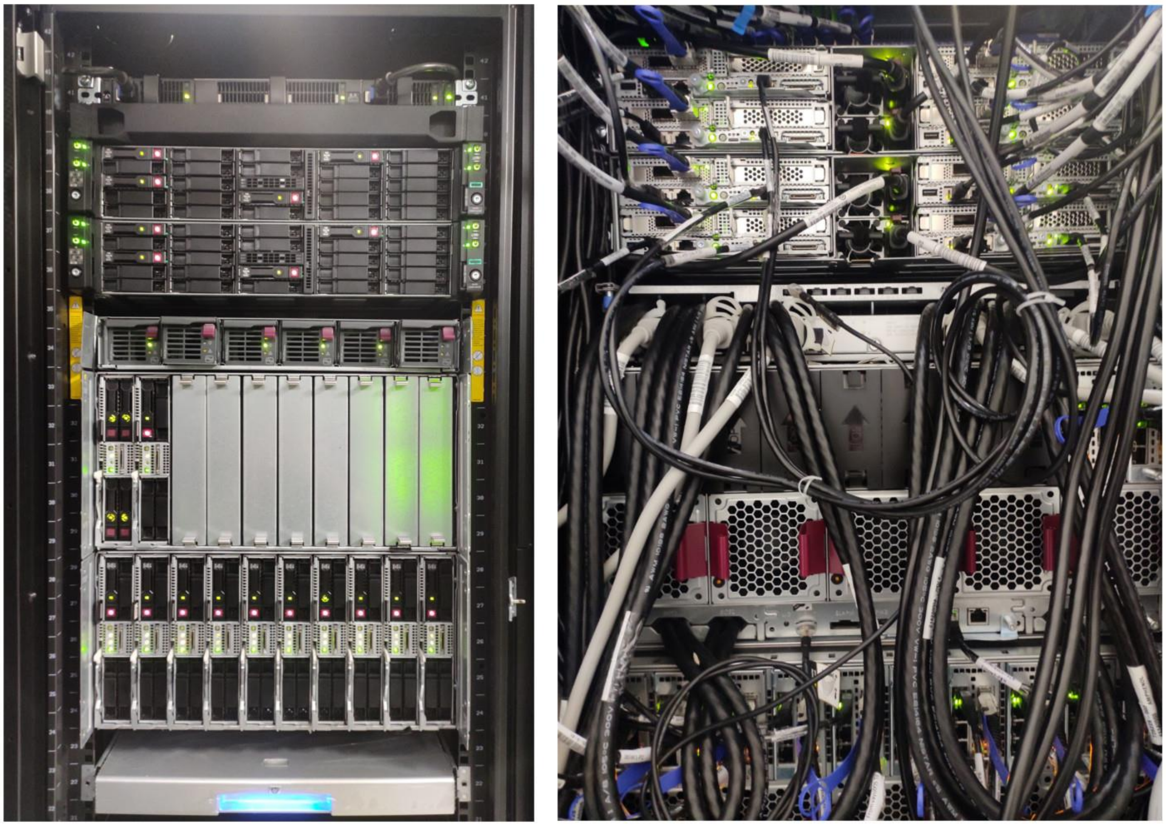


Figure #1: *Vayu*, a parallel cluster machine used for high-fidelity simulations.

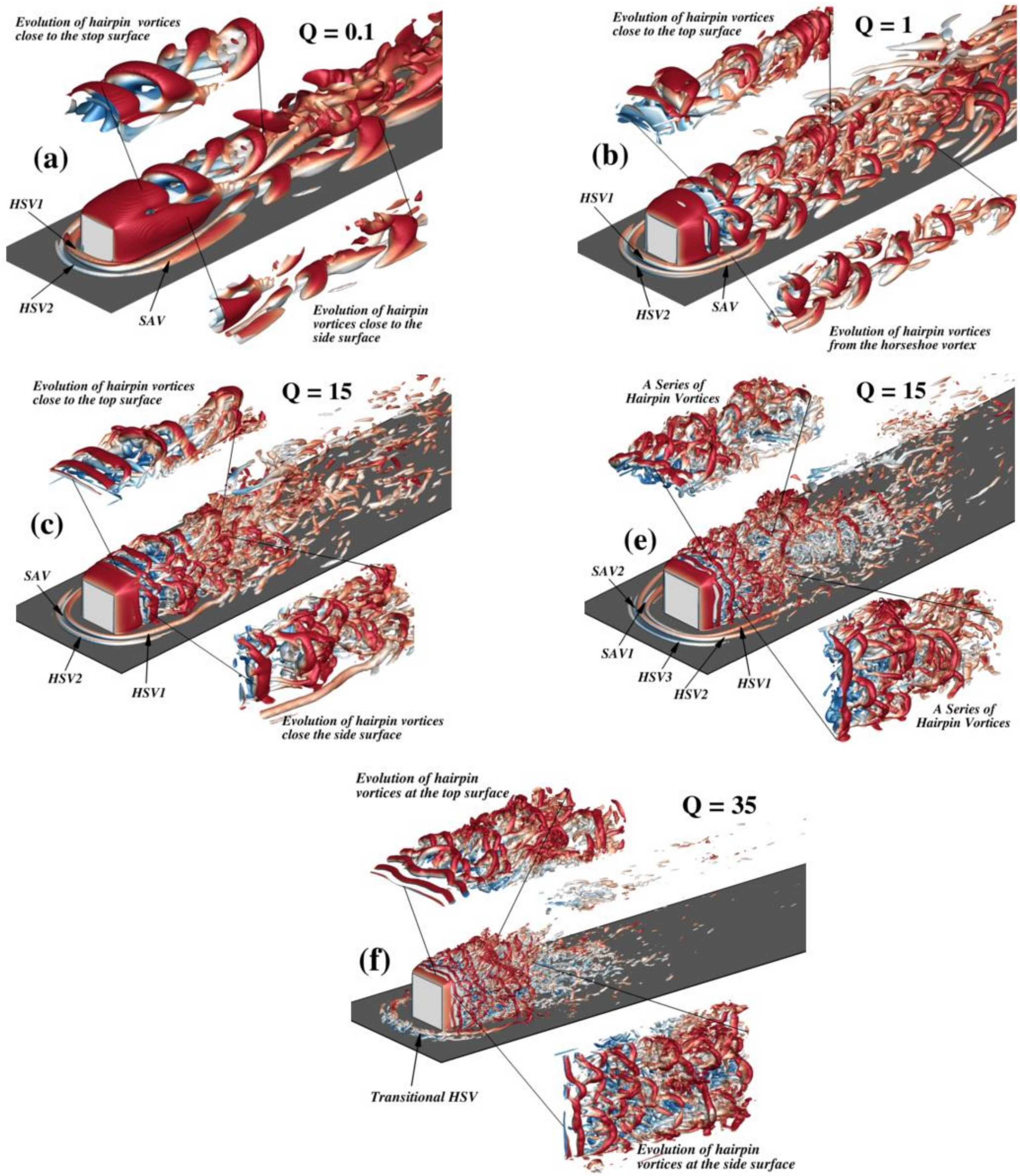


Figure #2: Iso-surface of instantaneous Q-criteria coloured by the streamwise velocity for the Reynolds numbers (a) 500 (b) 1000 (c) 2000 (d) 3500 and (e) 5000.

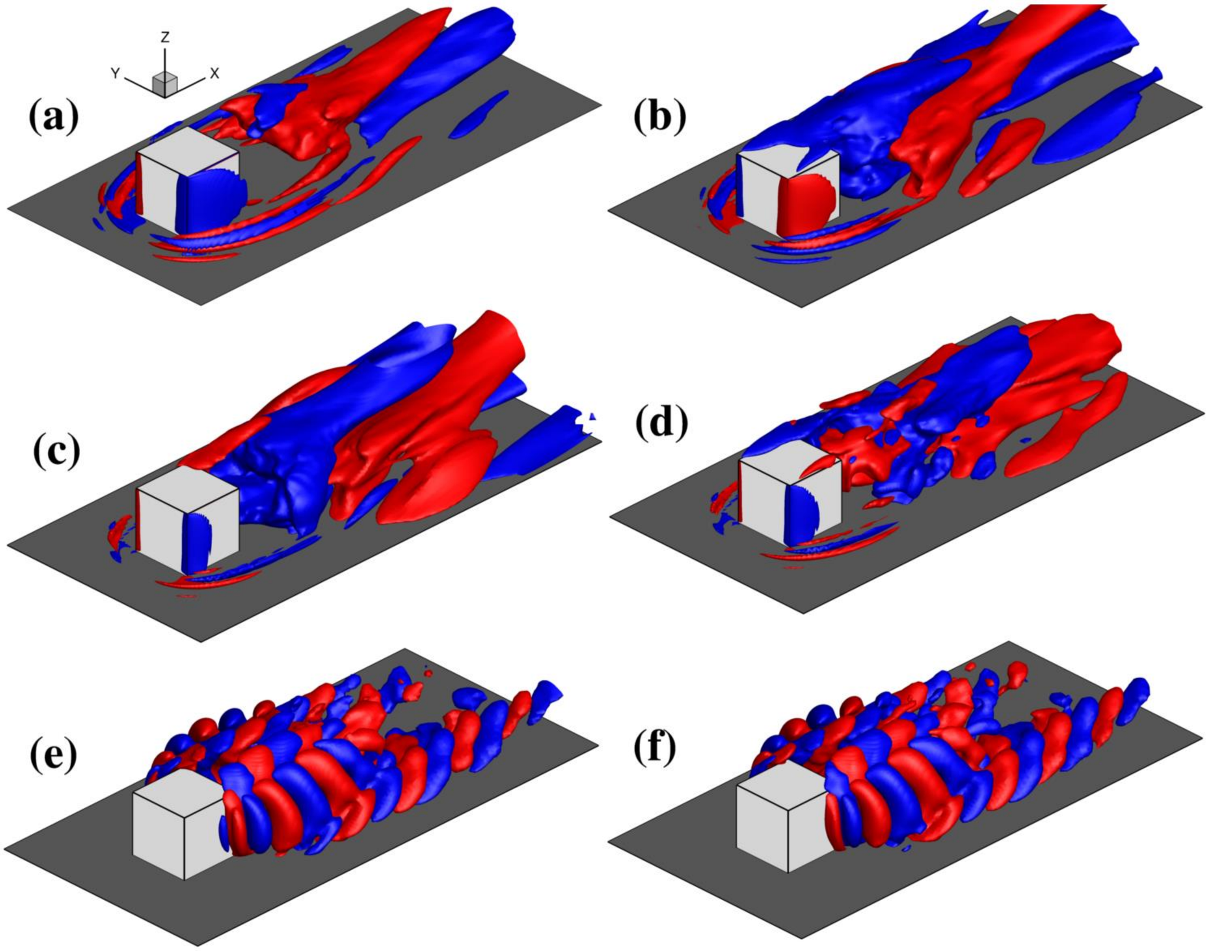


Figure #3: Iso-surface of fluctuating spanwise velocity (v') showing the three-dimensional POD modes: (a) mode 1 (b) mode 2 (c) mode 3 (d) mode 4 (e) mode 5 and (f) mode 6, for a Reynolds number of 1000

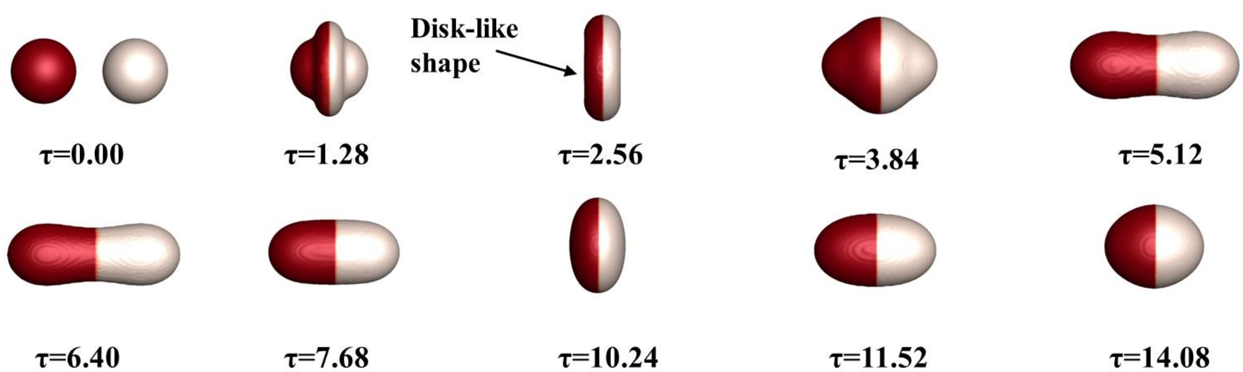


Figure #4: Head-on collision dynamics of ethanol (dark red) and water (white) drop resulting in coalescence at Reynolds Number=335 and Weber number=8.

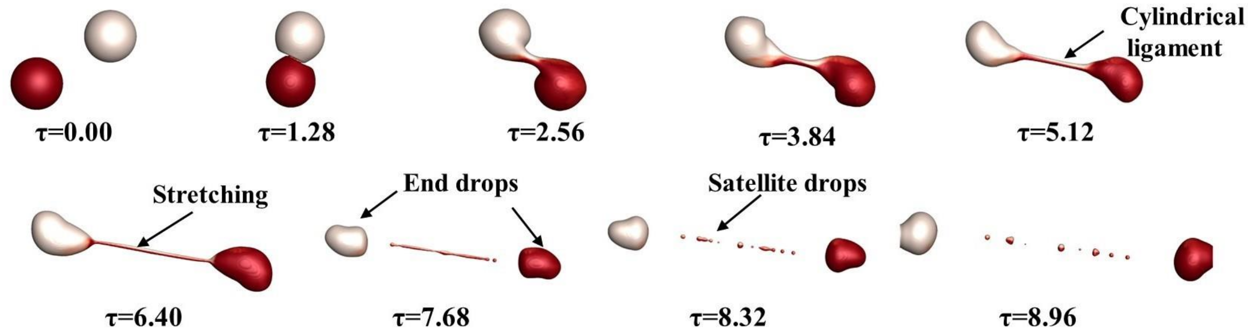


Figure #5: Off-center collision dynamics of ethanol (dark red) and water (white) drop resulting in stretching separation at Reynolds Number=710, Weber number=35 and impact parameter=0.9.

R&D facility

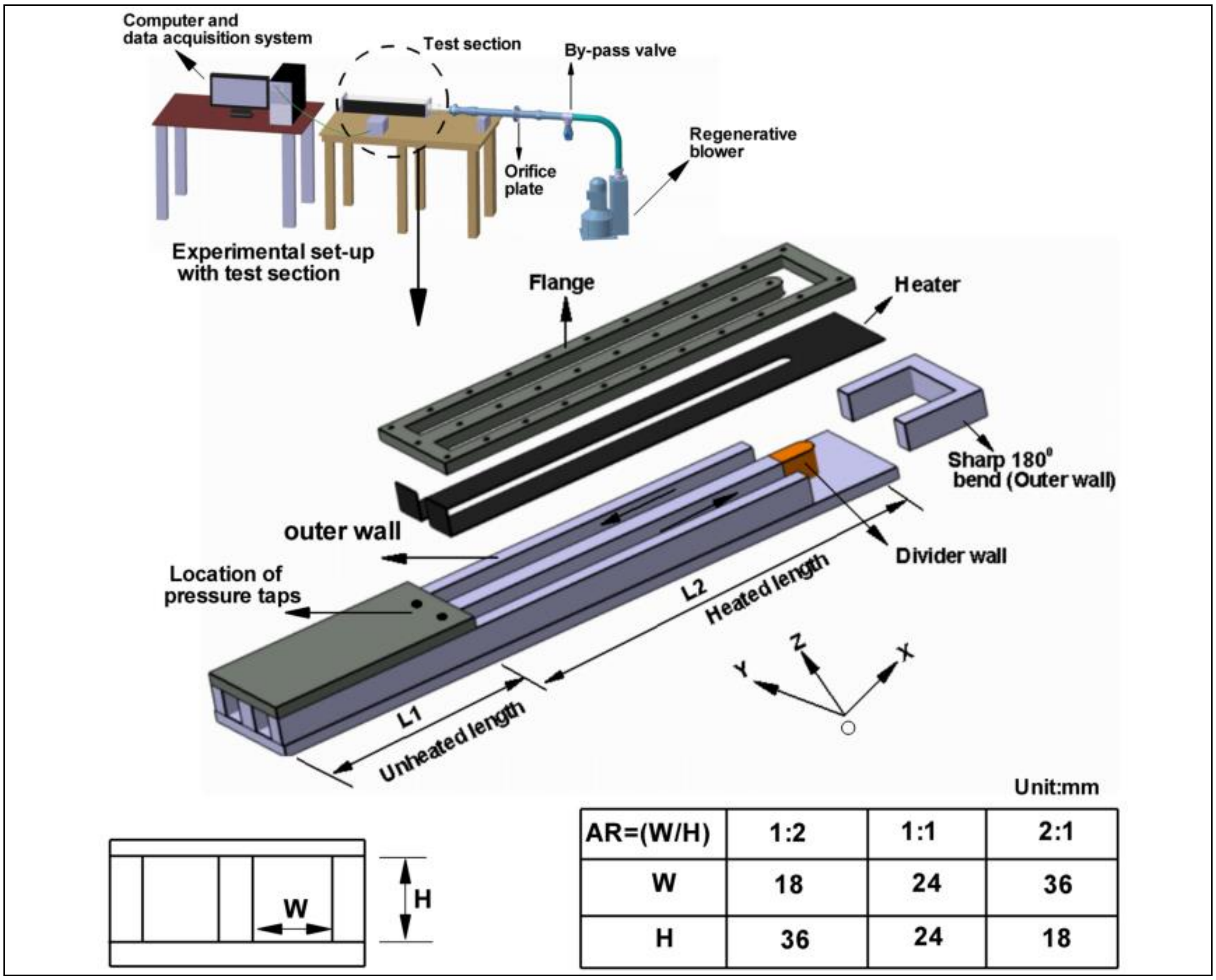
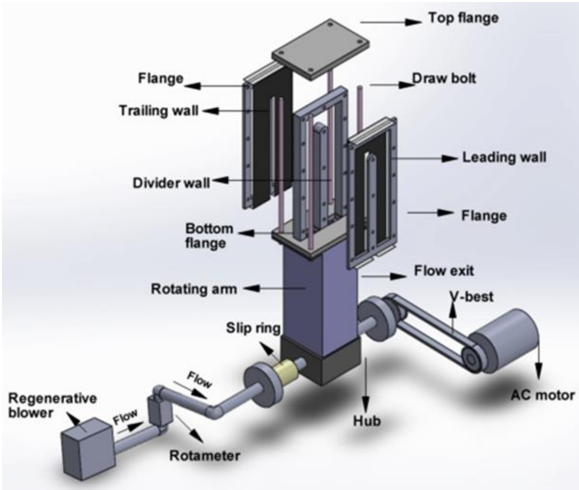


Figure #1: Stationary experimental set-up with exploded view of the test section used in experiments.



Experimental set-up #2: Rotating facility

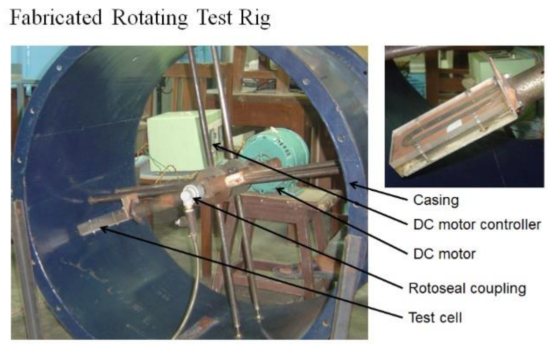


Figure #2: Rotating experimental set-up with exploded view of test section used in experiments

Figure #3: Infra-red camera.

Turbo Machinery Laboratory: Computation and Experiment

Laboratory Coordinator: Dr. S. Sarkar

Associated Faculty Members (if any):

List of Major Equipment:

Computational Equipment

- Developed High-performance computing Clusters:
- 48 Node Cluster with Intel Xeon Quad-core @2.96 GHz, Total 192 cores, 16 GB RAM, 40 Gbps InfiniBand Network with 12 TB Storage.
- 24 Node Cluster with Intel Xeon Hexacore @2.96 GHz, Total 288 cores, 16 GB RAM, 40 Gbps InfiniBand Network with 12 TB Storage
- 12 Node Cluster with Intel Xeon Quadcore @2.96 GHz, Total 96 cores, 16 GB RAM, 40 Gbps InfiniBand Network with 12 TB Storage.
- 3 Intel Xeon Workstations.
- 20 Personal Computers

Experimental Equipment

- A cascade tunnel
- A general-purpose wind tunnel
- Particle image velocimetry (PIV)
- Laser doppler anemometry (LDA)
- Hotwire anemometry
- Electronically scanned pressure transducer (ESP)
- Three-hole & Five-hole probes
- Three-axes traverse

Brief description of the laboratory

Turbo Machinery Lab actively works towards novel scientific and technological inventions, particularly in the field of aeronautics and turbomachinery. The lab is involved in developing fast, accurate and robust Navier-Stokes, LES, and DNS solvers as the desired design tool for aero-thermal analyses of flow encountered in turbomachines. Apart from the high-end CFD solver, the lab is also equipped with optical measurement instruments like PIV and LDA along with hotwire anemometry to keep pace with advanced technological development in flow and turbulence measurement. Turbo Machinery Lab provides a platform for many aspiring students and research scholars across various disciplines to work towards the betterment of society and nation-building through technological innovations and transfer.

Laboratory research keywords:

- A laminar separation bubble, its transition and busting.
- Blade wake interaction involving unsteady flow.
- Vortex dynamics, coherent structures, and breakdown.
- Transition and turbulence characteristics over turbine and compressor blades.
- Jet-crossflow interactions and heat transfer assessment related to blade cooling.
- Transition of leading-edge separation bubble on the rough surfaces.
- Transition of boundary layer under adverse pressure gradients.
- Flow features, turbulence statistics, and mechanism of drag reduction using micro-riblets.

Major Research Contribution of the Laboratory for the Last Two Years 2019-21

Year	Major research and development activity
2020-2021	• **Micro-Textured Surface for Varying Flow Environment (Ongoing)** Technologies for the reduction of drag have a huge potential for energy savings in applications ranging from the propulsion of aerospace/marine vessels to carrying liquids through pipes. Ever-increasing fuel costs, restrictions for environmental protection, and noise levels demand highly efficient aeroengines, where the aerodynamic drag plays an important role in detecting their performance. Thus, drag reduction is one of the state-of-art research in aviation industries. During the last two decades, the field of biomimetics, which mimics the objects in nature to enhance the current technologies, has emerged drastically. Attempts are being made to explore the mechanisms of interfacial interactions between the micro-textured surface and fluids via highly resolved LES and experiments for a wide range of Reynolds numbers involving transitional to turbulent regimes, mimicking textured surfaces of aquatic animals. The control of separation and downstream development are also being assessed on the textured surface via LES and Experiments. This innovative approach for drag reduction and separation control might facilitate the future development of aerospace/marine vessels. This is an ongoing SERB project. • **Flow and Thermal Analysis of Hot Air Oven for Design Optimization (ongoing)** An industrial hot-air oven (HAO) aims to transfer heat from hot air to a plastic tape of a varying thickness of 40-300 microns & width of 2-6 mm. The plastic tape moves inside the HAO at speed of 100-650 m/min with a mass flow rate of 350-900 kg/hr. Hot air flows over the running plastic tapes raising their temperature and helping them in stretching as a process requirement. The purpose of the analysis is to develop an optimal configuration of HOA along with the blower and the heater to maintain the best possible uniformity of air velocity and air temperature across the entire effective zone inside the oven, with minimum heat losses and minimum running power consumption. This an ongoing project funded by Lohia Industries Ltd. • **Effect of Hemispherical Protuberance on the Leading-Edge to Control the Laminar Separation Bubble (ongoing)** Flow separation is often inhabitable in several engineering applications, such as near the leading edge of an aerofoil at relatively high angles of attack or on the suction side of a low-pressure turbine (LPT) blade under low Reynolds number conditions. Often the laminar boundary layer separates and then reattaches as a turbulent boundary layer forming a laminar separation bubble (LSB). An LSB, once formed, dictates the development of the downstream boundary layer, enhancing aerodynamic losses and adversely affecting the stall characteristics of an aerofoil. Hence, it is desirable to delay or eliminate the laminar separation bubble on an aerofoil to enhance its performance. In this work, the excitation of an LSB under the influence of leading-edge protuberance has been investigated via hotwire and PIV measurements. The reduction of bubble length, flow features, shedding frequency, and turbulence statistics have been documented. The observations are reported in the form of a journal paper. • **Excitation of Boundary Layer on the Suction Surface of CD Compressor Blade** The excitation of a separated boundary layer on the suction surface of a controlled-diffusion compressor stator blade is studied using a high-fidelity LES. The boundary layer on the blade remains laminar till the mid-chord, where it separates, undergoes a rapid transition due to high receptivity to

	free-stream disturbances, and then reattaches as a turbulent boundary layer. Transition is induced by the Kelvin–Helmholtz instability in the first-half of the bubble, while a secondary instability occurs in the second-half, leading to the breakdown and turbulent flow. A paper in the physics of fluid has been published. • **Flow Transition and Heat Transfer on the Pressure Surface of a CD Compressor Blade** A highly resolved LES is employed to investigate the laminar-turbulent transition on the pressure surface of a controlled-diffusion compressor stator blade. Flow features appear laminar at the beginning, followed by the undulation of velocity fluctuations, attributing to the development of elongated streamwise streaks and then manifested to hairpin structures that lead to abundant small-scale eddies and increase the turbulent heat flux. The present research is useful in designing highly efficient compressor blades used in an aircraft engine. The observations are presented to ASME conferences, and a paper is in the process of being submitted to an ASME Journal. • **Excitation of Shear Layer Due to Surface Roughness Near the Leading Edge: An Experiment** The accumulation of hydrocarbon deposits and erosion of materials from the surface of a gas turbine blade are the common causes of surface roughness, which have a significant influence on the excitation of a boundary layer and, thus, the aerodynamic losses. A comprehensive study has been performed here to address the excitation of a separated boundary layer near the leading edge due to surface roughness. Experiments are performed on a model airfoil with three rough surfaces. The flow features are investigated for different angles of attack over the rough surfaces. The wall roughness results in an early transition and reattachment, leading to a reduction of the laminar shear layer length apart from the bubble length. A paper in the J. Fluid Eng., ASME, has been published.
2019-2020	• **Numerical Simulation of Two-Phase Flow: Air-Mist Film Cooling** The droplets of water act as local heat sinks in the secondary jet and reduce the thermal load of the blade by absorbing heat during their evaporation and advection. The performance of air-mist film cooling is evaluated for varying mist concentrations and droplet diameters using the Euler-Lagrange approach with an appropriate turbulence model. The downstream evolutions of droplets, their evaporation, and the thermal field are considerably influenced by the mist concentration and droplet diameter. The introduction of droplets in the secondary flow brings in significant improvements in film cooling effectiveness both in streamwise and spanwise directions. The droplet dynamics exhibit the two-layer system for a relatively larger diameter, where droplets penetrate more into the crossflow and stay away from the surface. A paper in the Int. Journal of Thermal Science has been accepted for publication. • **Leading Edge Contamination of a Compressor Blade Using Large Eddy Simulation** A high-fidelity LES is employed here to illustrate the leading-edge contamination of a compressor blade. LES resolves a tiny separation bubble near the leading-edge at the designed inflow angle. The objective of the present study is to assess how this leading-edge bubble influences the flow transition and further development downstream on the suction surface. The leading-edge bubble leads to

	a pre-transitional boundary layer, where the turbulence level rapidly increases, followed by decay due to local pressure gradient, and then it suffers from an adverse pressure gradient. Thus, the boundary layer separates again in the second half of the blade based on the inlet turbulence levels. The observations are presented to an ASME conference, and a paper is in the process of being submitted in an ASME Journal. • **Large Eddy Simulation of Wake-Shear Layer Interactions Over a Multi-Element Aerofoil** Modern commercial airliners use multi-element aerofoils to enhance take-off and landing performance. Further, multielement aerofoil configurations have been shown to improve the aerodynamic characteristics of wind turbines. In the present study, high-fidelity LES is used to explore the low Reynolds Number aerodynamics of a 30P30N multi-element aerofoil at an angle of attack, $\alpha = 4°$. In the present simulation, wake shed from a leading-edge element or slat is found to interact with the separated shear layer developing over the suction surface of the main wing. Results of the present LES are found to be in close agreement with the experiment depicting high vortical activity in the outer layer. Some features of the flow field here are similar to those occur due to interactions of passing wake and the boundary layer on the suction surface of high lift low-pressure turbine blades. The observations are presented at an ASME conference, and the work will be continued in the future. • **Flow structures and thermal field with modulated jet near the semi-circular leading edge** The influence of external modulation on unsteady flow and heat transfer near the leading edge of a constant-thickness aerofoil has been described through large eddy simulation. This is a simplified approach to study film cooling activities near the leading edge of a turbine blade. Discrete jets, which are forced at a Strouhal number (St) of 0.37 with an averaged blowing ratio of unity, are ejected normally from a series of film cooling holes to a separated boundary layer. Larger coherent structures appear for a forced jet with augmented vortex dynamics resulting in high jet lift-off, earlier break down, enhanced mixing with the cross flow, and dilution of the coolant layer. Resolved hairpins, which are the signature of coherent structures, illustrate that the vorticity and thermal field are highly correlated. Furthermore, the evolution of hairpins and their advection control scalar transport and mixing. In brief, the modulation of the coolant jet near the leading edge appears not beneficial for the combination of blowing ratio and frequency considered here. A paper in the J. Mechanical Science, IMechE, has been published. • **Large Eddy Simulation of Flows of Engineering Interest: A Review** A review paper was written on LES. The deeper insights of relationships between large and small scales lead to the development of large eddy simulation (LES), where large scales are explicitly resolved and small scales being universal are modeled. With the advent of high computing power, it is feasible now to successfully

	simulate the complex turbulent flows of engineering interest using LES. The paper starts with a brief discussion on features of turbulence leading to LES and subgrid-scale models. The evaluation of LES to resolve the physics of transitional and turbulent flows is made based on illustrations, where the few being previous studies of the author and his research group. Although results demonstrate an immense potential of LES to simulate the transitional and turbulent flows as an alternative to DNS with moderate computational cost, there exist several bottlenecks even today. The requirement of very fine meshes near walls is one of such bottlenecks in using LES at high Reynolds number flows. The hybrid LES-RANS, which was invented to eliminate the limitations, is also discussed here in brief. As a concluding remark, it can be stated that the method is particularly suitable and superior to RANS for situations, where unsteadiness and large-scale structures dominate the flow.

Major Research Contribution in Brief of the Laboratory in the Years 2016-19

Year	Major research and development activity
2016-19	• **Design and development of test-setup to perform an experiment on the influence of Wall Roughness on the aerofoil** A model airfoil is designed with a rough surface and installed in the cascade tunnel. Angles of attack can be changed with the different trail flap depletion. A detailed experiment is initiated to appreciate the physics of flow transition at low free-stream turbulence. • **Aero-thermal analysis of a compressor blade via LES** An in-house LES solver was tested for the analysis of transition flow over a compressor blade. Further, a refined grid is generated by a hyperbolic solver for LES analysis. Initial simulation indicated very favorable results revealing dynamics of coherent vortices and their non-linear interactions in transition. • **Flow and Heat Transfer Analysis of Mist-Film Cooling on a Flat Plate** A two-phase simulation on mist film cooling is initiated for different mist concentrations, duplet diameter, blowing ratio, density ratio, and Reynolds number. The results illustrate insight into complex transport phenomena associated with the mist of varying concentrations from 2% to 7%. The observations are presented at an ASME conference. • **Absolute and Convective Instabilities of a Separated Boundary Layer on an Aerofoil** The present work describes the stability analysis of a separated boundary layer over an aerofoil. The Orr-Somerfield (O-S) equation has been solved, where the mean velocity field is obtained from the experiment. It has been observed that the separated boundary layer near the leading edge is absolutely unstable for low angles of attack, whereas it is convectively unstable for higher angles of attack when the Kelvin-Helmholtz instability is bypassed. The observations are presented at an ASME conference.

	• **Effect of vortex generators on film cooling effectiveness** In the present study, the effects of both downwash and upwash types of vortex generators on film cooling are numerically analyzed. The results show that vortices generated by a downwash vortex generator (DWVG) counteract the effect of CRVP, preventing the jet lift-off, which results in increased effectiveness in streamwise as well as in spanwise directions. However, an upwash vortex generator (UWVG) augments the effect of CRVP, resulting in poor performance of film cooling. A paper in the J. Turbomachinery, ASME, has been published. • **An Experiment Illustrating Features of a leading-edge LSB for different angles of attack** The evolution of a separated boundary layer over a model airfoil with a semi-circular leading-edge has been illustrated for different angles of attack. The transition in the separated boundary layer occurs through Kelvin–Helmholtz (K–H) instability for angles of attack 0 deg and 3 deg, whereas the K–H mechanism is bypassed for higher angles of attack with a significant viscous effect. A paper in the J. Fluid Eng., ASME, has been published. • **Large eddy simulation of self-sustained cavity oscillation for subsonic and supersonic flows** The primary objective is to perform a large eddy simulation (LES) using the shear improved Smagorinsky model (SISM) to resolve the large-scale structures, which are primarily responsible for shear layer oscillations and acoustic loads in a cavity. The unsteady, three-dimensional (3D), compressible Navier–Stokes (N–S) equations have been solved following the AUSM+-up algorithm in the finite-volume formulation for subsonic and supersonic flows. The present LES resolves the formation of shear layer, its rollup resulting in large-scale structures apart from shock–shear layer interactions and evolution of acoustic waves. The present LES agrees well with the experimental data and is found to be accurate enough in resolving the shear layer growth, compressive wave structures, and radiated acoustic field. A paper in the J. Fluid Eng., ASME, has been published. • **Self-sustained oscillation for a three-dimensional transonic cavity using LES** The effect of the sidewall in the self-sustained oscillation of an open cavity has been analyzed to understand the flow instability and influence of acoustic waves for transonic flow using Large-Eddy Simulation (LES). The present simulation resolves the formation of shear layer, its rollup resulting in large-scale structures apart from shock-shear layer interactions and evolution of acoustic waves. The presence of sidewall generates streamwise vortices that grow and convect downstream while interacting with the spanwise rollup of shear layer. This results in coherent structures that finally impinge on the aft wall generating acoustics. • **Effects of free-stream turbulence on transition of boundary layer over an airfoil** This paper describes the change in the transition mechanism of a separated boundary layer formed from the semicircular leading-edge of a constant thickness airfoil as the free-stream turbulence (*fst*)

	increases. Experiments are carried out in a low-speed wind tunnel for three levels of *fst* at two Reynolds numbers. At low *fst*, the primary mode of instability of the shear layer is Kelvin–Helmholtz (K-H), although the local viscous effect may not be neglected. At high *fst*, the mechanism of shear layer rollup is bypassed with transient growth of perturbations along with evidence of spot formation. The predominant shedding frequency, when normalized with respect to the momentum thickness at separation, is almost constant and shows a good agreement with the previous studies. After reattachment, the flow takes a longer length to approach a canonical boundary layer. A paper in the J. Fluid Eng., ASME, has been published. • **Interactions of Separation Bubble with Oncoming Wakes by Large-Eddy Simulation** The unsteady flow physics and heat transfer characteristics due to interactions of periodic passing wakes and the boundary layer developing on a series of aerofoils are studied using large-eddy simulation (LES). Wake data extracted from precursor LES of flow past a cylinder are used to replicate a moving bar that generates wakes in front of a cascade. This setup is a simplified representation of the rotor-stator interaction in turbomachinery. Phase-averaged results illustrate the periodic behavior of both flow and heat transfer. Large undulations in the phase-averaged skin friction and Nusselt number distributions can be attributed to the excitation of the boundary layer by convective wakes forming coherent vortices, which are being shed and convect downstream. Further, the flow transition during the wake-induced path is governed by a mechanism that involves the convection of these vortices followed by increased fluctuations, where the viscous effect is substantial. A paper in the J. Heat Transfer, ASME, has been published.

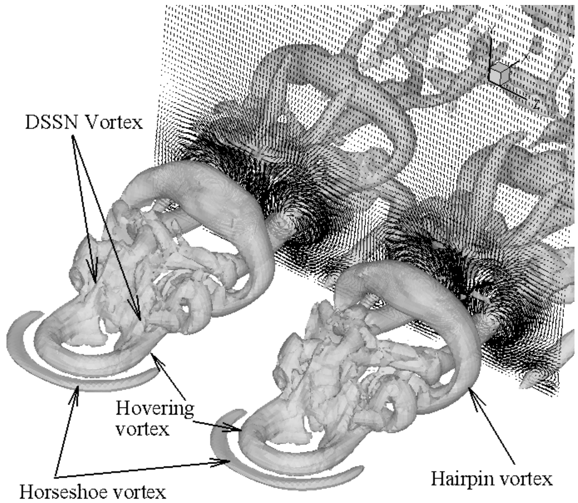


Figure #1: LES of injected jet in crossflow: Iso-surface of –λ2 depicting evolution of hairpins. Ref: Sarkar & Babu, *J. Turbomach.*, Vol. 139, 2015.

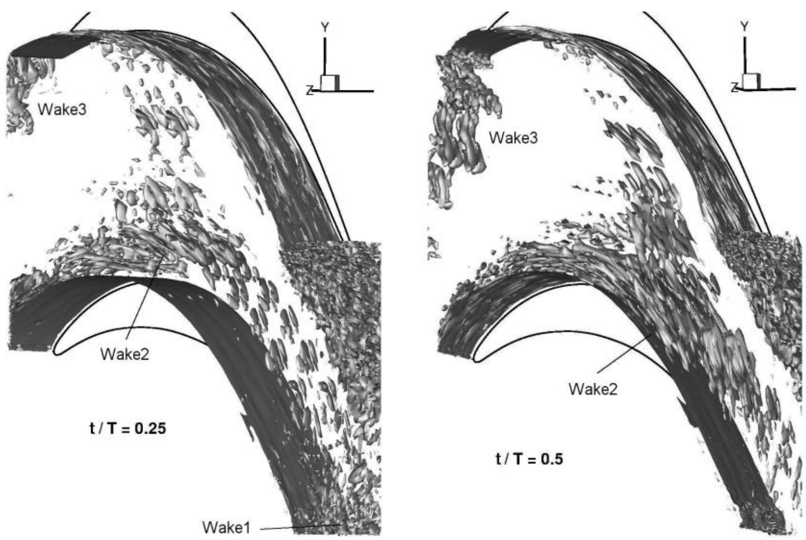


Figure #2: Visualization of wake distortion, orientation and stretching inside the blade passage. Ref. Sarkar, *J. Turbomach.*, 131(4): 041016, 2009.

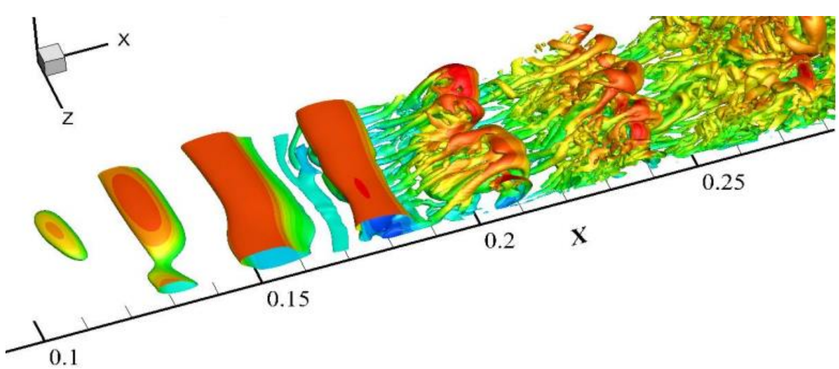


Figure #3. Visualization of flow structures forming hairpins of transitional flow subjected to an adverse pressure gradient via an LES. Ref. Ongoing PhD an MS work, Turbomachinery Laboratory, IIT Kanpur.

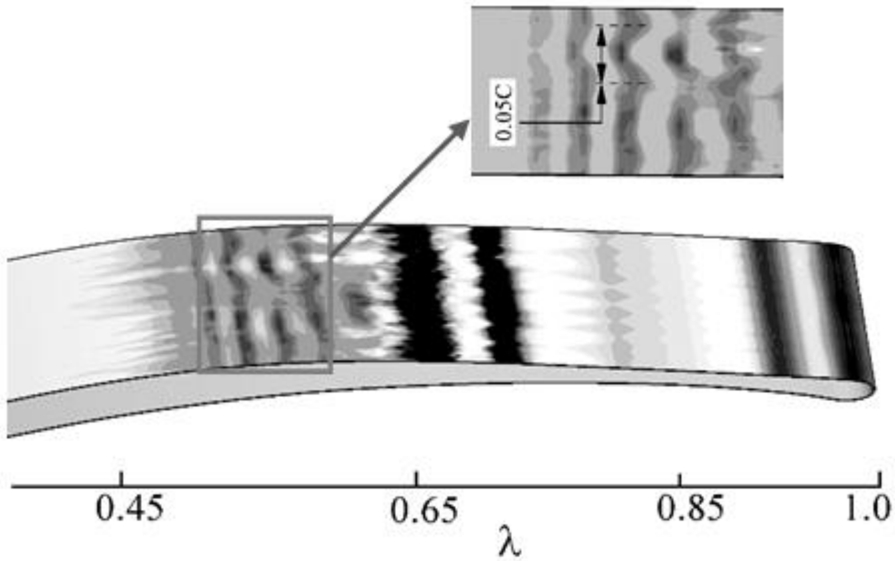
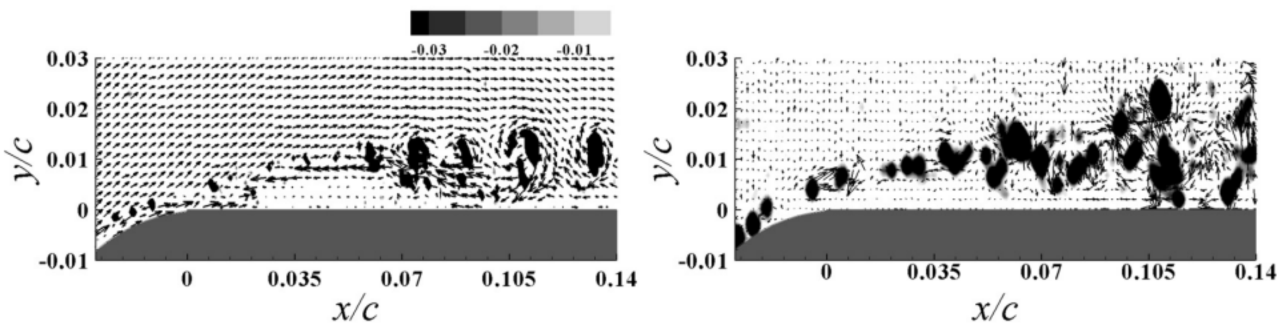


Figure #4. Boundary layer development on the second-half of the suction surface of a compressor blade at low *fst*. Ref. Katiyar & Sarkar, *Phys. Fluids*, 34, 094108, 2022.



- Smooth Surface

(b) Rough Surface

Figure #5. PIV results superimposing instantaneous velocity and $-\lambda_2$ illustrating leading edge separation on a smooth and rough Surface. Ref: Singh & Sarkar, *J. Fluids Eng.*, 143, 2021.

Figure #6: Particle image velocimetry setup.

Compliant and Robotics Systems (CARS) Laboratory

Laboratory Coordinator: Dr. Anupam Saxena

List of Major Equipment:

- Computer Systems

Brief description of the laboratory:

We find realizable solutions to design problems in areas of Compliant and Robotic Systems (CARS) with applications in product design, precision instrumentation, sensing and actuation, MEMS/NEMS, bio-medical devices, humanoid robotics, exploration, surveillance, search and rescue, transportation, prosthetic and orthotic/exoskeletal devices. We derive inspiration from designs in nature, which amongst having many interesting attributes, are sustainable (time tested and robust) and exemplify integration of subsystems of a variety of properties and scales.

Laboratory research keywords:

Design of compliant mechanisms and MEMS, Structural Topology Design/Optimization, Computer Aided Engineering Design and Graphics, Geometrically/Materially Large displacement Finite Element Analysis, Robotics, Kinematics.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• Developed a Normalized Field Product method for Topology Optimization • Topology Optimization in 3-dimensions with Tetra-kai-decahedra and Spheroidal Masks • Compliant Constant Output/Input Force Mechanisms — Topology Optimization with Contact • A Material Mask Overlay Strategy for Close to Binary Design-dependent Pressure-loaded Optimized Topologies • Comprehending finger flexor tendon pulley system using systematic computational analysis • Topology synthesis of a 3-kink Contact-aided compliant switch. ASME Journal of Mechanical Design
2019-2020	• On topology optimization of large deformation contact-aided shape morphing compliant mechanisms • On Topology Optimization with Elliptical Masks and Honeycomb Tessellation with Explicit Length Scale Constraints
2018-2019	• On Upper Bounds with $ABC = 2^m p^n$ and $ABC = 2^m p^n q^r$ with p and q as Mersenne or Fermat Primes • Computational optimization of large deformation compliant mechanisms undergoing self and mutual contact

2017-2018	• Adaptive Discretization for Computerized Tomography. • On Redundancy Resolution of the Human Thumb, Index and Middle Fingers in Cooperative Object Translation.
2016-2017	• On Synthesis of C^0 Path Generating Compliant Mechanisms with Mutual Contact using the Material Mask Overlay Method
2015-2016	• Optimal Spatial filtering schemes and compact tomography setups • On topology optimization with embedded boundary resolution and smoothing • Reliable reconstruction strategy with higher grid resolution for limited data tomography • Non-uniform Arrangement of Emitter-Receiver Pairs Arrangement and Compact Ultrasonic Tomography Setup

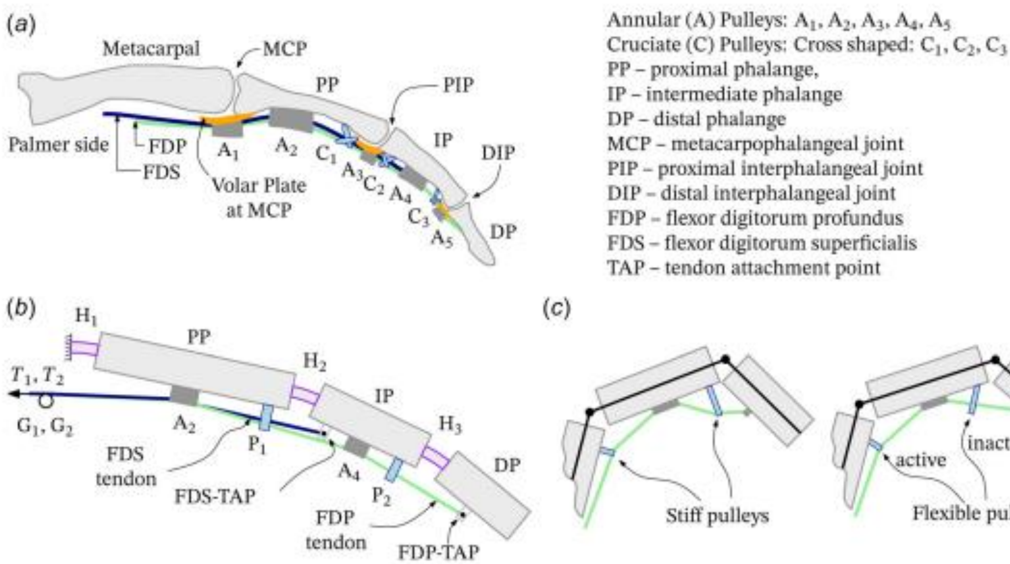


Figure #1: Computational modeling the human finger tendon pulley system using FEM and 3R PRBM to study the role of individual pulleys and tendons. [Khatik V. M., et. Al. 2021]

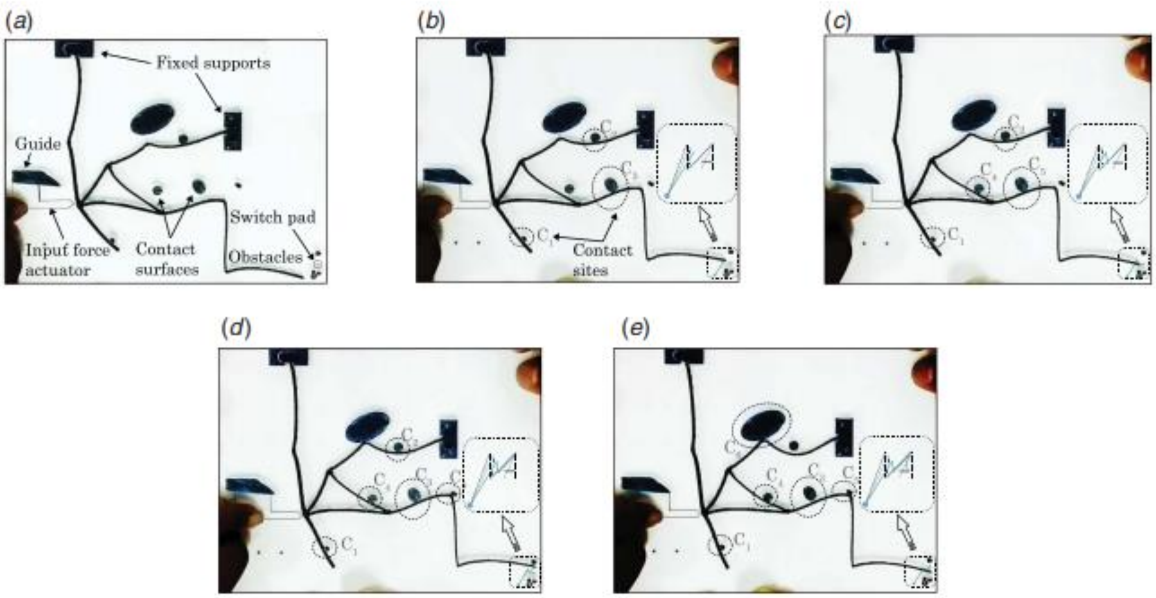


Figure #2: Prototype of CCM generating three-kinks. (a) Undeformed configuration with fixed supports and contact surfaces. (b)–(d) Intermediate configurations at the instance of a kink generation. (e) Final deformed configuration after tracing the complete three kink path. Path traced up to each intermediate stage is shown as green continuous line. Black dashed line represents the user specified path and blue dotted line represents the simulation result. [BVS Nagendra Reddy, et al. 2021]

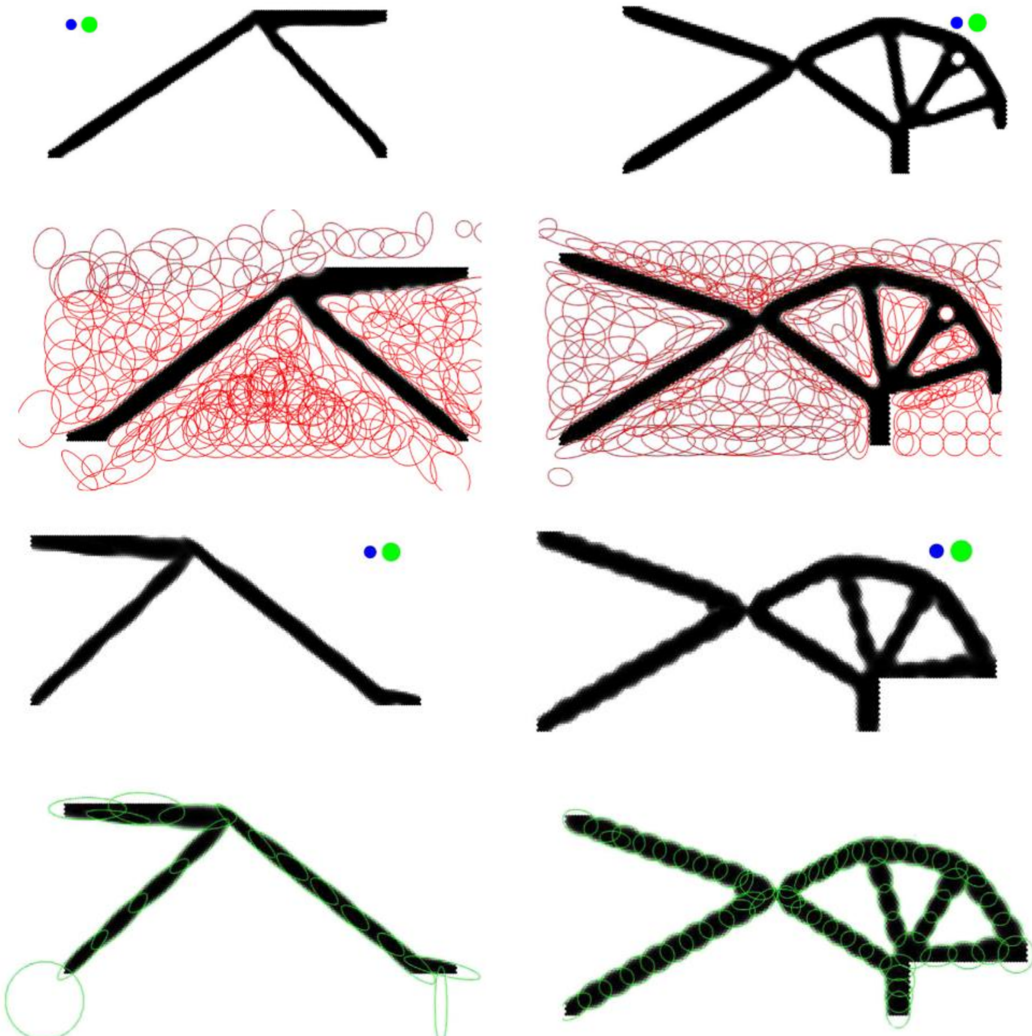


Figure #3: Topology Optimization with Elliptical Masks and Honeycomb Tessellation with Explicit Length Scale Constraints. Topological solutions obtained using 20 × 10 negative elliptical masks as design variables. Domain of size 100 × 46 unit2 is discretized via 150 by 80 regular honeycomb mesh. [Singh N., et al. 2020]

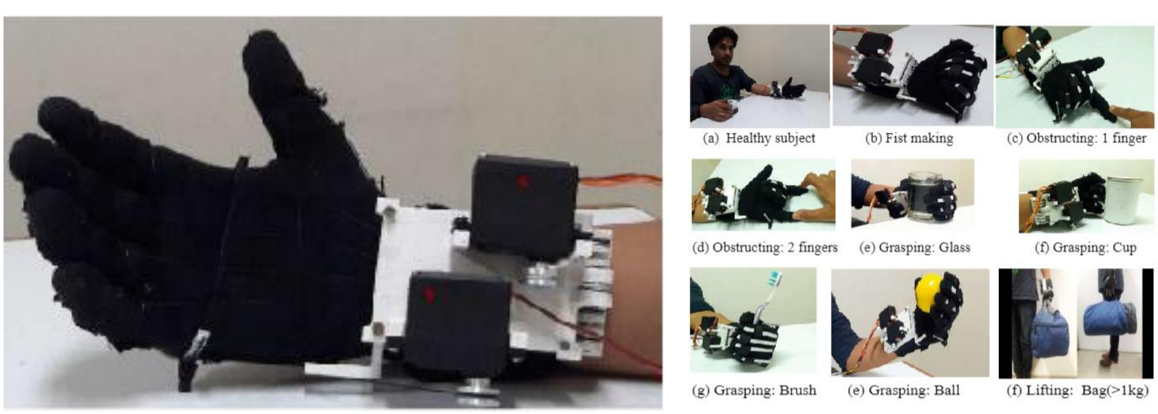


Figure #4: Soft Hand Exoskeleton for Adaptive Grasping using a Novel Differential Mechanism. [Bajaj et al. 2018]

Figure #5: Synthesis of C^0 Path-Generating Contact-Aided Compliant Mechanisms Using the Material Mask Overlay Method. [Prabhat Kumar, et Al. 2016]

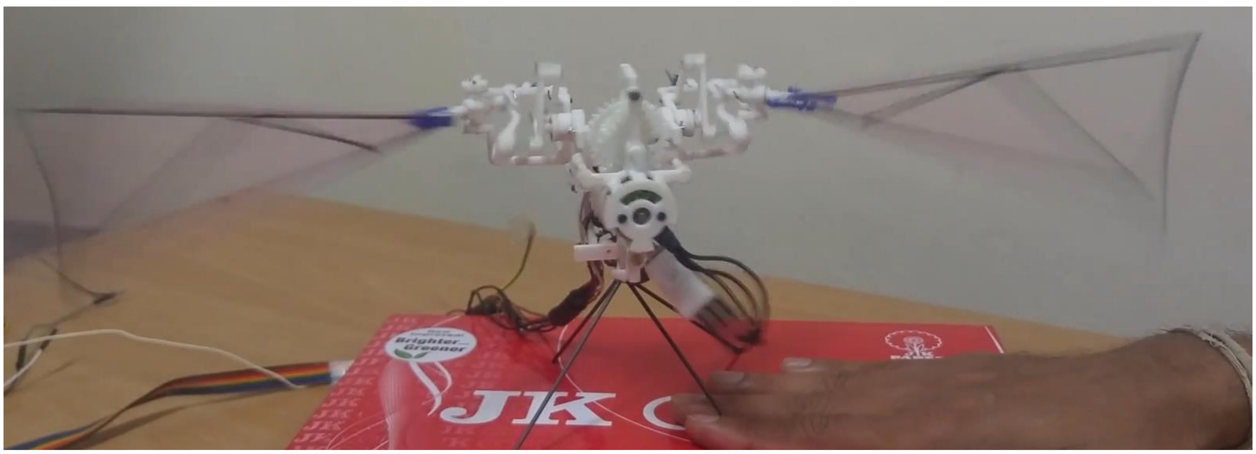


Figure #6: Flapping wing arial vehicle-1. [Anuj, et al. 2016]

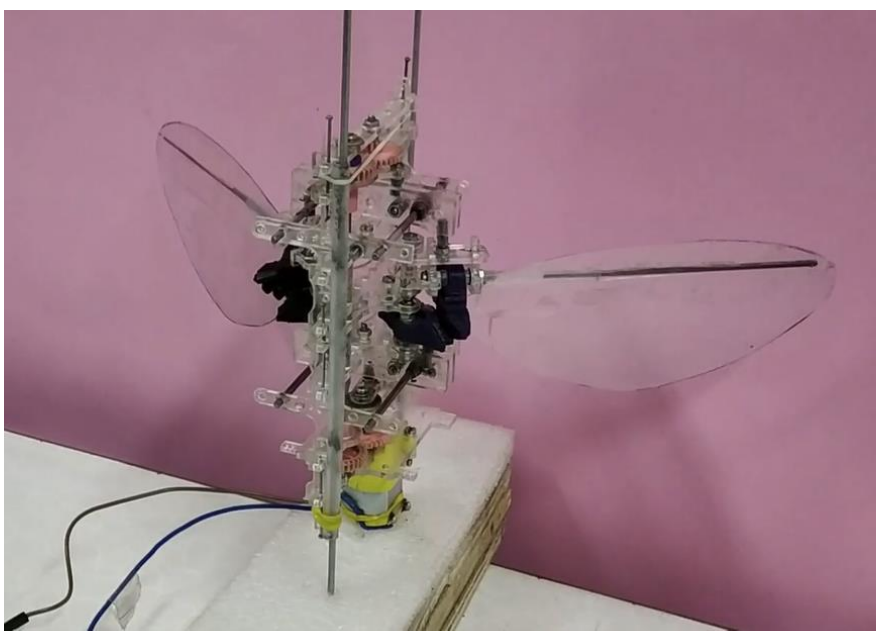


Figure #7: Flapping wing arial vehicle-2. [Vishal Jain, et al. 2016]

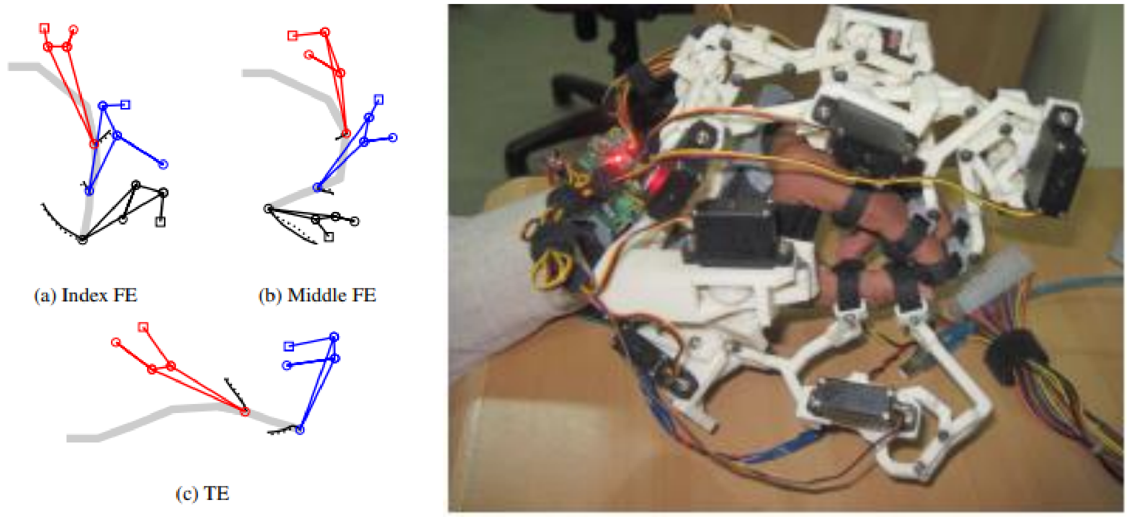


Figure #8: Three Finger Hand Exoskeleton for Translation of a slender object. [Shyam, et al. 2014]

Biomedical Research Laboratory

Laboratory Coordinator: Dr. Niraj Sinha

List of Major Equipment:

- Polymer based additive manufacturing machine
- Ceramic based additive manufacturing setup
- Filament maker for 3D printing
- UV Vis Spectrophotometer
- Ball milling machine
- Probe sonicator
- Semi-automatic grinding and polishing machine
- Muffle furnace
- Tubular furnace

Laboratory research keywords:

Additive manufacturing; Scaffold fabrication; Prosthetic devices; Water treatment; Drug delivery simulation

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	The laboratory has been involved in both theoretical as well as experimental work. On the purely theoretical front, we have focused on simulating the drug delivery in brain tumors and bone mechanics. Our study on bone mechanics mainly involved investigating the role of centroidal profile in tibia for implant design and the role of bone marrow in tibia as a damper. In the domain of work involving combination of theory and experiments, we have developed an in-house ceramic-based 3D printing system for fabricating scaffolds. We have developed a methodology for determination of their properties such as interconnectivity, tortuosity and pore size distribution in addition to predicting their mechanical strength and fluid flow properties. We have also developed prosthetic devices such as artificial hand for below elbow disability and artificial leg for above knee disability. Finally, we have successfully fabricated nanomaterials-reinforced membranes for water purification and have demonstrated it capability to purify contaminated water. During this time, we have filed 4 patents in addition to publishing more than 30 journal papers. We have received funding from several sources such as SERB, DST, DRDO, Portescap and POSOCO.

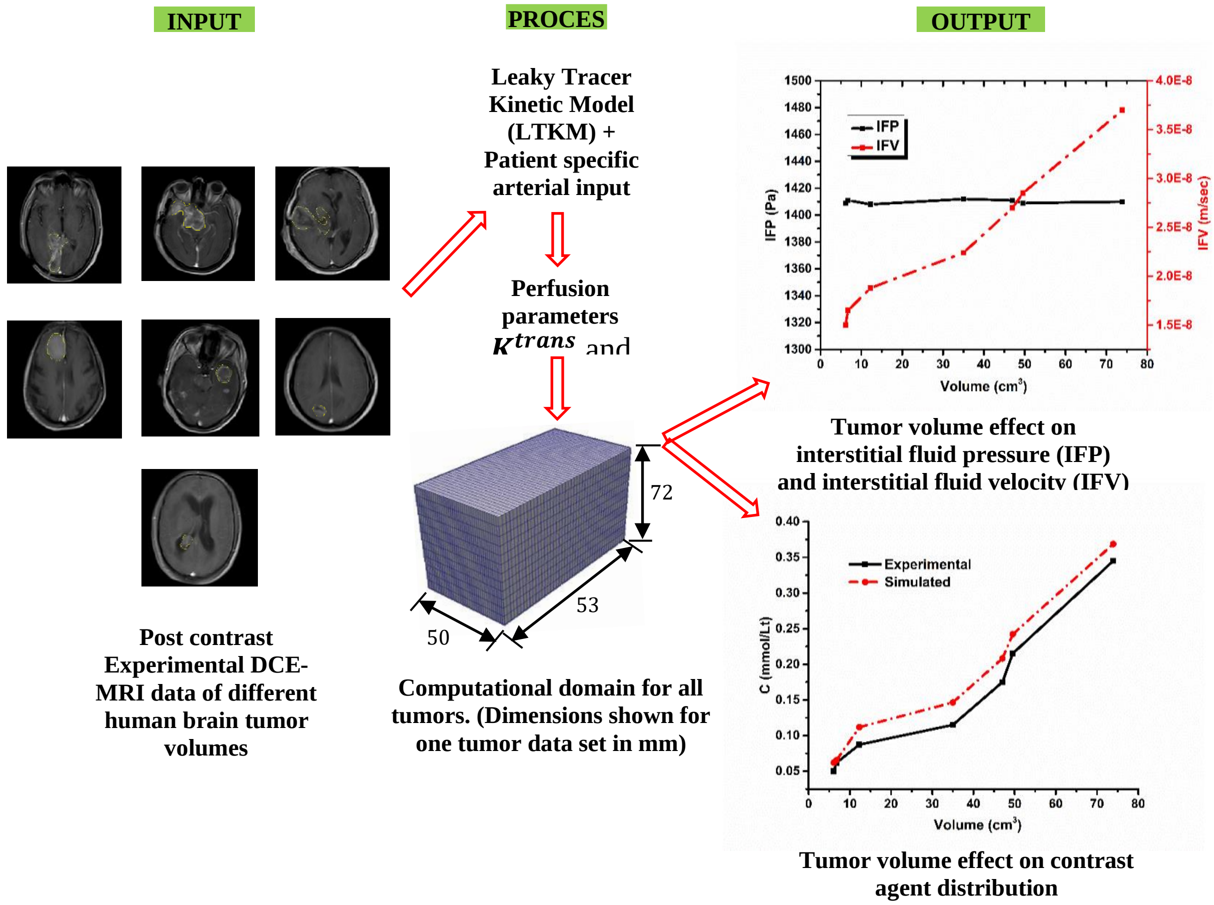


Figure #1: Effect of tumor volume on drug delivery in heterogeneous vasculature of human brain tumors.

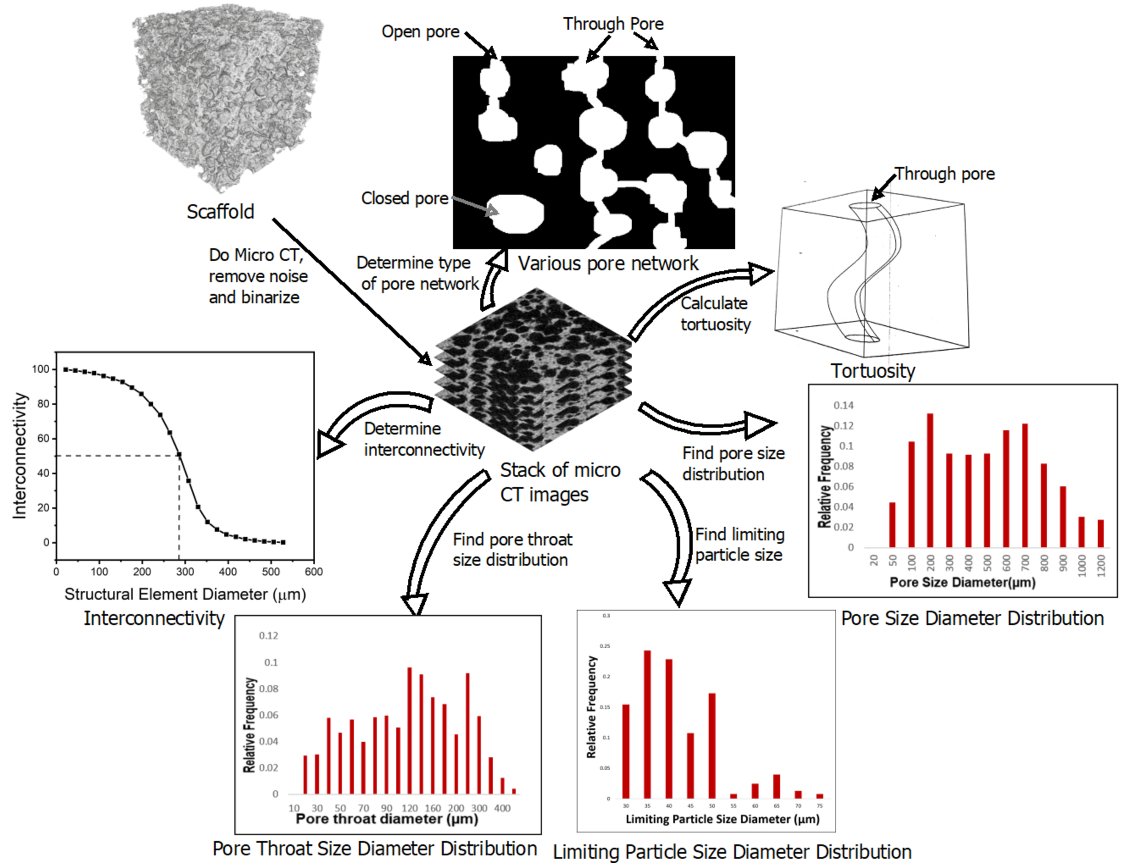


Figure #2: Structural analysis of porous bioactive glass scaffold using micro computed tomographic images.

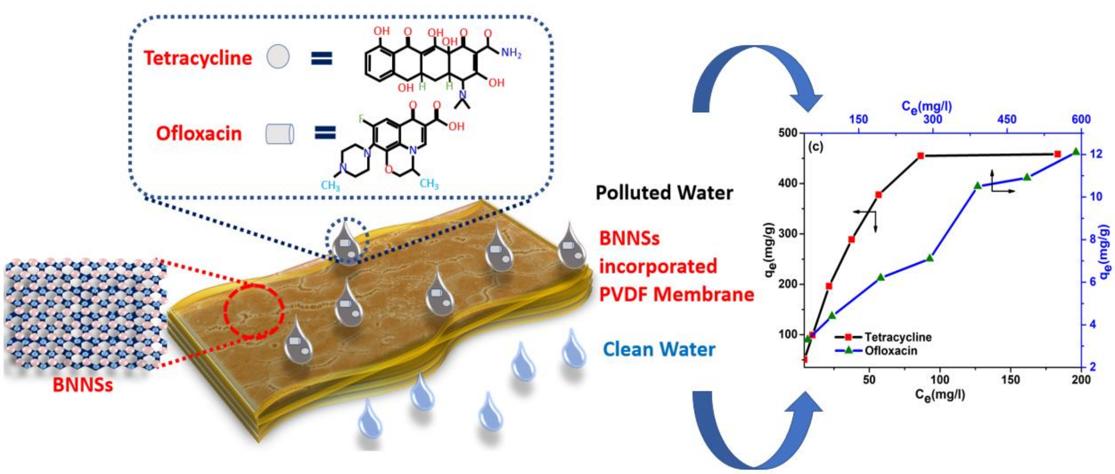


Figure #3: Nanomaterial-reinforced polymeric membranes for simultaneous removal of antibiotic contaminants from water.

High Speed Experimental Mechanics Laboratory

Laboratory Coordinator: Dr. P. Venkitanarayanan

List of Major Equipment:

- SIM02-16 Ultra high speed camera
- Photran SA1.1 high speed cameras for stereo imaging
- 25 KN UTM
- Digital Image correlation System (2D and 3D)
- Split Hopkinson pressure bars (tension & compression)
- High speed data acquisition systems (10 MHz sampling)
- 200 kHz bandwidth 6 channel strain conditioner
- 3 MHz bandwidth 2 channel strain conditioner
- Convective Oven
- Probe Sonicator
- 4 Channel Digital Oscilloscope
- Leica stereo microscope

Brief description of the laboratory:

Please provide a brief description of the laboratory in about 8-10 lines, focusing on the main thrust area of the laboratory activities.

The activities in this laboratory focus on understanding the response and failure of materials when subject to extreme conditions as in high-speed impact and high strain rate loading. The facilities such as split Hopkinson pressure bars capable of testing soft gels to Armour grade ceramics have been designed and built indigenously. Coupled with ultra-high-speed imaging and high-speed image correlation, we are able to capture in real-time the response and also evolution and propagation of damage in a variety of materials such as armour grade ceramics, fiber composites, fiber metal laminates, polymers, concrete and rocks.

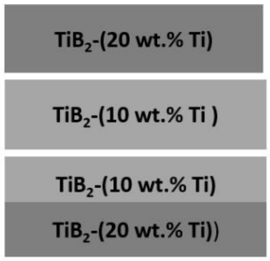
Laboratory research keywords:

High strain rate mechanics, impact mechanics, dynamic fracture, ceramics, fibre metal laminates, fibre composites, rocks

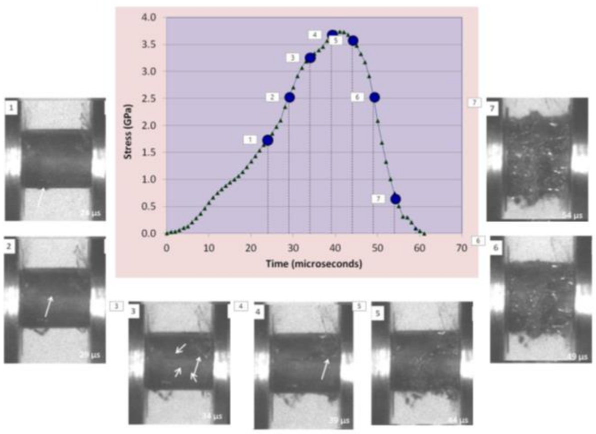
Major Research and Development Contribution of the Laboratory

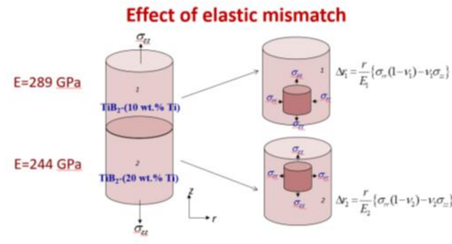
Year	Major research and development activity
2020-2021	Study of delamination and deboning in adhesive joints and layered systems through the shaft loaded blister test (SLBT) under dynamic loading. Test are performed from which the far field responses like deformation and force histories are recorded synchronously with high-speed images which provide the propagation of de-bond. Using this information parameters of the cohesive zone models (CZ) are determined.
2019-2020	Study of de-bonding in layered materials using SLBT and evaluating the de-bond energy (toughness) profile. The effect of deboning layer thickness and level of out of plane deformation affects the mode-mixity during debonding. This was characterized through numerical analysis and a new scheme of data reduction was developed to determine the toughness as a function of the mode-mixity. The same was used in FE simulations with CZ to simulate the experimentally observed de-bonding process.
2018-2019	In collaboration with Department of Earth Science, the formation of fragments when rocks which are isotropic and rocks which had a foliated structure, were subjected to high strain rate tensile loading. The study brought out valuable insights into the formation of fractures in rocks. The kinetics involved in texture development in Al-Mg alloy was investigated when the alloy was subjected to high strain rate tensile loading. High speed DIC was used to obtain the full field strain history in the specimen so that subsequent texture analysis can be correlated to the accumulated strain in the specimen. This work was in collaboration with Department of Material Science and Engineering. HSEML was primarily involved in the high strain rate experiments High entropy alloys (HEA) are a recent innovation. Deformation behaviour of FCC CoCuFeMnNi single phase high entropy alloy (HEA) was studied at strain rate of 0.001/s and 3000/s in collaboration with the Department of Material Science and Engineering. The material showed high strain rate hardening as well as higher strain hardening due to the operation of deformation twinning which was observed from EBSD of tested samples.
2017-2018	The response and failure of fiber metal laminates (FML) subjected to high strain rate tension was investigated. FMLs having different layer sequences but the same metallic volume fraction was prepared and subjected to high strain rate tension. The evolution of strain and damage was imaged using two high speed cameras. The strength of the FMLs were not significantly different however, relative placement of the metallic layers had an effect on the damage progression. The effect of glass fillers on the high strain rate response of epoxy was studied in collaboration with Department of Aerospace Engineering. The effect of the shape and volume fraction of the glass fillers on the compressive strength was established through this study

2016-2017	The effect of circular perforations on the progressive collapse of circular tubes when subjected to axial impact was studied through experiments and numerical simulation. Hole configurations which can provide peak load reduction without compromising the energy efficiency were identified The effect of metal layer positioning on the tensile response and damage progression of FMLs when subjected to quasi-static tensile loading was studied. The relative position of the metallic and composite layers had a significant influence on the post peak response. Numerical simulations were also performed to gain more insight into the mechanics involved. The effect of metal layer positioning on the energy absorption and damage progression of FMLs when subjected low velocity impact loading was studied. The relative position of the metallic and composite layers had a significant influence on the damage progression. Numerical simulations were also performed to gain more insight into the mechanics involved.
2015-2016	The effect of multiple perforations on the collapse characteristics of stubby cylinders was investigated through SHPB experiments and FE simulations. Fracture propagation in layered plates having elastic mismatch when subjected to in-plane dynamic bending was studied. An analytical investigation was carried out to understand the effect of elastic gradient along the crack front on the crack-tip fields for a propagating crack in a graded material



Material	Compressive Strength (GPa)	Hardness (GPa)	Fracture toughness (MPa-m$^{1/2}$)
TiB_2-10%Ti	4.6 ± 0.6	41.7 ± 2.9	11.8 ± 1.4
TiB_2-20%TI	4.0 ± 0.4	38.0 ± 2.3	12.1 ± 1.1
Bi-layer	3.7 ± 0.4		





$$\sigma_{rr} = \sigma_{\theta\theta} = \frac{E_2\nu_1 - E_1\nu_2}{E_2(1-\nu_1)+E_1(1-\nu_2)}\sigma_{zz} = \alpha\sigma_{zz}$$

- When σ_{zz} is compressive, σ_{rr} and $\sigma_{\theta\theta}$ will be tensile in the stiffer layer (layer 1)

- Tensile stresses in the stiffer layer because of the elastic mismatch can adversely affect the compressive strength of the bi-layer composite

Figure #1: Weaking of bi-layer ceramics due to elastic mis-match

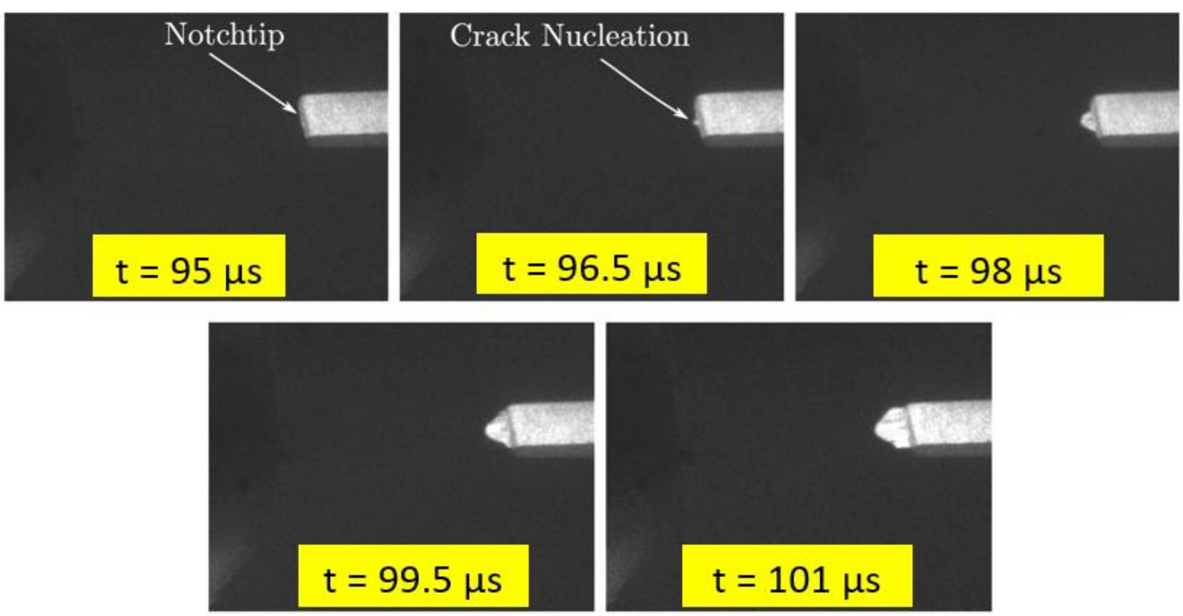


Figure #2: Crack nucleation and growth in PMMA under impact loading

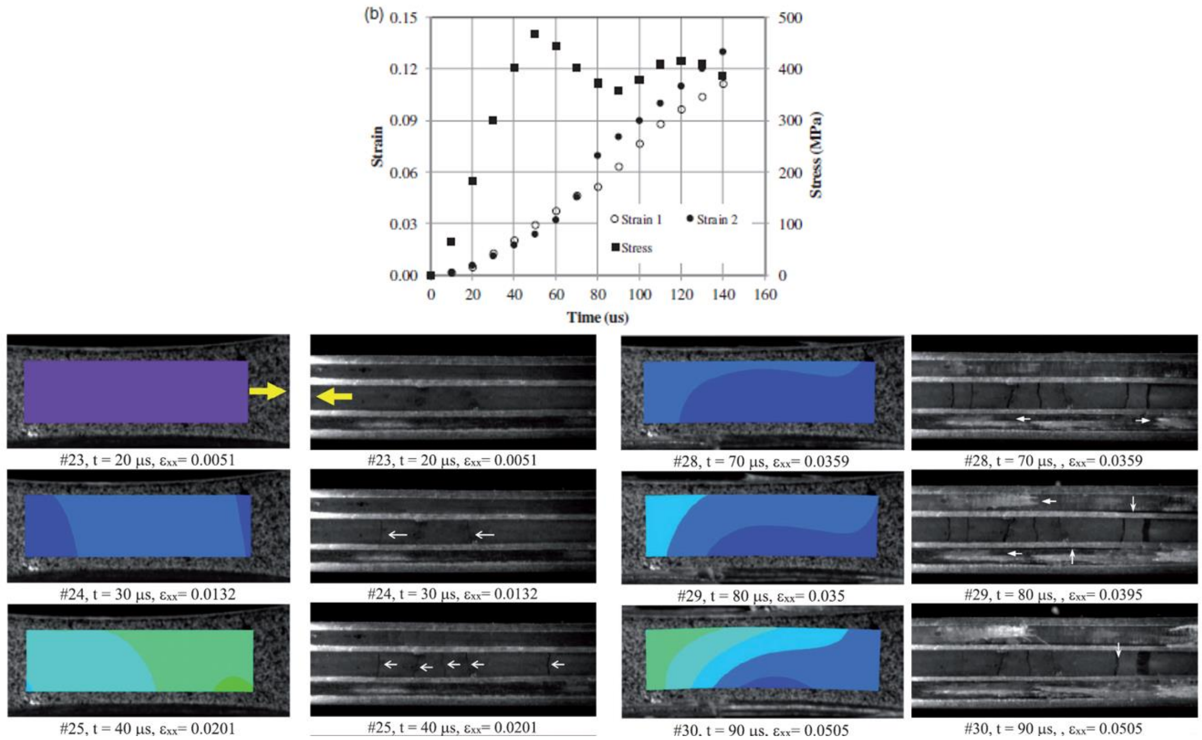


Figure #3: Strain and dagame correlation in FML under high strain rate tensile loading

Condition Monitoring Laboratory

Laboratory Coordinator: Dr. N. S. Vyas

List of Major Equipment:

- Automotive Brake-Testing Test Bed
- Automotive Steering System Test Bed
- Instrumented 4-wheeler (Indica Car)
- Multi-Channel Instrumentation System for Vibration, Pressure, Temperature sensing
- Rotor Test Beds
    - Bentley-Nevada
    - Spectraquest
    - Local make

Brief description of the laboratory:

The laboratory has been involved with the National Programs in Automotive, Railways and Rotor Dynamic Research. Major areas include

(a) analytical modelling

(b) simulation studies on industrial platforms

(c) experimental validation and parameter estimation

(d) inverse problems

(e) neural networks for condition monitoring

(f) deep learning for big system level data

Laboratory research keywords:

Vehicle Dynamics, Rotor Dynamics, Condition Monitoring, Neural Networks, Deep Learning, Integrated Vehicle Health Monitoring

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	Industry 4.0 for Rail Coach Manufacturing
2019-2020	Deep Learning Protocols for Rotor Bearing Systems
2018-2019	Rail-Wheel Dynamic Studies for Indian Railways
2017-2018	RuTAG Projects on Portable Food Processing Units
2016-2017	IC Engine Structural Health Monitoring
2015-2016	Vehicle Dynamics Instrumentation & Control Brake System Health Monitoring Steering System Health Monitoring

Characterization Facilities

Department of Mechanical Engineering
Indian Institute of Technology Kanpur
Kanpur 208016

FIST Facility on Additive Manufacturing

Laboratory Coordinator: Dr. Arvind Kumar

Associated Faculty Members (if any): Dr. Shakti Singh Gupta, Dr. Jishnu Bhattacharya, Dr. Niraj Sinha, Dr. J. Ramkumar

List of Major Equipment:

- Metal additive manufacturing equipment (make: ConceptLaser) with accessories (Wet separator, Nitrogen flow generator, Sieving station, Micro-blasting machine, Furnace)

Brief description of the laboratory:

The laboratory has a facility for 3D printing of metals based on powder bed fusion additive manufacturing. The research focus is on development of comprehensive multiscale (from particle to part) and multiphysics predictive tools to enable model-based control for design and manufacturing for 3D metal printing. Cutting edge experimental and numerical research activities are being performed in the areas of (i) computational modelling of the PBF additive manufacturing process, (ii) experimental studies on the printed samples characterizing meltpool, porosity, layer bonding, microstructure and data for model development and (iii) implementation of additive manufacturing to make complex parts for industrial applications in aerospace and automotive industries. The comprehensive approach, that includes development and implementation of benchmarks, state-of-the-art computational models, validations with controlled laboratory experiments, and process development, is helping to acquire advanced scientific understanding, and predictive and control capability for defects and microstructure in additive manufacturing process.

Laboratory research keywords:

Metal additive manufacturing; Powder bed fusion; Laser-matter interaction; Particle-scale modelling; Meltpool; Free surface tracking; Solidification; Inter-layer binding; Keyhole mode melting; Porosity.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	• High-fidelity ray tracing heat source model is developed for laser-matter interaction. Using an Open MPI algorithm this is coupled to the Laser Powder Bed Fusion (L-PBF) additive manufacturing process model to predict melt pool hydrodynamics and thermal behaviour during laser-matter interaction, and grain structure in the solidified build. • Processed bimetallic-structure using laser powder bed fusion technique. • Additive manufacturing of aerospace component. • 3D metal printing with aluminium powder.
2019-2020	• Developed open-source tool for predictions in metal additive manufacturing.

	• The predictive tool incorporates particle-scale modelling by coupling the optical and the thermo-hydrodynamical phenomena of the L-PBF additive manufacturing process. Physical phenomena namely beam-internal reflection and beam-trapping in the powder bed and the keyhole, thermo-capillary flow, evaporation-induced recoil pressure, and different phase changes (melting, vaporization, solidification) are incorporated. • Incorporated this tool for another metal additive manufacturing process namely Laser Directed Energy Deposition (L-DED).
2018-2019	• Developed predictive macroscopic modelling and simulation of Laser Powder Bed Fusion additive manufacturing process. • 3D metal printing with stainless steel powder. Optimized the process window to print dense and defect-free parts.
2017-2018	• A state-of-the-art facility for 3D Metal Printing is established.

Figure #1: Photograph of Laser Powder Bed Fusion (L-PBF) based metal additive manufacturing system along with accessories.

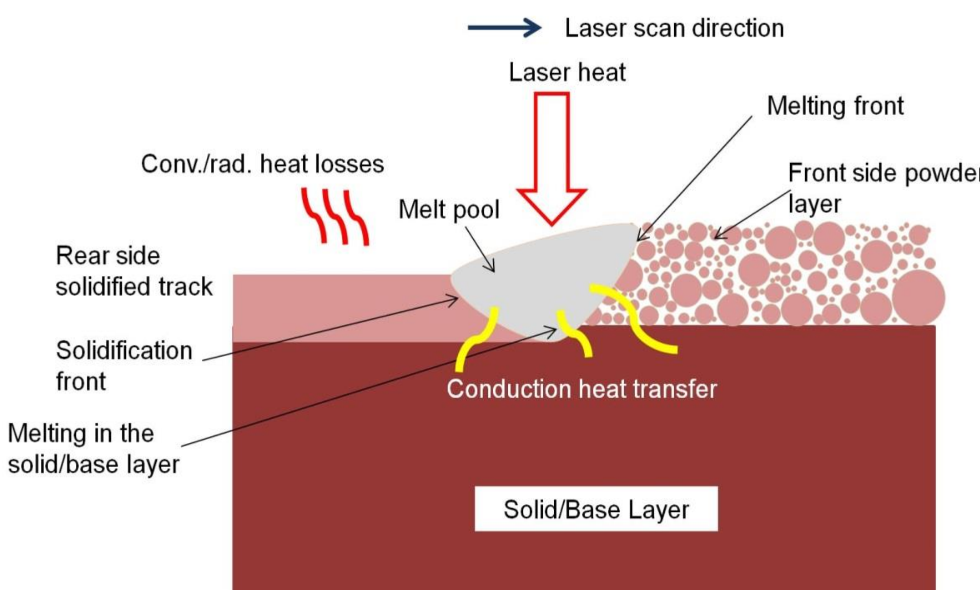


Figure #2: Coupled thermal-physical-metallurgical phenomena during laser - powder material interaction.

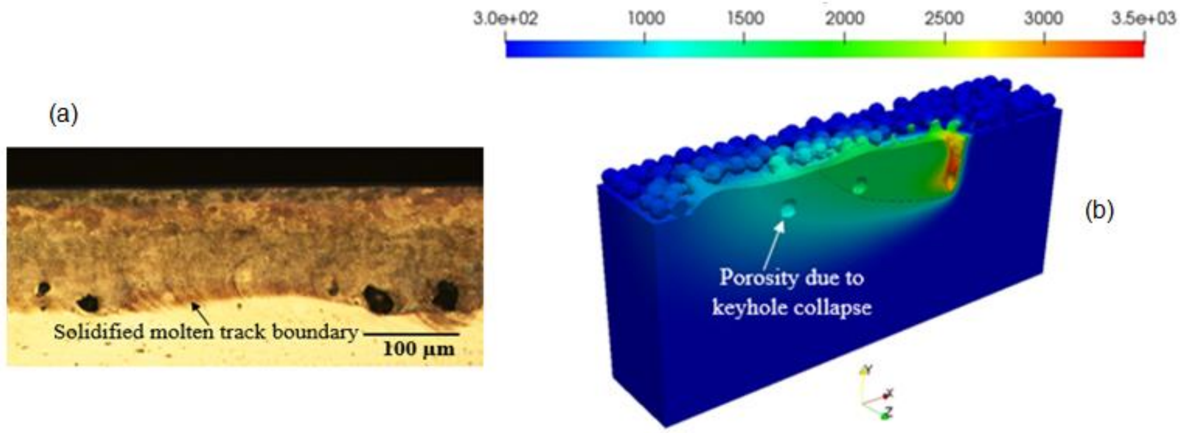


Figure #3: (a) Longitudinal cross section of deposited single track showing porosity formed during Laser Powder Bed Fusion (L-PBF) of IN718 (P = 100 W, scan speed = 500 mm/s). (b) Temperature field (longitudinal cross-sectional view, in K) and the porosity formation. Collapse of the vapour cavity formed by the evaporation of the metal results in a trail of voids (known as as-solidified porosity) in the wake of the laser beam.

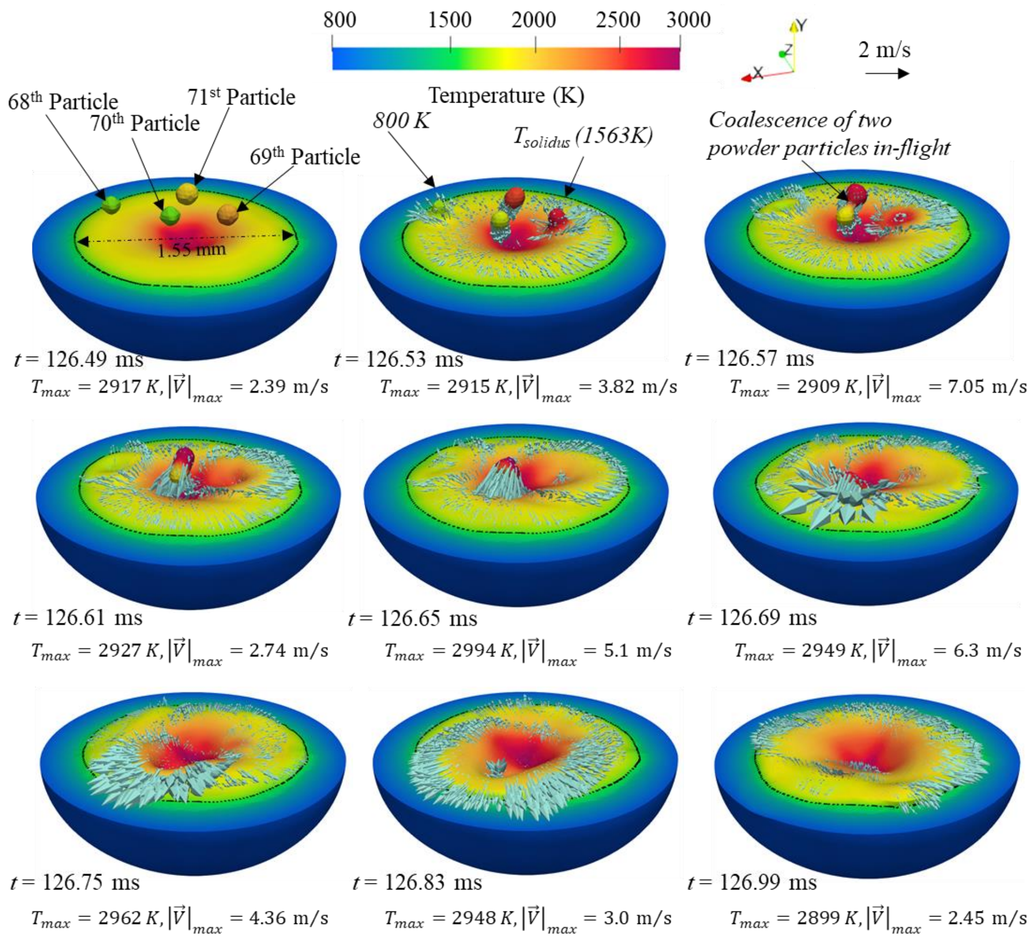


Figure #4: Particle - melt pool interaction in Laser Directed Energy Deposition (L-DED) metal additive manufacturing process. Temperature field with superimposed velocity vectors during 126.49 ms to 126.99 ms timeframe of particle impingement is displayed. Such interaction causes highly transient variation of temperature and melt velocity.

Water Tunnel Facility

Laboratory Coordinator: Dr. Arun K. Saha

Associated Faculty Members (if any):

List of Major Equipment:

- Closed Circuit Water Tunnel Facility (maximum flow speed is 1 m/s) with a test section of 1.0m × 0.4 m × 0.4 m.
- Laser Doppler Velocimetry (LDV)
- Hot-wire Anemometer
- Load-Cell
- Laser Induced Fluorescence (LIF) System
- Smoke and Dye Visualization Facility
- Argon-Ion Continuous Laser
- Solid State Continuous Laser
- Nd-YLF High Speed Laser
- Two-dimensional Two-component (2D2C) Particle Image Velocimetry
- Two-dimensional Three-component (2D3C or Stereo) Particle Image Velocimetry
- Three-dimensional Tomographic (4 high speed camera-3D) Particle Image Velocimetry

Brief description of the laboratory:

The water tunnel facility is used for the various fundamental as well as industrial research. Since the laboratory has various state-of-the-art equipment, different research such as the investigations of the pollution dispersion from a chimney stack or effluent discharging into a river or ocean, skin friction reduction from an underwater vehicle, electronic chip cooling using synthetic jet etc.

Laboratory research keywords:

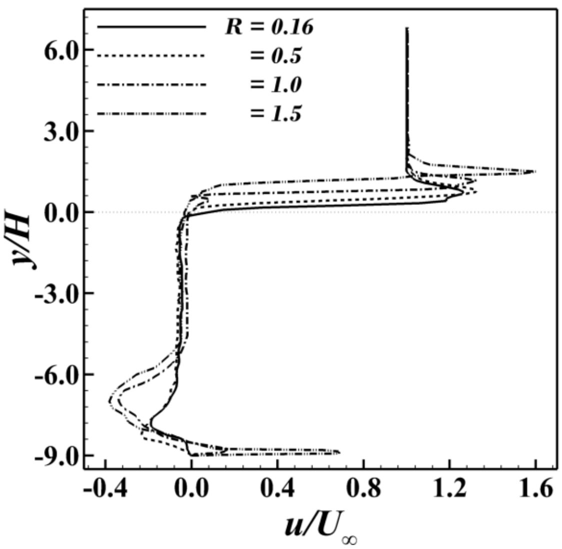
LDV; PIV; Hotwire anemometry; LIF; Bulk flow visualization, Synthetic jet, Elevated jet, Torpedo model

Major Research and Development Contribution of the Laboratory

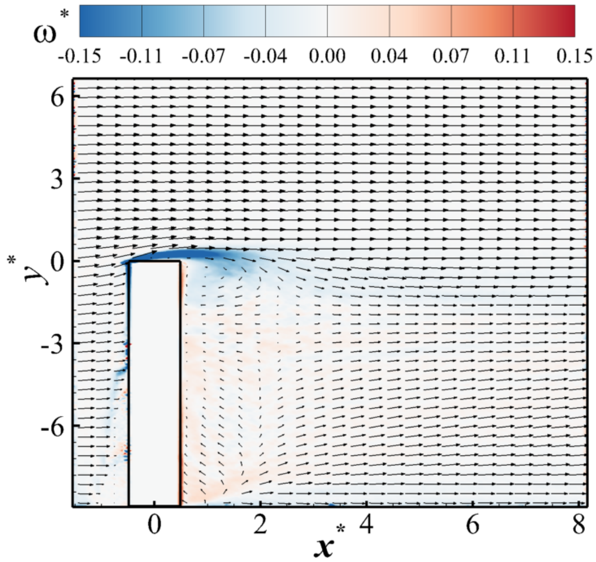
Year	Major research and development activity
2022 - 2023	• 2D PIV for Investigation of pollutant dispersion from a chimney. • Wake analysis of elevated jet in crossflow using LDV at different streamwise locations and velocity ratio. • Machine learning based control of heat transfer using synthetic jet.
2021-2022	• 2D PIV and 3D Tomographic PIV of elliptical and circular synthetic jet. • 2D PIV for skin friction drag from a slender underwater • LIF experiments were conducted to capture the vortical structures within the stack. • Laser based planar flow visualization was performed to highlight

	vortical structures in a plane. The corresponding temperature measurement was performed using thermocouples and Infrared thermography.
2020-2021	• LIF experiments were conducted to capture the vortical structures involved in elevated jet in crossflow. • Frequency response of synthetic jet was studied using Hot wire anemometry. Experiments were performed to investigate heat transfer performance of synthetic jet under effect of stroke length.
2019-2020	• Wake analysis of elevated jet (chimney) in crossflow using LDV at different flow conditions. • Laser based planar flow visualization was performed to highlight vortical structures in a plane. Characterization of synthetic jet was performed using Laser doppler velocimetry.
2018-2019	• Bulk flow visualization for Investigation of pollutant dispersion from a chimney. • LIF of flow control over torpedo model using synthetic jet. • Smoke flow visualization experiments were conducted to highlight the vortical structures involved in synthetic jet impinging on flat heated and isothermal surfaces. The corresponding temperature measurement was performed using thermocouples and Infrared thermography.
2017-2018	• Bulk flow visualization of flow control over torpedo model using synthetic jet in crossflow. • PIV study for characterization of synthetic jet with rectangular orifice.
2016-2017	• Laser Doppler Velocimetry for quantification of skin friction drag from a slender underwater using an active flow control technique: the use of synthetic jet. • Study of rectangular synthetic jet using LIF.
2015-2016	• Laser Doppler Velocimetry for quantification of skin friction drag from a slender underwater using an active flow control technique: the use of synthetic jet.

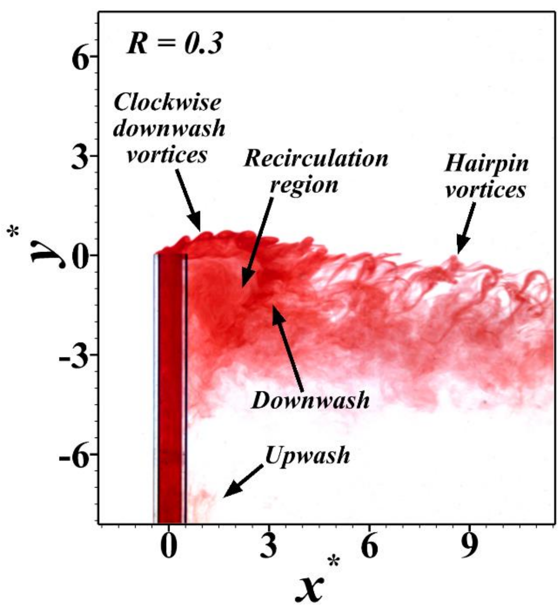
R&D results

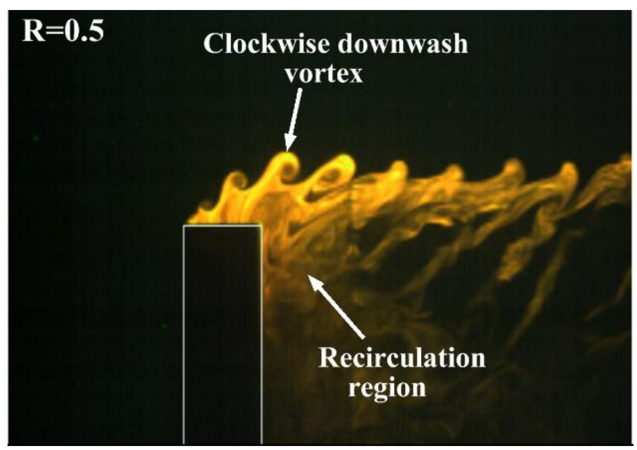


- LDV Results, Effect of velocity ratio in Summetric plane [2].



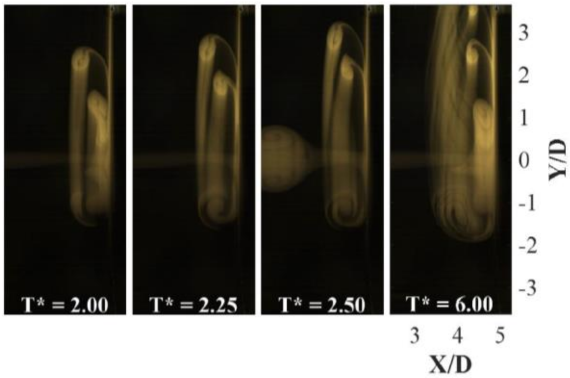
(b) PIV Study of Elevated jet in crossflow in symmetric XY plane at velocity ratio R = 0 [2].



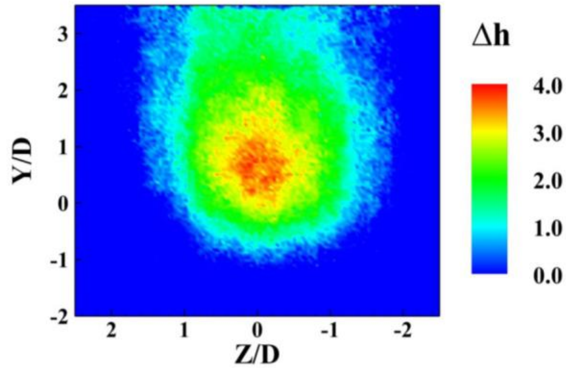


(c) Instantaneous dye-visualization flow pattern of clockwise downwash vortices at *R* = 0.3 [2].

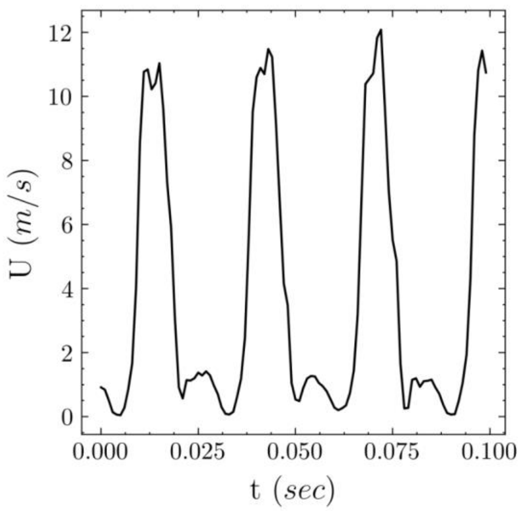
(d) LIF Flow visualization of stack-jet in water tunnel at R = 0.5 [2].



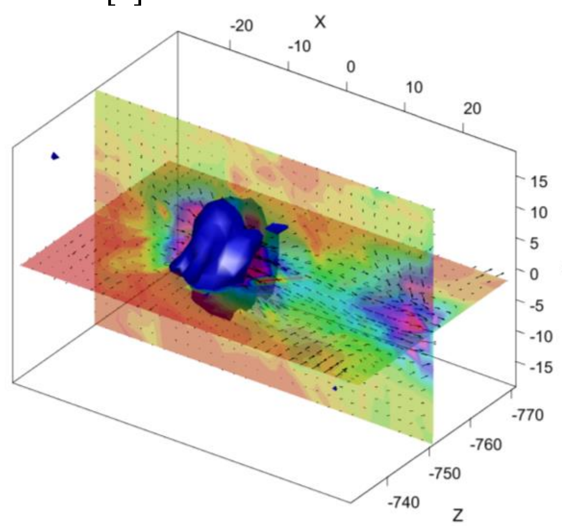
(e) Instantaneous smoke-visualization flow structures of synthetic jet impingement on the heated surface [3].



(f) Infrared thermography of heat transfer by synthetic jet impingement on the heated surface [3].



(g) Synthetic jet center-line velocity at Re = 2429 and L/D = 11.5, using hot wire anemometry [3].

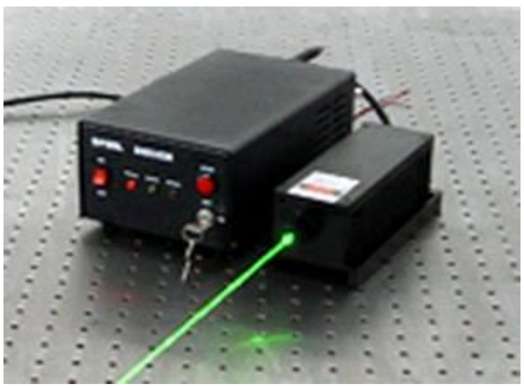


(h) Three-dimensional Tomo-graphic PIV of isolated synthetic jet [2,3,4].

R&D facility

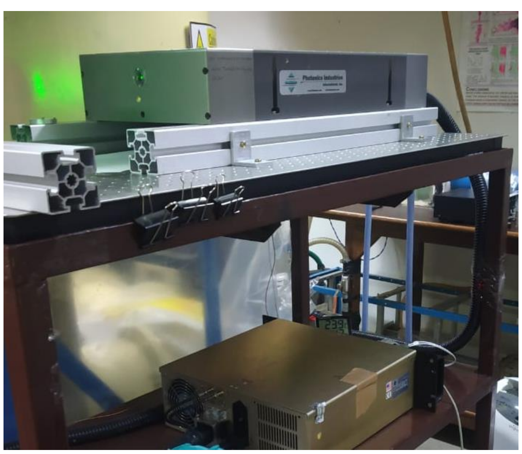
Water Tunnel

Stereo (2D3C) PIV setup



Solid State Continuous Laser

Hot wire/ Film



Nd: YLF High Speed Laser

Laser Doppler Velocimeter

Thermal Characterization Facility

Laboratory Coordinator: Dr. Sameer Khandekar

Associated Faculty Members (if any):

List of Major Equipment:

- Thermal Diffusivity: Nano Flash Thermal Diffusivity Testing Apparatus (LFA 447)
- Thermal conductivity: Hot Disk Thermal Constants Analyser (TPS 500) for the measurement of Thermal conductivity.

Brief description of the facility:

The facility is widely being utilized by users of IIT Kanpur, other institutions and industrial research. Our laboratory has two state-of-the-art equipment, for the measurement of thermal conductivity, thermal diffusivity, and specific heat capacity of the solid, semi solids and liquid sample. Thermal characterization can be done for metal, nonmetals, insulating material, ceramic, epoxy etc.

Thermal Constants Analyser:

The Hot Disk TPS 500 Thermal Constants Analyser combines the flexibility for characterizing thermal properties of various materials quickly and accurately measures thermal conductivity, thermal diffusivity and specific heat capacity of an extended range of materials. We can measure the thermal transport properties of solids, pastes, gels and powders and encompasses similar accuracy and sample size flexibility as the instruments designed according to ISO 22007-2. The test & analysis software for the system incorporates tools for automated measurements. The software also includes tools for exporting results to MS Excel.

Technical Specifications:

Thermal Conductivity	0.03 to 100 W/m/K using standard isotropic method. 5 to 200 W/m/K using slab or one-dimensional methods.
Thermal Diffusivity	0.02 to 40 mm^2/s using standard isotropic method. 2 to 100 mm^2/s using slab or one-dimensional methods.
Specific Heat Capacity	0.10 to 4.5 MJ/m^3K.
Measurement Time	2.5 to 2560 seconds.
Reproducibility	2 % (thermal conductivity). 10 % (thermal diffusivity, sensor radius 6.4 mm). 12 % (volumetric specific heat, sensor radius 6.4 mm).
Accuracy	Better than 5 % (thermal conductivity).
Smallest Sample Dimensions	3 mm × 8 mm diameter or square for bulk testing. 0.1 mm × 12 mm diameter or square for slab testing. 10 mm × 5 mm diameter or square for one-dimensional testing.
Largest Sample Size	Unlimited.
Sensor Types Available	Kapton-insulated sensors 7577 (radius 2.0 mm), 5465 (radius 3.2 mm) and 5501 (radius 6.4 mm)

Nano Flash Thermal Diffusivity Testing Apparatus (LFA 447):

The laser flash method is capable of non-contact measurements of thermal diffusivity and thermal conductivity of solid, semisolids and liquid samples.

Thermal diffusivity (α)

The LFA 447 apparatus gives us direct experimental value of thermal diffusivity between the range of 0.1 to 1000 mm2/s of various materials, preferably at room temperature i.e., 250C. The measurement is possible for elevated sample temperatures also.

Thermal Conductivity (λ)

It is common practice to determine thermal conductivity from measurements of thermal diffusivity, assuming that specific heat and density data are available. Once experimental value of α is achieved then thermal conductivity may be calculated by using appropriate equations.

Technical Specifications:

Standard Sample Size	up to 25.4 mm (1") diameter, or 8 mm / 10 mm / 12.7 mm square, up to 3 mm (0.12") thick
Temperature Range	Ambient to 300°C
Thermal Diffusivity Range	0.01 mm2/s to 1000 mm2/s
Thermal Conductivity	0.1 W/(m·K) to 2000 W/(m·K)
Repeatability	Thermal Diffusivity: +/-2 %, Specific Heat: +/-3 %
Accuracy	Thermal Diffusivity: +/-3 %, Specific Heat: +/-5 %
Flash Source	Xenon Flash Lamp, wavelength: 150 nm to 2000 nm Pulse Energy: up to ≈10 Joules (selectable)
Sensor Type	InSb IR Detector with integral dewar

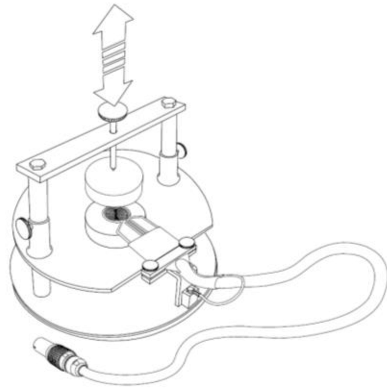
Laboratory research keywords:

Thermal conductivity, thermal diffusivity, specific heat capacity, LFA, TPS, hot disc,

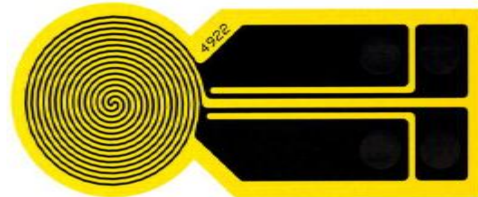
Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2022 - 2023	Test samples from across IIT Kanpur, other institutions and industries has been undertaken continuously since the establishment of the facility in the year 2014 onwards.
2021-2022	Measurements conducted to support research on copper wick-based loop heat pipe for thermal management of a high-power LED module. Testing of samples from NITs, CFTIs for thermal conductivity/diffusivity.
2020-2021	Testing of nano-polymeric samples. Measurements for studying the effect of wick oxidation on the thermal performance of a copper-acetone loop heat pipe.
2019-2020	Measurement of thermal constants from samples sent from across India; various materials; composites; CNT based products etc. \
2018-2019	Effect of Surface Inclination on Filmwise Condensation Heat Transfer During Flow of Steam– Air Mixtures.
2017-2018	Measurements conducted for understanding the thermal-fluidic transport characteristics of bi-porous wicks for potential loop heat pipe systems. Testing done for ISRO projects/ BARC projects/ NET samples.
2016-2017	Measurements conducted on porous wicks for developing miniature ammonia loop heat pipe for terrestrial systems.
2015-2016	Measurement of thermal conductivity of various condensing surfaces for supporting research work on steam condensation inside reactor containment structures.

R&D facility

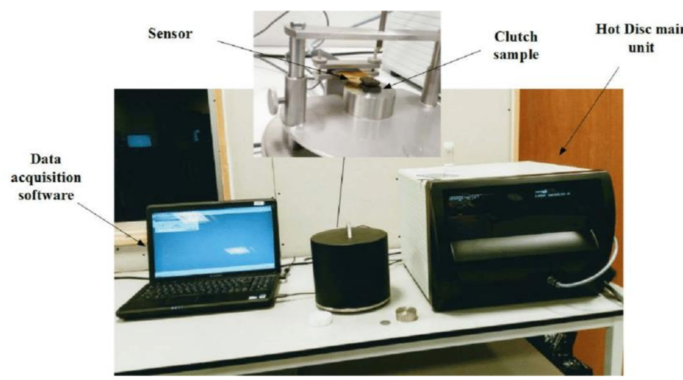


Room-Temperature sample holder with reference sample.



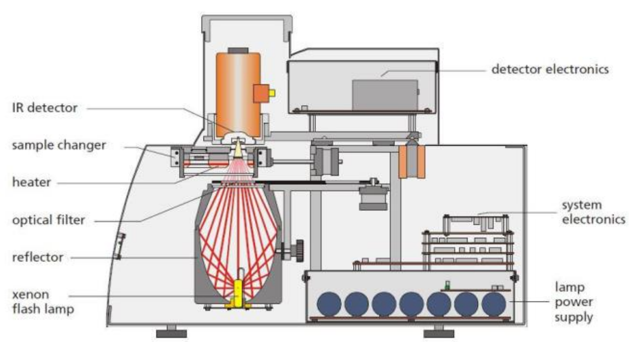
Self-heating temperature probe

Photograph of the TPS 500



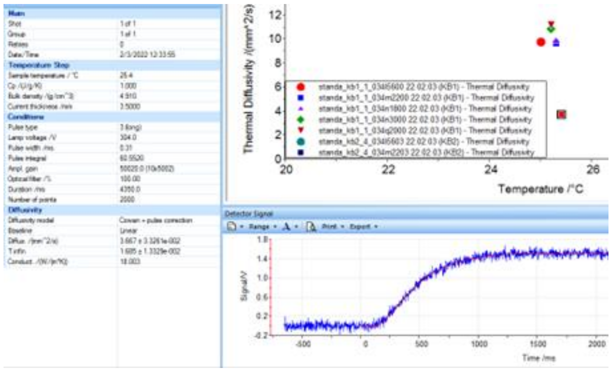
TPS 500 Set up

Photograph of the LFA 447 facility

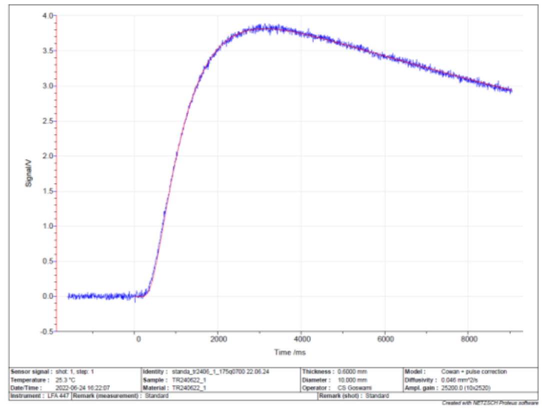


LFA System

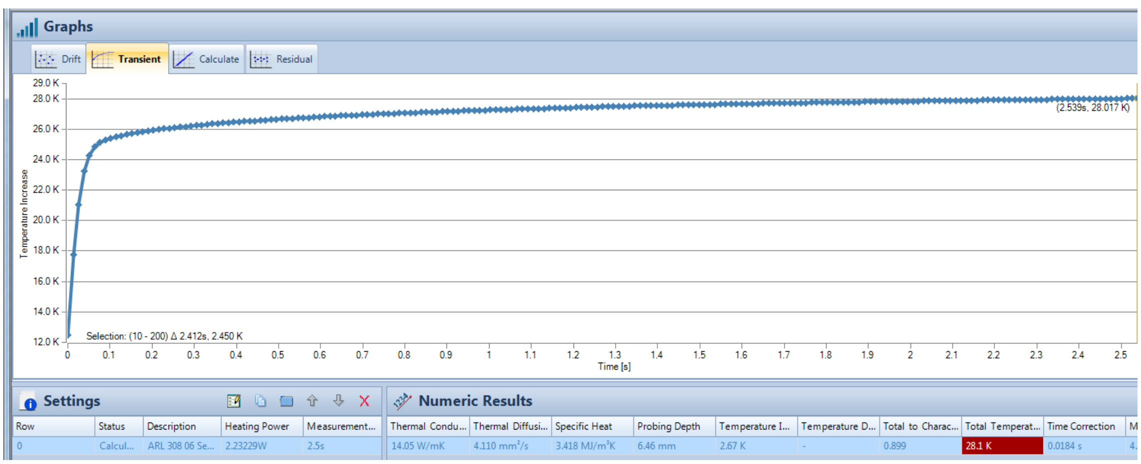
Results and Data



Test Results LFA



Test Graph LFA



Test results TPS

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Papers published in past seven years (year wise) with details of co-authors and ranking of journals / conferences

Details \ Year	2015	2016	2017	2018	2019	2020	2021	**2022**
#Papers published	133	151	147	194	211	212	239	75
#Papers with department co-authors	10	18	22	34	29	23	25	04
#Papers with institute co-authors outside dept	26	28	36	56	68	62	52	16
#Papers with co-authors outside institute	59	82	44	86	132	96	162	12
#Papers with student co-authors	**34**	**38**	**58**	**66**	**66**	**63**	**51**	**16**
# Citations in Web of Science	**76**	**389**	**751**	**1372**	**2447**	**3438**	**4909**	**3174**

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Sponsored research projects in past seven years

Sl No.	Project Sponsor	Start Date	Sanctioned Amount (INR)	Expiry Date	Principal investigator	Co-Principal investigator	Project Title
1	**SERB**	22-03-2022	7988200	21-03-2025	Avinash Kumar Agarwal	Ashish Dutta	Low-Temperature Combustion and Conventional Diesel Combustion (CDC) Engine Development Using Modified Piston and Variable Swirl Control Strategies
2	**SERB**	16-03-2022	3543760	15-03-2025	Pradipta K Panigrahi		Novel Micro DBD Plasma Actuators for Enhancement of Wind Turbine Performance
3	**SERB**	24-01-2022	7073000	23-01-2025	K Muralidhar	Sameer Khandekar	Dropwise Condensation of Water Vapor Over Patterned Surfaces
4	**SERB**	28-12-2021	3122900	27-12-2023	Umesh Madanan		Fine-Grained Porous Media Convection at High Rayleigh Numbers
5	**SERB**	21-12-2021	6996264	20-12-2024	Arun Kumar Saha	Alakesh Chandra Mandal	Experimental Study of Flow Characteristics of Elevated Jet in Crossflow at Moderate Reynolds Numbers
6	**SERB**	21-12-2021	3284688	20-12-2024	Subrata Sarkar		investigations on Drag-Reduction Characteristics By Bio-inspired Micro-Textured Surface for Varying Flow Environment
7	**MOT**	17-06-2021	15500000	16-06-2024	Sameer Khandekar	K Muralidhar	Engineering Fibers for Fog Harvesting and interfacial Solar Water Purification
8	**DST**	30-03-2021	3316800	29-03-2023	Janakarajan Ramkumar	Amandeep Singh Oberoi	Design Development of Sabjokothi, a Preservative Setup for use for Vegetable/Fruit Vendors
9	**DST**	26-	3277760	25-	Malay Kumar	Pradipta K	A Coupled Multiphase

		03-2021		03-2023	Das	Panigrahi	Flow, Heat Transfer and Geomechanics Solver with Ai Based Smart Predictor-Optimizer Tools for Porous Media Applications
10	**SERB**	26-03-2021	7101820	25-03-2024	Sameer Khandekar	K Muralidhar	Thermosyphon Based Passive Interfacial Solar Steam Generation for High-Productivity Desalination
11	**SERB**	25-03-2021	4492400	24-03-2024	Jishnu Bhattacharya		Building a Prototype of an NESMD Based Solar-thermal Water Distillation System and Developing the analysis Model thereof
12	**SERB**	25-03-2021	2653750	24-03-2024	Mohit Subhash Law		Vision Based Modal analysis of Machine Tool Systems
13	**DST**	09-03-2021	5204018	08-03-2024	Avinash Kumar Agarwal	Ashish Dutta	Prototype Development and Experimental investigation of Cng Fueled Direct injection Spark Ignition Engine
14	**SERB**	09-03-2021	7856400	08-03-2024	Santanu De		Investigation of Effects of Shear and Stratification on Swirling H2/Cng- Air Flames
15	**SERB**	28-12-2020	660000	27-12-2023	Shakti Singh Gupta		Eigenfunction Localization in Gradient Elastic Micro-Nano-Plates
16	**SERB**	19-12-2020	3073400	18-12-2022	Manjesh Kumar Singh		Roughness, Adhesion and Friction: a Computer Simulation and Experiment Approach
17	**CSIR**	15-11-2020	2616000	14-11-2023	Arvind Kumar		Experimental and Computational analysis of Concentration Polarization induced Fouling in Reverse Osmosis (Ro) Feed Channel

18	**SERB**	06-11-2020	3289000	05-11-2022	Anikesh Pal		Experimental and Numerical investigations of the Dynamics of Walking Droplets
19	**STC**	07-10-2020	1422000	06-10-2022	Anurag Gupta		Biomechanical Aspects of Plant and Root Growth in Microgravity Environments
20	**BRNS**	29-09-2020	2888750	28-03-2022	Anikesh Pal	Harshwardhan Hemant Katkar	Accelerating Screening and Repurposing of Drugs for the Sars-Cov-2 Virus using Artificial intelligence
21	**DST**	14-09-2020	4326297	13-09-2023	Avinash Kumar Agarwal		Development of Primary Alcohols Fueled Engine Prototype
22	**CEAT**	26-05-2020	3086880	25-05-2023	Nachiketa Tiwari		Tire Modeling and Testing
23	**DST**	07-05-2020	8674955	04-11-2022	B Bhattacharya		Design and Development of Autonomous Robot for Crop-Monitoring and Localized Pest Neutralization
24	**SERB**	19-03-2020	1830400	18-03-2023	Pankaj Wahi		Investigation of instabilities and Vibrations in Cables and Belts Travelling Over Pulleys
25	**DST**	02-03-2020	2677950	01-03-2023	Satyabati Das		Flexible Hybrid Nano Generators Towards Large-Scale Green and Renewable Energy Harvesting
26	**SERB**	25-02-2020	5920400	24-02-2023	Avinash Kumar Agarwal	Tarun Gupta	Highly Efficient, Low Emission Gasoline Compression Ignition Engine Prototype Development
27	**MHRD**	24-02-2020	3227000	23-02-2023	Anurag Gupta		On Some Challenging Boundary-Value-Problems Arising in Vibro-Acoustical Study of

							Indian Musical instruments
28	**DST**	19-02-2020	25040080	18-02-2023	Santanu De	Ashoke De	Design, Development, Testing and Evaluation of a Lean-Premixed Swirl Stabilized Gas Turbine Combustor for Stationary Power Generation Using High-Hydrogen-Content Fuel
29	**SERB**	14-02-2020	660000	13-02-2023	Anurag Gupta		Topological Transformation of Elastic Surfaces
30	**STC**	01-02-2020	2592000	31-10-2022	Sumit Basu	Nandini Gupta	Development and Evaluation of Multiscale Cnt/Polymer Composites
31	**SERB**	23-01-2020	15972000	22-01-2023	Avinash Kumar Agarwal	Tarun Gupta	Ultra-Clean Emissions DME Fueled Tractor Engine Prototype Development for Agricultural Applications
32	**ORDINANCE FACTORY KANPUR**	13-01-2020	3889400	12-01-2022	Nachiketa Tiwari		Study of Pressure Wave Effects in Barrels for Artillery Guns
33	**INAE**	01-04-2020	5700000	31-03-2023	S. Bhattacharya		Abdul Kalam Tech. Innovation Fellowship
34	**SERB**	30-12-2019	2994260	29-04-2022	Akhilesh Mimani		Resolving Airfoil Self-Noise Mechanism Using Diagnostic Acoustic Imaging Tool
35	**SERB**	30-12-2019	3037100	29-06-2022	Supratik Mukhopadhyay		Experimental and Numerical investigation into the Longitudinal Compressive Failure of Carbon Fibre Reinforced Composites

36	**SERB**	24-12-2019	3079200	23-06-2022	Pranav Ramkrishna Joshi		Exploring an Alternate Route to Geostrophic Turbulence Through instability
37	**DST**	01-10-2019	166384000	30-09-2022	N S Vyas	Brij Mohan Shukla, Navpreet Singh, Ishan Sharma, Nischal K Verma	Pilot Project on Development and Implementation of industry 4.0 Protocols for Rail-Coach Design and Manufacturing at Modern Coach Factory, Raebareli
38	**BIRAC**	30-07-2019	45802000	29-07-2023	Janakarajan Ramkumar		Establishment of a State-of-the-Art Facility for Design and Fabrication of Medical Devices and Equipment with in House Quality Control System for Cultivating a Local Production Hub of Medical Grade Te
39	**SERB**	04-07-2019	13600000	31-01-2021	Gautam Biswas		J C Bose National Fellowship
40	**SERB**	24-06-2019	3616800	23-12-2022	Chandraprakash Chindam		Soft Acoustic Metamaterials: Fabrication, Computation and instrument Development
41	**SERB**	22-05-2019	2391200	21-11-2022	Sumit Basu	Nandini Gupta	Investigation into the Correlation Between Porosity, Mechanical Properties and Performance of Supercapacitors Based on Vertically Aligned Carbon Nanotube Arrays
42	**SERB**	15-05-2019	4766510	14-05-2023	Sachin Y. Shinde		Effect of Flexibility in Flapping Foil on Flow and Thrust Generation
43	**DST**	01-04-2019	3500000	31-03-2024	Aditya Saurabh		Enhanced Liquid atomization Through Acoustic Cavitation
44	**DST**	29-03-	4974640	28-03-	P Venkitanarayan		Fracture and Delamination under

		2019		2022	nan		Dynamic Loading
45	**SERB**	28-03-2019	2359500	27-06-2022	Anurag Gupta		Micromechanics of Defects in Thin Elastic Structures
46	**SERB**	26-03-2019	12239040	25-03-2022	Arvind Kumar		Towards Realization of Additive Manufacturing of Aerospace Structural Component in India
47	**MHRD**	15-03-2019	9723515	30-09-2022	B Bhattacharya		Sparc: Vibration Absorption Using Metamaterial Based Composites
48	**MHRD**	15-03-2019	4798775	30-09-2022	Santanu De		SPARC: Lean Premixed Pre-vaporized Combustion of Diesel and Biofuels in a Laboratory-Scale Gas Turbine Combustor
49	**NAVAL RESEARCH BOARD**	14-03-2019	7295000	30-09-2022	Arun Kumar Saha	Pradipta K Panigrahi	Skin-Friction Drag Reduction Through Control of the Turbulent Boundary Layer on Axisymmetric Bodies
50	**DST**	02-01-2019	1860400	30-06-2021	K Muralidhar	Sameer Khandekar	Thermodynamics of Micro-Droplets interacting with Engineered Surfaces
51	**KEHR Industries**	01-03-2019	500000	31-04-2022	Shantanu Bhattacharya		System design for automatic stacking of surgery blades
52	**DST**	24-09-2018	4905000	23-05-2021	Arvind Kumar		Development of Process Map for Additive Manufacturing of Ti6a14v and Inconel Alloys
53	**DST**	01-09-2018	4035744	31-08-2020	Janakarajan Ramkumar		Designing and Developing a Desktop Micro Wire ECM Machine
54	**DST**	10-08-2018	2220328	09-02-2020	N S Vyas		Design/Prototyping of Machinery for Achieving Cleaner Habitat Environ.

55	**DST**	01-08-2018	628000	31-07-2020	B Bhattacharya		Neuro-Cognitive instrumentation of Validated Human-Robot interactions to Enhance Learning and Developmental Processes in Children
56	**OFFICE OF PRINCIPAL ADVISER**	01-08-2018	14103840	31-07-2023	Janakarajan Ramkumar	Brij Mohan Shukla, Sudhansu Shekhar Singh	Rural Technology Action Group (RUTAG)
57	**DST**	01-08-2018	3745840	16-10-2021	Sameer Khandekar		Development of Novel Cooling Systems for High Power LEDs for Enhanced Reliability and Lifetime
58	**SERB**	13-06-2018	660000	12-06-2021	Basant Lal Sharma		Wave Propagation in Lattice Waveguides with Defects
59	**STC**	01-05-2018	6672688	30-11-2022	Nachiketa Tiwari		Stabilization of 3D Platform for Space Applications against Rolling and Pitching Excitations
60	**STC**	16-04-2018	3000000	31-10-2021	Arvind Kumar		Numerical and Experimental Framework for Laser Based Additive Manufacturing of High-Performance Parts of Titanium Alloy
61	**STC**	16-04-2018	3678400	31-07-2020	B Bhattacharya		Shape Memory Alloys Actuated Mechanically Active Reconfigurable Lightweight PEEK material Based Parabolic Reflector for Active Control on RF Patterns for high Frequency Micro/Nano Spacecraft Application
62	**STC**	16-04-2018	2250000	15-04-2020	Malay Kumar Das	Ashoke De	Modeling and Simulation of Lox-Ch4 (Semi-Cryogenic) Combustion

63	**STC**	16-04-2018	1013000	15-07-2019	Santanu De		Numerical investigation of a Kerosene-Fueled Scramjet Combustor Using Rans Based Flamelet Model
64	**SERB**	15-03-2018	4644239	14-03-2022	Ishan Sharma		Contact Mechanics of Soft and Thin Adhesive Structures
65	**GE**	01-03-2018	0	28-02-2023	Arvind Kumar		Evaluating Technology, Exploring Research Opportunities in the Area of Physical and Mechanical Metallurgy of High Temperature Metallic Materials
66	**DST (MES)**	01-04-2018	4000000	31.03.2021	Shantanu Bhattacharya		Inkjet-printed electrodes of Graphene oxide- Metal oxide hierarchical nanostructured nanocomposites for improved energy density and power density thin flexible supercapacitors
67	**ONGC**	29-12-2017	4804480	28-12-2020	Sumit Basu	Arghya Das	Micro-Pore-Mechanical Modelling of Shale anisotropy and Permeability
68	**DST**	27-12-2017	37235000	26-03-2020	Avinash Kumar Agarwal	Tarun Gupta	Design and Retro fitment for Development Methanol Fueled Large Bore Engine (EMD 710: 4500 HP) for Locomotive Marine and Power Generation Application
69	**DST (IDC)**	01-04-2017	4200000	31-03-2020	Shantanu Bhattacharya		A novel labelled electronic gene identification system using impedance spectroscopy for molecular diagnostics of water and food borne pathogens

70	**IUSSTF**	22-12-2017	11143115	30-06-2021	B Bhattacharya		Design and Development of Aquatic Autonomous Observatory (Niracara Svayamsasita Vedhshala-NSVS) for in-Situ Monitoring, Real Time Data Transmission and Web Based Visualization (Sub Project-)
71	**IUSSTF**	22-12-2017	90000000	21-12-2022	B Bhattacharya	Ketan Rajawat, Indrasekhar Sen, Mangal Kothari	Design and Development of Aquatic Autonomous Observatory (Niracara Svayamsasita Vedhshala-Nsvs) for in Situ Monitoring, Real Time Data Transmission and Web Based Visualization
72	**IUSSTF**	30-11-2017	8500000	29-11-2022	Jishnu Bhattacharya		Streaming analytics Over Temporal Variables from Air Quality Monitoring (Satvam)
73	**SERB**	13-10-2017	1995000	12-10-2020	Anirban Guha	Sachin Y. Shinde	Numerical investigation on Wave Activities in the Stratosphere
74	**MHRD**	01-09-2017	35608515	31-03-2022	Nachiketa Tiwari	Janakarajan Ramkumar	Design and Fabrication of a Firing Impulse Generator
75	**MHRD**	23-08-2017	2520000	22-08-2021	Jishnu Bhattacharya		Hybrid Sodium-Ion Cell/Super-Capacitor.... Vehicles
76	**MHRD**	16-08-2017	468500	15-08-2019	Janakarajan Ramkumar		Indigenization and Improvisation of Puncher Gun for Manual Tissue Micro-Array Construction
77	**RDSO**	16-08-2017	1500000	15-11-2017	N S Vyas		Initiation Phase Development of Capability for Testing of High-Speed Rolling Stock
78	**ARDB**	08-08-2017	2752300	31-12-2020	Janakarajan Ramkumar		Experimental and theoretical investigation in Nano-Finishing of Freeform/Sculptured Surfaces

79	**STC**	02-08-2017	1976019	01-08-2019	Shantanu Bhattacharya		Development of a Gas Sensor to Detect Leakage of Helium Gas from inflatable Space Structures
80	**STC**	28-07-2017	840000	27-07-2018	B Bhattacharya		Design Validation of Active Flexible and Reconfigurable Parabolic antenna Using SMA Based Smart Actuator
81	**STC**	28-07-2017	2520000	30-04-2020	Kamal K Kar		Development of High-Power Density Polymer Electrolyte Membrane Fuel Cell (PEMFC) for Space Applications Biomass-Derived Multi-doped Carbon/Multi-helix Carbon Nanotubes (MHCN) Free Catalyst
82	**STC**	28-07-2017	2222000	27-07-2019	Santanu De		Numerical Simulation of Liquid-Sheet Breakup in Gas-cantered Swirl Coaxial atomizers
83	**MHRD**	12-05-2017	924000	11-05-2019	Nachiketa Tiwari		Development of Prosthetic Pinna
84	**MHRD**	12-05-2017	1495000	11-05-2019	Nachiketa Tiwari		Design and Development of Implants for Middle Ear
85	**GAIL**	10-05-2017	20313600	23-10-2021	B Bhattacharya	Pradipta K Panigrahi	Design and Development of Adoptive intelligent PHMR for Fuel Transportation Systems
86	**MHRD**	08-05-2017	1490000	28-03-2019	Janakarajan Ramkumar		Design and Development of Dual Wavelength Led Based Phototherapy Unit
87	**MHRD**	03-05-2017	468500	31-08-2019	B Bhattacharya		Development of a Fibre Optic intubation Device with a Co-Sensor at Its Tip for Facilitation of Endoctracheal intubation

88	**MHRD**	03-05-2017	512539	31-08-2019	B Bhattacharya		Design and Construction of Computer Controlled Automated Radio-Chemistry Synthesizer
89	**MHRD**	03-05-2017	687758	31-08-2019	B Bhattacharya		Designing and Manufacturing of Prototype of Dynamic Endotracheal Tube Holder
90	**DST**	06-04-2017	4664000	05-04-2020	Kamal K Kar		Nanostructured Carbon Decorated with Metal Nanoparticle...thermoelec tric
91	**IFCPAR**	01-04-2017	6539694	31-03-2020	Sameer Khandekar		Loop Heat Pipes for Avionics and Terrestrial Applications
92	**MHRD**	27-03-2017	18980000	30-09-2021	B Bhattacharya	Pradipta K Panigrahi	Design and Development of Adaptive intelligent PHMR for Fuel Transportation Systems MHRD (DST) UAY
93	**SERB**	24-03-2017	4938560	23-03-2020	Santanu De		Mixing and Autoignition of Dimethyl Ether Jets in a Preheated Turbulent Coflowing Air Stream
94	**MHRD**	24-03-2017	750000	31-03-2020	B Bhattacharya	Mohit Subhash Law	Sub Project a of MHRD/Me/2016408u
95	**MHRD**	24-03-2017	20280000	31-03-2022	Mohit Subhash Law	B Bhattacharya, Suparno Mukhopadhyay	Structure integrated Sensors and Actuators to Monitor and Renew Machine Tool Performance
96	**MHRD**	16-03-2017	3700000	15-03-2020	Kamal K Kar		Indigenous Low-Cost Polymer Electrolyte Membrane (PEM) Fuel Cell
97	**MHRD**	15-02-2017	39696000	28-03-2022	Arun Kumar Saha	Malay Kumar Das, Arvind Kumar, a.K. Singh	Development of an Open-Source Solidification/Meeting Simulation Platform -

							Open Sol.
98	**MHRD**	15-02-2017	17000000	31-03-2022	Kamal K Kar	Malay Kumar Das, Md. Jaleel Akhtar, Niraj Sinha	Hierarchically Structured Micro-Nano Pore Nanocomposite Membrane
99	**MHRD**	08-02-2017	19240000	31-03-2022	Santanu De	B Bhattacharya, Shantanu Bhattacharya, Vaibhav Kumar Arghode	Development of Pressurized Dual Fluidized Bed Gasifier for High-Ash India Coal
100	**MHRD**	08-02-2017	40000000	31-03-2022	Santanu De	S. Sarkar, B. Bhattacharya, S. Bhattacharya, J. Bhattacharya	Decentralized Power Generation Using Micro Gas Turbines
101	**SERB**	25-01-2017	4494560	24-07-2020	Mohit Subhash Law		Dynamics and Stability of Circular Sawing: Experimental Characterization, Modelling and Control
102	**DRDO**	01-01-2017	1053120	31-12-2017	Janakarajan Ramkumar		Development of Magnetic Abrasive Finishing (MAF) Technology for CNC Machined Diaphragms
103	**DST**	01-12-2016	12353000	31-05-2020	Shantanu Bhattacharya		installation of a Pilot Plant of 10 Kld Capacity...on Acid Modified Soil
104	**DST**	01-11-2016	38000000	07-03-2022	Sameer Khandekar		Fist Program-2016
105	**ARMREB**	01-09-2016	3602835	31-08-2018	Janakarajan Ramkumar	Deepu Philip, Subrahmanyam Saderla	Modification of Conventional Artillery Rocket to a Guided Rocket with Freely Spinning Tail
106	**STC**	15-08-2016	1536000	31-12-2018	Anirban Guha		Numerical investigations on Surface Gravity Waves and internal Tides
107	**STC**	10-08-	3632000	30-10-	Janakarajan	Kallol Mondal	Surface Texturing on Biocompatible Titanium

		2016		2018	Ramkumar		Alloy to Enhance Adhesion interface Between Dissimilar Materials Using ECMM
108	**DMSRDE**	08-08-2016	965000	31-03-2018	P Venkitanarayanan		Design of Experimental Setup and Evaluation of Mechanical Properties of Ballistic Grade Ceramic Materials under High Strain Rate
109	**ONGC**	02-08-2016	10511000	28-03-2019	Malay Kumar Das	Pradipta K Panigrahi	Optical Diagnostics of Transport Phenomena During Gas Hydrate formation and Dissociation
110	**INSA**	01-08-2016	777600	31-07-2017	Anurag Gupta		On Vibrations and Acoustics in ancient and Medieval India: Focusing on Design and Construction of Indian Stringed instruments
111	**MHRD**	15-07-2016	1500000	14-07-2018	Kamal K Kar	P. K. Panigrahi, Mamta Vyas, Arun Kumar Saha, M. K. Das, Ragunandan Sharma	Prototype Heart Valve
112	**DST /**	10-06-2016	2050000	31-03-2020	Ashish Dutta	K S Venkatesh	Development of a Programmable Robotic Motion Phantom
113	**RDSO**	01-06-2016	1500000	31-08-2016	N S Vyas		Initiation Phase of Development of Testing Capability of High-Speed Rolling Stock
114	**RDSO**	01-06-2016	1500000	31-08-2016	N S Vyas		Initiation Phase of Design of Advance Performance Next Generation Track Friendly Freight Bogies as Well as to Augment in House Capability of RDSO for Optimization and Numerical Analysis of Freight Bog

115	**BOEING**	01-06-2016	9602010	30-11-2022	Shantanu Bhattacharya		Additive Manufacturing of Functionally Engineered Materials
116	**SERB**	04-04-2016	1104000	03-04-2019	Jishnu Bhattacharya		Developing an Efficient Algorithm to Automate Configuration Modelling for Multi Component Materials
117	**PRINCIPAL SCIENTIFIC ADVISER**	01-04-2016	152000	30-11-2016	Janakarajan Ramkumar		RUTAG: Development of a Manually Operated Seed Drill
118	**DST**	31-03-2016	4260000	30-03-2019	Niraj Sinha	Jayant K Singh, Raju Kumar Gupta	Boron Nitride Based Adsorbent for Removal of Arsenic from Aqueous Streams
119	**SERB**	28-03-2016	2010000	27-09-2019	Anindya Chatterjee	Pankaj Wahi	Three Application Areas of a Novel Hysteresis
120	**ARDB**	01-03-2016	1505400	28-02-2019	Ishan Sharma	Shakti Singh Gupta	Stability analysis of Ring Shaped under-stung Loads
121	**CEAT**	25-02-2016	2112000	01-07-2020	Nachiketa Tiwari		Study of Tire Noise and Vibrations
122	**ONGC**	17-02-2016	9972000	16-02-2019	Malay Kumar Das	K Muralidhar	Modeling and Simulation of Methane Extraction from Gas Hydrates Via Simultaneous Depressurization and CO_2 injection
123	**PRINCIPAL SCIENTIFIC ADVISER**	15-12-2015	190000	31-07-2018	Sandeep Sangal		RUTAG Sub Project (Improved Horse Shoe Making Technology)
124	**PRINCIPAL SCIENT**	15-12-2015	250000	31-07-2018	Sandeep Sangal	Kallol Mondal, Naveen Tiwari	RUTAG Sub Project (Development of a thermal Solar Dryer for

	IFIC ADVISER						Food Processing)
125	**PRINCIPAL SCIENTIFIC ADVISER**	01-12-2015	210000	31-03-2021	Janakarajan Ramkumar		RUTAG Sub Project (Design and Development of Amla Pricking Machine)
126	**NATIONAL INSTITUTE FOR RandD IN DEFENCE SHIPBUILDING**	01-12-2015	852000	30-09-2017	Shakti Singh Gupta	Pankaj Wahi	Developing and Validating the Algorithm Suitable for HVAC and Validation for Implementation at Design Stage.
127	**TECHNOLOGY MISSION FOR INDIAN RAILWAYS**	18-11-2015	1980000	31-03-2020	N S Vyas		Seed Money -TMIR (Technology Mission for indian Railways)
128	**MHRD**	02-11-2015	1944000	01-11-2018	B Bhattacharya	Niraj Sinha	HBTI Spoke
129	**MHRD**	02-11-2015	7700000	30-09-2021	Janakarajan Ramkumar		DIC-Pd Lab
130	**MHRD**	02-11-2015	0	01-11-2018	Manindra Agrawal		DIC Outreach
131	**BARC**	15-10-2015	12900000	31-03-2020	Sameer Khandekar	K Muralidhar	Studies on Heat Transfer During Condensation of Steam-Hydrogen Mixtures inside Closed Containments
132	**IGCAR**	01-08-2015	3314580	31-03-2019	Pradipta K Panigrahi		CSRDM Shroud Tube Hydraulics of Control Plug in Fast Breeder

							Reactors
133	**STC**	20-07-2015	600000	19-09-2016	Janakarajan Ramkumar	V K Jain	Surface Texturing on Biocompatible Titanium Alloy for inducing Hydrophobicity Using ECMM
134	**STC**	20-07-2015	3259456	16-11-2018	Nachiketa Tiwari		Vibration Control of Cryo-Coolers Used for Satellite Applications
135	**STC**	20-07-2015	3850000	02-04-2018	Sameer Khandekar	B Bhattacharya	Development of Flexible Heat Pipe Based Passive Thermal Management Platforms
136	**STC**	17-07-2015	1110000	16-07-2018	Anurag Gupta		Growth and Aging of Tissues under Microgravity Environment
137	**GAIL**	01-06-2015	7819520	31-03-2019	B Bhattacharya	Pradipta K Panigrahi	Development of Compressed Air Based Test Bed for Pipe-Line Health Monitoring Robot
138	**DBT**	01-04-2015	4571000	31-03-2018	Saravanan Matheshwaran	Pankaj Wahi	Membrane Curvature Sensing and Generation By Proteins in Lipid Bilayer Membrane

Total Funding: Rs. 110 crores (Sponsored Research) in six-year window

Consultancy in past seven years

S. No.	Project No.	Start Date	Sanctioned Amount	Expiry Date	Principal Investigator	Co-Principal Investigator	Project Title
1	POWER GRID CORPORATION OF INDIA LIMITED	16-02-2022	10789920	15-08-2023	B Bhattacharya	Janakarajan Ramkumar	Development of Substation Inspection Robot
2	SHEELA FOAM LIMITED	01-01-2022	894000	15-06-2022	N S Vyas		Study of Global Fire Safety Standards Used on Rail Transport Applications Across the Globe
3	IMPERIAL TOBACCO COMPANY OF INDIA LIMITED	08-12-2021	837500	07-12-2022	Shakti Singh Gupta		Pack Modelling Project
4	AAKAAR ARCHITECH, ENGINEERS, VALUERS, INTERIOR DESIGNERS	02-12-2021	95875	01-04-2022	Sameer Khandekar	Vinay Kumar Tiwari	Third Party Vetting of Two HVAC Building Designs
5	JPC INFRATECH P LTD.	10-10-2021	88500	12-12-2021	Janakarajan Ramkumar		Construction of 2 No. Water Tanks of 1061 Kl Nominal Capacity Each At Itarsi Depot
6	LOHIA CORP	01-10-2021	1032500	31-12-2022	Mohit Subhash Law	Chandraprakash Chindam	Finite Element Based Design Optimization and Testing of Extruder Frame and Godet Stand
7	UP SMALL INDUSTRIES CORPORATION LIMITED	09-09-2021	423620	31-03-2022	Sameer Khandekar	Vinay Kumar Tiwari	Third Party Quality Inspection of the Medical Gas Pipeline Project Executed By UPSIC In Autonomous Medical College, Shajahanpur (Up)
8	UP PROJECTS CORPORATION LIMITED	16-08-2021	1430750	31-08-2022	Sameer Khandekar	Vinay Kumar Tiwari	Third Party Inspection of Oxygen Plant

9	PUBLIC WORKS DEPARTMENT, LUCKNOW	15-07-2021	855500	14-01-2022	Sameer Khandekar	Vinay Kumar Tiwari	Quality Inspection of Central Air-Conditioning Plant of Indira Bhavan Lucknow
10	AIR FORCE STATION	23-02-2021	177000	22-04-2021	Sameer Khandekar		Thermal Design of Central Air Heating System
11	AIRSHED PLANNING PROFESSIONALS PRIVATE LIMITED	16-02-2021	177000	15-02-2022	Satyabati Das		Micro-Morphological Characteristics and Elemental Composition of Particulate Matter
12	CLIMATENZA SOLAR PVT LTD	29-01-2021	977335	28-10-2021	Jishnu Bhattacharya	Pritam Chakraborty	Testing of Fresnel Lens Concentrator and Design of Support Structure Thereof
13	JPC INFRATECH P LTD.	22-01-2021	200000	21-02-2021	Janakarajan Ramkumar	Rajesh Sathiyamoorthy	J.P. Constructions
14	MITSUBISHI ELECTRIC RESEARCH LABORATORIES	01-12-2020	730000	31-05-2021	Anindya Chatterjee		Contact Models and Mechanics
15	MISCELLANEOUS	01-11-2020	2500000	31-10-2025	Janakarajan Ramkumar		Miscellaneous
16	U. P. RAJKIYA NIRMAN NIGAM	01-10-2020	295000	30-11-2020	Arun Kumar Saha	Vinay Kumar Tiwari	Consultancy - UPRNN
17	TAFE MOTORS	01-08-2020	0	31-07-2023	Avinash Kumar Agarwal		Ultra Clean Emission DME Fuelled Tractor Engine Prototype Development for Agricultural Applications
18	EDCIL (INDIA) LIMITED	17-07-2020	236000	16-08-2020	S K Choudhury		Consultancy for Artificial Intelligence Enabled Internet Based Examination with Human Proctoring Solutions for End Clients of EDCIL
19	U.P.RAJKIYA NIRMAN NIGAM	26-05-2020	73750	25-06-2020	Arun Kumar Saha	Vinay Kumar	Consultancy UPRNN AC Works

						Tiwari	
20	AMIDC AUTOMATION TECHNOLOGIES PVT. LTD.	27-02-2020	1570000	13-07-2023	Anindya Chatterjee		Advice on Mechanical Design and Performance Aspects of Autonomous Vehicle
21	JPC INFRATECH P LTD.	15-02-2020	200000	14-05-2020	Janakarajan Ramkumar		JPC Consultancy
22	EXEDY INDIA	12-11-2019	1400000	11-11-2021	Kamal K Kar		Spring Analysis
23	BRD AIRFORCE STATION OJHAR NASHIK	18-09-2019	3513450	03-07-2022	Shakti Singh Gupta	Chandraprakash Chindam	Validation of Tt227 and 214 Recommended By OEM and Identification of Alternate NDE for In-Situ Detection of Corrosion In Mig-29 Fin
24	MISCELLANEOUS	22-04-2019	0	21-04-2024	B Bhattacharya		Miscellaneous Structural and Product Design
25	U.P.RAJKIYA NIRMAN NIGAM	18-01-2019	236000	17-03-2019	Arun Kumar Saha	Vinay Kumar Tiwari	Third Party Inspection of the Upgradation of the Ac Facility At Sgpgi Lucknow
26	SECO TOOLS INDIA (P) LTD.	15-11-2018	1106250	30-09-2019	Mohit Subhash Law	Janakarajan Ramkumar	Finish Machining of Harsenes Laser Textured BN Tools
27	EDCIL (INDIA) LIMITED	01-11-2018	590000	31-12-2018	S K Choudhury		Consultancy for Online Testing and Assessment Services for EDCIL (India) Ltd.
28	LARSEN AND TAUBRO	16-08-2018	354000	31-01-2019	Chandraprakash Chindam	Rajeev Gupta	Silicon Carbide Coating on Carbon Fiber Fabric
29	ORDNANCE FACTORY PROJECT KORWA	11-06-2018	2559125	31-03-2021	Nachiketa Tiwari		Design and Analysis of Breech Mechanism
30	ORDNANCE FACTORY PROJECT KORWA	25-04-2018	3629688	31-12-2021	Nachiketa Tiwari		Design of SRS for 30 mm Gun
31	CENTRAL INSTITUTE OF	08-04-2018	130000	07-07-2018	Arvind Kumar		Work for Scanning and 3D Modelling

	PLASTICS ENGINEERING and TECHNOLOGY						for Plastic for Defence
32	U.P. AVAS VIKAS	05-04-2018	236000	04-07-2018	Arun Kumar Saha	Vinay Kumar Tiwari	Inspection of Prefabricated Bio Safety (Level-3) Lab In Microbiology Department of Medical College Allahabad
33	GUN CARRIAGE FACTORY	17-01-2018	3849750	31-12-2021	Nachiketa Tiwari		Analysis of Rammer Dynamics for Dhanush
34	ORDNANCE FACTORY PROJECT KORWA	08-01-2018	2498650	30-06-2020	Nachiketa Tiwari		Design of 9mm Pistol
35	U.P.RAJKIYA NIRMAN NIGAM	15-12-2017	236000	14-02-2018	Arun Kumar Saha		Third Party Audit of the Upgradation of the Air-Conditioning At SGPGI, Lucknow
36	GUN CARRIAGE FACTORY JABALPUR	25-10-2017	885885	31-12-2020	Nachiketa Tiwari		Strain Measurement and Analysis on 30mm Double Barrel Gun
37	MANIPAL UNIVER JAIPUR	09-10-2017	110035	08-10-2018	Pradipta K Panigrahi		Thermal University Samples
38	STERLITE TECHNOLOGIES LTD	01-09-2017	5900000	28-02-2019	Shakti Singh Gupta	Ishan Sharma, Pradeep Kumar K	Optical Losses In Cables In Cables In Crush and Tension Tests and Due to Imperfections
39	SACHIN BHARADWAJ	06-07-2017	177000	31-03-2018	Nachiketa Tiwari		FEA Analysis of Portable Stool
40	KENNAMETAL INDIA LTD.	17-02-2017	402500	16-08-2017	Mohit Subhash Law		Static and Dynamic Finite Element Analysis of Special Purpose Machine
41	ORDNANCE FACTORY PROJECT KORWA	08-01-2017	0	09-01-2017	Nachiketa Tiwari		Design of 9 mm Pistol
42	POWER GRID CORP OF INDIA	30-11-2016	50000	29-11-2017	Kamal K Kar		Analysis of Mechanical and Chemical Composition...for PGCI Limited

43	BHEL	27-11-2016	300000	31-03-2017	Shakti Singh Gupta	Sumit Basu	Vetting of Design of Hydro Turbine Runner...Element Method
44	COUNCIL OF SCI AND TECHNOLOGY	10-10-2016	40000000	23-04-2019	S K Choudhury	Amit Mitra	CST Up Science Talent Search Test
45	SMALL ARMS FACTORY	01-09-2016	2496938	31-03-2019	Nachiketa Tiwari		Design of 0.38 Mm Revolver
46	DRDO	15-05-2016	4060000	30-09-2019	N S Vyas		Vibration Based Conditioning Monitoring and Life Estimation of An Aero Engine Blades and Bladed Discs
47	STERLITE TECHNOLOGIES LTD	09-02-2016	2565000	29-03-2017	Ishan Sharma	C S Upadhyay, Pankaj Wahi, Sovan Das, Shakti Singh Gupta	Stress Induced Optical Attenuation and Degradation In Optical Fibres
48	COSMO FILMS LIMITED	12-10-2015	100000	11-10-2016	Kamal K Kar		Bi-Axially Oriented Polypropylene
49	HECTOR BEVERAGES P LIMITED	15-09-2015	500000	28-03-2020	Anindya Chatterjee		Consultancy Project for Improvements In Pouch Filling and Capping Processes
50	HECTOR BEVERAGES P LIMITED	24-08-2015	550000	31-12-2020	Anindya Chatterjee	Devlina Chatterjee	Continued Interaction and Industry Oriented Student Project
51	TITAN	17-07-2015	92625	16-10-2015	Shikha Prasad		Prompt Gamma Neutron Activation analysis: Feasibility Study
52	HAL	01-06-2015	1426000	31-12-2017	B Bhattacharya		Development of Cabin Pressure Control System for LCA

Total Funding: Rs. 40 crores (Consultancy) in six-year window

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Patents in past seven years

2021

1. Ms. Vandana Jain (Post-Doctoral Fellow, ME), Dr. K. Muralidhar (ME), Dr. Sameer Khandekar (ME), A Printed Circuit Board (PCB) Based Electro-wetting-on-dielectric (EWOD) Medical Diagnostic System, 202111053889.00, 23.11.2021, 2021.

2. Ms. Geeta Bhatt (Research Scholar, ME), Mr. Mohammed Rashiku B C (Research Scholar, ME), Mr. Poonam Sundriyal (Research Scholar, ME), Dr. Shantanu Bhattacharya (ME), Lateral Flow Immunoassay based Point of Care Diagnostic Device for Ultrasensitive Colorimetric Detection of Dengue, 202111024379.00, 01.06.2021, 2021

3. Ms. Archana Raichur (Post Doc, ME), Dr. Niraj Sinha (ME), Nanothylakoids for Selective Removal of Antibiotic- and Metal- Resistant Bacteria from Polluted Water, 202111061161.00, 28.12.2021, 2021.

4. Mr. Siddhant Shrivastava (PhD Student, Design Program), Dr. J. Ramkumar (ME & Design Program), Jaw Opening Device Design, 355721-001, 29.12.2021, 2021.

5. Mr. Siddhant Shrivastava (PhD Student, Design Program), Dr. J. Ramkumar (ME & Design Program), Gear Based Jaw Opening Device Design, 355728-001, 29.12.2021, 2021.

6. Mr. Siddhant Shrivastava (PhD Student, Design Program), Dr. J. Ramkumar (ME & Design Program), Spring Based Jaw Opening Device Design, 355749-001, 29.12.2021, 2021.

7. Mr. Santosh Pramanik (Tech Supdt, Imagineering Lab), Dr. Amandeep Singh (REO, Imagineering Lab), Dr. J. Ramkumar (ME), Smart Biogas Plant Design, 355718-001, 29.12.2021, 2021.

8. Mr. Pankaj Singh Chauhan (Proj. Scientist, ME), Mr. Aditya Choudhary (Proj. Scientist, ME), Dr. Urmila Brighu (Dr. MNIT Jaipur), Dr. Shantanu Bhattacharya (ME), Method And Apparatus for the Treatment of Industrial Wastewater, 202111015994.00, 05.04.2021, Â , Â, 2021.

9. Mr. Mahendra Kumar Gohil (PhD Student, ME), Mr. Anirudha Bhattacharjee (Proj. Engg., ME), Mr. Divya Jyoti Pandey (Proj. Technician, ME), Mr. Chetan Vashishtha (Proj. Associate, ME), Dr.Bishakh Bhattacharya (ME), A System for Facilitating Two-dimensional Fluid Movement of an Object Over An Area, 202111053668.00, 22.11.2021, 2021.

10. Mr. Kanhaiya Lal Chaurasiya (Sr. Proj. Engg, ME), Dr.Bishakh Bhattacharya (ME), Mr. A. Sri Harsha, Shape Memory Alloy Embedded Bipennate Actuator System for Enhancing Output Torque or Force, 202111028327.00, 24.06.2021, 2021.

11. Mr. Jitendra Kumar Sharma (Jr. Tech, Med Tech), Dr. Amandeep Singh (REO, Imagineering Lab), Dr. J. Ramkumar (ME & Design Program), Lotus Shaped Holding Device Design, 355860-001, 30.12.2021, 2021.

12. Mr. Jitendra Kumar Sharma (Jr. Tech, Med Tech), Dr. Amandeep Singh (REO, Imagineering Lab), Dr. J. Ramkumar (ME & Design Program), Seed Oil ExtractorDesign, 355861-001, 30.12.2021, 2021.

13. Mr. Anubhav Mishra (PhD Student, Design Program), Dr. Nachiketa Tiwari (ME & Design Program), Robotic Three Finger Gripper Design, 355774-001, 30.12.2021, 2021.

14. Mr. Anubhav Mishra (PhD Student, Design Program), Dr. Nachiketa Tiwari (ME & Design Program), Freewheel Differential Clutch Design, 355773-001, 30.12.2021, 2021.

15. Md Haseen Akhtar (Research Scholor, Design Program), Dr. Janakarajan Ramkumar (ME & Design Program), A Process for Making A House from Recycled Waste Materials, 202111061685.00, 30.12.2021, 2021.

16. Md Haseen Akhtar (Research Scholor, Design Program), Dr. Janakarajan Ramkumar (ME & Design Program), Process for Making Collapsible Furniture from Recycled Waste Materials, 202111061712.00, 30.12.2021, 2021.

17. Mr. Siddhant Shrivastava (PhD. Student, Design Program), Dr. J. Ramkumar (ME & Design Program), SITOLIA-The Table GameDesign, 340094-001, 03.03.2021, Design, Â, 2021.

18. Dr. Shantanu Bhattacharaya (ME), Mr. Akshay Purwar (Student), Mr. Sandip Kumar Jain (Student), Mr. Kuldeepak Mahto (Student), Mr. Nishant Kumar, Mr. Swagatam Mitra (Student), Mr. Shishir Kumar Singh (Student), Mr. Virendra Singh (Junior Technical Superintendent), Commode on Wheels Design, 301001.00, 04.01.2018, Design, 18.01.2021.

19. Megha Sahu, Om Prakash, Shantanu Bhattacharya, Poonam Sundriyal, Method for enhanced bonding of thermoplastic composites", , Patent No. US 2021/0269608 A1, granted 2021.

2020

1. Mr. Ayaj Ahamad Ansari (PhD. Student, ME), Dr.Samarshi Chakraborty (Post Doc. Student, ME), Mr. Randeep Ravesh (Post Doc. Student, ME), Dr. Malay K. Das (ME), Dr. Pradipta Kumar Panigrahi (ME), A Nanofluid for CO2 Sequestration via Hydrate Formation and Process of Synthesizing Thereof, 202011047522.00, 30.10.2020, 373515, 02.08.2021, 2020.

2. Mr. Surya Prakash Singh (M. Tech. Student, ME), Ms. Shruti Dubey (PhD Student, MSE), Dr. Kantesh Balani (MSE), Dr. J. Ramkumar (ME), A Thermally Stable and Reinforced Polypropylene-SiC Nanocomposite, A Method and Application Thereof, 202011056116.00, 23.12.2020, 373838, 04.08.2021, 2020.

3. Ms. Geeta Bhatt (Research Scholar, ME), Dr. Shantanu Bhattacharya (ME), A Device for Detecting One or More Fragments of DNA, 202011056963.00, 29.12.2020,Â, Â, 2020.

4. Mr. Siddhant Shrivastava (PhD. Student, Design Program), Dr. Shalini Gupta (KGMU), Dr. J. Ramkumar (ME & Design Program), Dr. M. L. B. Bhatt (KGMU), Dr. Sameer Gupta (KGMU), Jaw Opening device for Diagnostic Inspection, 202011057432.00, 31.12.2020, Â , Â , 2020.

5. Mr. Siddhant Shrivastava (PhD. Student, Design Program), Dr. J. Ramkumar (ME & Design Program), An Automatic Safety Gate System for Staircase, 202011056117.00, 23.12.2020 , 2020.

6. Mr. Shlok Sharma (B. Tech. Student, ME), Mr. Vaibhav Raj Singh (B. Tech. Student, ME), Mr. Varun Garg (B. Tech. Student, ME), Mr. Divya Jyoti Pandey (Proj. Associate, ME), Mr. Sahil Kalra (PhD Student, ME), Dr.Bishakh Bhattacharya (ME), Dr. Darren J Hartl (Texas A&M University), A System for Origami Based Re-configurable Antenna with Steering Mechanism, 202011031690.00, 24.07.2020, 2020.

7. Mr. Kanhaiya Lal Chaurasiya (Sr. Proj. Engg, ME), Dr. Bishakh Bhattacharya (ME), Mr. S. Barathy (DGM, GAIL), Mr. Sanjeev Kumar (CGM, GAIL), Speed Control System for Pipe Health Monitoring Robot, 202011016379.00, 15.04.2020, 2020.

8. Mr. Anubhav Mishra (Research Scholar, Design Prog.), Dr. Janakarajan Ramkumar (ME), Mr. Abhishek Verma (Research Scholar, Design Prog.), Mr. Amandeep Singh (REO, Imagineering Lab), A Walking Device for Enhancing Capabilities of a Visually Impaired Person, 202011026370.00, 22.06.2020, 2020.

9. Dr. Sounak Kumar Choudhury (ME), Mr. Muhammed Muaz (PhD. Student, ME), Adaptive Minimum Quantity Lubricant System and Process for Monitoring and Controlling Temperature During Machining Operation, 202011044010.00, 09.10.2020, 2020.

10. Dr. Nachiketa Tiwari (ME), Dr. Devendra Gupta (SGPGI), Mr. Girijesh Mathur (Design Programme), A Protective Respirator System and Method Thereof, 202011016198.00, 15.04.2020, 2020.

11. Dr. Kamal K. Kar (ME & MSP), Ms. Prerna Sinha (PhD. Student, MSP),Human Hair Derived Activated Carbon Nanosheets, Process of Preparation and Application Thereof, 202011026603.00, 23.06.2020, 2020

12. Mr. Siddhant Shrivastava (PhD Student, Design Prog.), Dr. J. Ramkumar (ME & Design Prog.), Multipurpose Extension Key to reduce human contacts in public Places Design, 329190-001, 05.05.2020, Design, 19.04.2021, 2020.

13. Mr. Saurabh Gupta (PhD. Student, CE), Mr. Sanjeet Kumar Singh (PhD. Student, Design Prog.), Dr. Syam Nair (CE), Dr. Shantanu Bhattacharya (ME & Design Prog.), Three-dimensional Adjustable Video Recording Setup for Smart phones Design, 335731-001, 01.12.2020, Design, 06.01.2022, 2020.

14. Mr. Saurabh Gupta (PhD Student, CE), Mr. Sanjeet Kumar Singh (Design Program), Dr. Syam Nair (CE), Dr. Shantanu Bhattacharya (ME & Design Program), Collapsible Multiple Drawing Sheets Holding Device Design, 332952-001, 08.09.2020, Design, Â, 2020.

15. Mr. Shyam Sunder Nishad (PhD Student, ME), Mr. Anirban Choudhary (PhD Student, ME), Dr. Ashish Dutta (ME), Dr. Anupam Saxena (ME), Robotic Hand Rehabilitation Device for Post Stroke Therapy Design, 304112.00, 27.03.2018, Design, 08.01.2020.

16. Om Prakash, Megha Sahu , Shantanu Bhattacharya; Sanjay Kumar; Pulak Bhushan, Sound attenuation panel and methods of constructing and installing the same, Patent No. US 2020/0239125A1, granted 2020.

2019

1. Mr. Pawandeep Singh Matharu (Sr. Proj. Engg., ME), Dr.Bishakh Bhattacharya (ME), Apparatus and Method for Real-time, in Situ Monitoring of Water Quality, 201911041227.00, 11.10.2019, 372496, 22.07.2021, 2019.

2. Dr. Kamal Krishna Kar (ME & MSP), Dr. J. Ramkumar (ME & MSP), Mr. Kiran Kumar Surthi (PhD. Student, MSP), A Process for Synthesis of Nano Particles of LiNi0.5C0.5PO4 (LNCP) and Use Thereof, 201911049732.00, 03.12.2019, 382405, 23.11.2021, 2019.

3. Ms. Kajal Chaudhary (PhD Student, MSP), Dr. J. Ramkumar (ME), Dr. S. A. Ramakrishna (Physics), Dr. K. V. Srivastava (EE), Dr. Praveen C. Ramamurthy (MSE, IISC Bangalore), Protective Layer for Microwave Metamaterial Absorbers and Method Thereof, 201911050380.00, 06.12.2019, Â , Â, 2019.

4. Mr. Shubhankar Khara (M. Tech. Student, MSE), Mr. Jayesh Zambre (B. Tech. Student, MSE), Dr. Sandeep Sangal (MSE), Dr. Kallol Mondal (MSE), Dr. Bishakh Bhattacharya (ME), Mr. Ashim Bose (Dr. Virendra Swarup Education Centre), Art of Making Earthenware with Variable Porosity and High Damping Capacity, 201911038028.00, 20.09.2019, 2019.

5. Mr. Divyansh Patel (Student, ME), Dr. J. Ramkumar (ME), Dr. V. K. Jain (Professor Retired, ME), Large Area Micro-Texturing on Free-Form Surfaces by Flexible-Electrode Through-Mask Electrochemical Machining, 201911022950.00, 10.06.2019, 2019.

6. Dr. Pranav Joshi (ME), Dr. Archana Raichur (ME), An Espresso Emulsification Method for Synthesis of Uniform Hollow Polymer Nanoparticles

7. 201911050823.00, 09.12.2019, 2019.

8. Mr. Divyansh Patel (Student, ME), Dr. J. Ramkumar (ME), Dr. V. K. Jain (Retired Dr., ME), Apparatus for Performing an Electrochemical Micro-machining Process, 202011012055.00, 20.03.2020, 2020.

9. Mr. Siddhant Srivastava (PhD. Student, Design Prog.), Mr. Ayush Gupta (B. Tech. Student, BSBE), Dr. Arshad Ahmad (KGMU), Dr. J. Ramkumar (ME & Design Prog.), Multipurpose Proctoscope: Nested Type Design, 325057-001, 27.12.2019, Design, 28.07.2020, 2019.

10. Dr. J. Ramkumar (ME), Mr. Ravi Raj (Student, ME), Mr. Om Prakash (Tech Superintendent, Physics), Mr. Shantanu Agarwal (Research Engineer, Matribhoomi), Mr. Sunil Kumar (Student, ME), Grater Design, 325203-001, 30.12.2019, Design, 07.12.2020, 2019.

11. Om Prakash, Shantanu Bhattacharya Sanjay Kumar, Pulak Bhushan Composite sound absorption panel assembly, Patent No. US 2019/0103089A1 , granted 2019.

2018

1. Dr. Kamal Krishna Kar (ME & MSP), Dr. J. Ramkumar (ME & MSP), Mr. Yaswanth Kumar Penke (Student, MSP), Mr. Amit Kumar Yadav (PhD Student, MSP), Ms. Iram Malik (PhD Student, MSP), Ms. Alekha Tyagi (PhD Student, MSP), Mn-Al-Fe Impregnated RGO Hybrid Composite for Arsenic Adsorption and its Sludge as Super-capacitor, 201911002684.00, 22.01.2019, 356878, 28.01.2021.

2. Ms. Surekha Yadav (PhD Student, MSE), Dr. Krishanu Biswas (MSE), Dr. Arvind Kumar (ME), A Multicomponent High-entropy Alloy Composite, a Preparation Method and Characterization Thereof, 201811047924.00, 18.12.2018.

3. Mr. Nishant Agarwal (Student, ME), Dr. Niraj Sinha (ME), Dr. Pankaj Wahi (ME), A Bionic Prosthetic Hand Device for Trans-radial Amputee, 201811024019.00, 27.06.2018 .

4. Mr. Gaganpreet Singh (Student, ME), Ms. Kajal Chaudhary (PhD Student, MSP), Dr. Kumar Vaibhav Srivastava (EE), Dr. J. Ramkumar (ME), Dr. S. Anantha Ramakrishnan (Physics), A Metamaterial Based Wearable and A Method Thereof, 201811038763.00, 12.10.2018.

5. Mr. Gaganpreet Singh (R Scholar, ME), Dr. S. A. Ramakrishna (Phy), Dr. J. Ramkumar (ME), Mr. Kumar Vaibhav Srivastava (EE), Controlled Micro-texturing of Transparent Conducting Oxide Thin Films for Uniform Transparency, 201811038031.00, 08.10.2018.

6. Mr. Dhananjay Dubey (Student, MSP), Dr. J. Ramkumar (ME), Dr. V. K. Jain (Retired Dr., ME), Mr. Sanjeev Verma (Tech. Supt.), Apparatus for Finishing of Ball using Abrasive Flow Finishing, 201811016131.00, 28.04.2018.

7. Mr. Aman Garg (Sr. Proj. Associate, ME), Mr. Chinthulal V. S. (Proj. Engineer, ME), Dr.Bishakh Bhattacharya (ME), Dr. Devender Gupta (SGPGI), A Wireless Pressure Sensor Node for an Inflatable Structure, 201811042160.00, 08.11.2018.

8. Mr. Aman Garg (Sr. Proj. Associate, ME), Dr. Bishakh Bhattacharya (ME), Dr. Anil Agarwal (SGPGI), Dr. Sujeet Gautam (SGPGI), A Sensing-Based Guidance Device for Endotracheal Intubation and a Method for Operating the Same, 201811046913.00, 12.12.2018.

9. Dr. J. Ramkumar (ME), Mr. Amal Sudheendran Kumar (Student, DP), Dr. Mohan Gurjar (SGPGIMS, LKO), Automated Subglottic Aspiration Device, 201811016906.00, 04.05.2018.

10. Dr. J. Ramkumar, ME, Mr. Vimal C (Student, Design), Irilla (Lamp) Design, 292052.00, 17.04.2017, Design, 07.02.2018.

11. Eshan Sadasivan, Mainak Das, Shantanu Bhattacharya, Carry Bag Making Machine”, Patent Application No. 03/2018, Filed 2018.

2017

1. Dr. Nachiketa Tiwari (ME), Mahendra Kumar Gohil (Student, ME), Saurabh Zajam (Student, ME), Sandep Kumar (Student, ME), Ankur Dwivedi (Student, ME), Madhavrao Londhe. (Student, ME), Shalab Vaishnav (Student, DP), A Device for Measuring the Amount of Fuel Introduced Into a Vehicle, 201711034630.00, 29.09.2017.

2. Dr. Kamal K Kar (ME), Dr. Nirmal Kumar Gupta (SGPGI), Mr. Mridul Bharadwaj (ME), Mr. Meraj Ahmed (ME), Dr. Malay Kumar Das (ME), Dr. Krishnamurthy Muralidhar (ME), Mrs. Sutapa Mondal (HC, IITK), Spherical Tri-leaflet Heart Valve, 201711043075.00, 30.11.2017, Â , Â.

3. Dr.Bishakh Bhattacharya, Dr.Nachiketa Tiwari, Dr. J Ramkumar, Mr. Girijesh Mathur (Design), Mr. Shivyansh Tandon (Mathematics), Mr. Chetan Lodhi (BSBE), A Packing Case for One or More Large-caliber Ammunition Shells, 201711043201.00, 01.12.2017.

4. Dr. Bishakh Bhattacharya (ME), Mr. Shubham Kumar (Student, ME), Mr. Dhrupal R Shah (Student, ME), Mr. Harshit Kumar Sankhla (Student, LNMIIT, Jaipur), Smart Stick, 201711043515.00, 05.12.2017.

5. Sachin NP, Vimal C., Satyaki Roy, Shantanu Bhattacharya, An Efficient Writing, Patent Application No. 201711026411, Filed 2017.

2016

1. Shantanu Bhattacharya, Gurunath Ramanathan, Monalisa Nayak, Deepak Singh, Rishi Kant, An Integrated Microchip for the Detection of a Biological Cell, Patent Application No. 28/2016, Filed 2016.

2. Rishi Kant, Shantanu Bhattacharya, Abhijit Verma, Naman Kumar Rawal, Micropump for Fluidic Applications", Patent Application No. 201611005750, Filed 2016.

Copyrights

1. Mr. Siddhant Shrivastava (PhD Student, Design Program), Dr. J. Ramkumar (ME & Design Program), Mr. Akshat Shrivastava (SV Polytechnic Bhopal), Mr. Abhishek Verma (PhD Student, Design Program), Learn by Shapes, 5346/2022-CO/L, 2021-22.

2. Mr. Siddhant Shrivastava (PhD Student, Design Program), Dr. J Ramkumar (ME & Design Program), Mr. Praveen Kumar (MDES, Design Program), Mr. Abhishek Verma (PhD Student, Design Program), Smart, Multilinguistic Talking Bot for Learning & Educating Children for Child Abuse, 9484/2022-CO/L, 2022-23.

Awards won by faculty of the department in past seven years

2022

1. Dr. Avinash Kumar Agarwal, Dr. Bushra Ateeq, Dr. Nitin Saxena and Dr. Sachchidananda Tripathi were featured in "75 under 50: Scientists Shaping Today's India" a compendium released by the Department of Science and Technology, Ministry of Science and Technology.

2. Dr. Avinash Kumar Agarwal has been elected as Fellow of Combustion Institute (CI), USA.

2021

1. Dr. Mohit S. Law (ME) has been elected for the "Gopal Das Bhandari Memorial Distinguished Teacher Award" for the year 2020.

2. Dr. Shantanu Bhattacharya (ME) has received the IETE R. S. Khandpur award for 2020 for his research contributions in domains related to medical devices for detection and sensing.

3. Dr. Shantanu Bhattacharya (ME) has been bestowed with the Fellowship of the Royal Society of Chemistry, UK.

2020

1. Dr. Manjesh Kumar Singh (ME) has been awarded the first prize for his contributed oral talk at recently held IndiaTrib 2019 at IISc Bangalore, jointly organized by the Tribological Society of India and IISc Bangalore.

2. Dr. P. Venkitanarayanan (ME) has been selected for F. Zandman Award by Society for Experimental Mechanics, USA.

3. Dr. P. Venkitanarayanan (ME) has been selected to receive Excellence in teaching award by IIT Kanpur.

4. Dr. Shantanu Bhattacharya (ME) has received the Abdul Kalam Technology Innovation National Fellowship for the years 2020-2023.

2019

1. Dr. K. Muralidhar, Department of Mechanical Engineering, has been recommended by ASTFE Honors and Awards Committee to become a Fellow of The American Society of Thermal and Fluids Engineers (ASTFE) in recognition of his outstanding contributions to the field of Thermal and Fluids Engineering.

2. Dr. Gautam Biswas, Department of Mechanical Engineering, has conferred Honorary Doctorate by Aristotle University of Thessaloniki, Greece.

3. Dr. P. Venkitanarayanan, Department of Mechanical Engineering, has been selected for the prestigious 2019 F. Zandman award of the Society of Experimental Mechanics based in CT-USA.

4. Dr. Avinash K. Agarwal (ME) was admitted Fellow of The Royal Society of Chemistry..

5. Dr. Avinash Agarwal (ME) has been elected Fellow of the National Academy of Sciences, India (NASI)

6. Dr. Shantanu Bhattacharya (ME) has been selected for the NASI Reliance Platinum Jubilee Award-2019.

7. Dr. Shantanu Bhattacharya (ME) has been selected to receive the Er. M. P. Baya National Award-2019 by Institution of Engineering, India.

8. Dr. Shantanu Bhattacharya (ME) has received Senior Member Status of IEEE in the year 2019.

2018

1. Dr. Sameer Khandekar (ME) has been elected Fellow of Institution of Engineers (India).

2. Dr. Avinash Kr. Agarwal (ME) received the 6th edition of the India Research Excellence-Citation Awards by Clarivate Analytics.

3. Dr. Gautam Biswas (ME) (presently Director, IIT Guwahati) has been awarded Honorary Doctorate (Honoris Causa) by NIT Agartala.

4. Dr. Bhaskar Dasgupta (ME) received the Mechanism and Machine Theory Award for Excellence.

2017

1. Dr. Anindya Chatterjee (ME) has been elected Fellow of the National Academy of Sciences India, for the year 2016

2. Dr. Kamal Kar (ME) has been awarded the Tenth Foundation Polymer Award, given by Dr. Sukumar Maiti Polymer Award Foundation, for his outstanding contributions in Polymer Science and Technology for the year 2015.

3. Dr. Bishakh Bhattacharya (ME) received Sakura Fellowship by Japan Science & Technology Agency (JST).

4. Dr. Avinash K Agarwal (ME) has been honoured with Shanti Swarup Bhatnagar Prize for Science and Technology - 2016 in Engineering Sciences by CSIR, Government of India and

also has been selected for the Rajib Goyal Prize for young scientists in Physical Sciences by Kurukshetra University.

5. Dr. J. Ramkumar (ME) has been honoured with Young Alumni Achievement award for excellence in academics, research, and innovation by National Institute of Technology, Trichy, Tamil Nadu.

6. Dr. Kamal Kar (ME) has been awarded the Tenth Foundation Polymer Award given by Prof. Sukumar Maiti Polymer Award Foundation, for his outstanding contributions in Polymer Science and Technology for the year 2015.

7. Dr. Gautam Biswas (ME) has been honored with the Distinguised Alumnus Award of IIT Kharagpur.

2016

1. Dr. Avinash Kumar Agarwal (ME) has been elected as Fellow of Indian National Academy of Engineering, India.

2. Dr. J. Ramkumar (ME) received National Design And Research Forum award by the Institution of Engineers (India).

3. Dr. J. Ramkumar (ME) received Eminent Engineer Award, The Institution of Engineers (India).

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Editorship of Journals in the Past Seven Years

2022

1. Dr. Kamal K Kar (ME) has been invited to serve as a Member of the Advisory Board of SPE Polymers published by Wiley.

2021

1. Dr. Kamal K. Kar (ME) has been invited to serve as a Member of the Advisory Board of Journal SPE Polymers, Wiley Publications.

2. Dr. Kamal K. Kar(ME) has been invited to serve as an Associate Editor for the Journal Applied Nanoscience (Springer Nature).

2020

1. Dr. Avinash K Agarwal (ME) has been invited to join as Associate Principal Editor of FUEL, Elsevier.

2. Dr. P. Venkitanarayanan (ME) has been invited to join as a Member of Editorial Board International Journal of Adhesion & Adhesives, Elsevier.

3. Dr. P. Venkitanarayanan (ME) has been invited to join as a Member of International Advisory Board of Experimental Mechanics.

4. Dr. Shantanu Bhattacharya (ME) has been invited to join as an Associate Editor of Journal of Micro-manufacturing, SAGE.

5. Dr. Sameer Khandekar (ME) has been invited to join the Editorial Board of the International Journal of Thermal Sciences, as an Associate Editor.

2019

1. Dr. K. Muralidhar, Department of Mechanical Engineering, joins as the Editor -in-Chief of Journal of Flow Visualization and Image Processing.

2. Dr. Bishakh Bhattacharya, Department of Mechanical Engineering, joins the International Journal of Systems Science as an Associate Editor.

3. Dr. Sameer Khandekar, Department of Mechanical Engineering, will guest editor a special issue of Microgravity Science and Technology entitled Heat pipe systems for thermal management in space.

2018

1. Dr. Anindya Chatterjee (ME), Editorial Board Member, International Journal of Mechanical Sciences, Elsevier.

2. Dr. Avinash Kumar Agarwal (ME), Editor-in-Chief, Journal of Energy and Environmental Sustainability, International Society for Energy, Environment and Sustainability.

3. Dr. Bishakh Bhattacharya (ME), Editorial Board Member, Journal of Low Frequency Noise and Vibration Control, SAGE Publishing.

4. Dr. K. Muralidhar (ME), Editor-in-Chief, Journal of Flow Visualization and Image Processing, Begell House.

5. Dr. P. S. Ghoshdastidar (ME), Editorial Board Member, Engineering Science and Technology, an International Journal, Elsevier.

6. Dr. Sameer Khandekar (ME), Editorial Board Member, Interfacial Phenomena and Heat Transfer, Begell House.

7. Dr. Sumit Basu (ME), Associate Editor, Sadhana, Indian Academy of Sciences.

2017

1. Dr. Avinash K Agarwal (ME), Board Member, International Journal of Engine Research, SAE International and IMechE, London, UK.

2. Dr. Avinash K Agarwal (ME), Associate Editor, Journal of the Institution of Engineers (India): Series C, Springer.

3. Dr. Avinash K Agarwal (ME), Associate Editor (Reappointed in 2017), Journal of Energy Resource Technology, Transactions of ASME, American Society of Mechanical Engineers.

4. Dr. J. Ramkumar (ME), Board member, IJP Tech, Inderscience Publisher.

5. Dr. Bishakh Bhattacharya (ME), Associate Editor, ISSS Journal of Micro and Smart Systems, Springer.

6. Dr. Anurag Gupta (ME), Board Member, Journal of Mathematics and Mechanics of Solids, SAGE Publications.

7. Dr. Anindya Chatterjee (ME) has been appointed Associate Editor of ASME Journal of Computational & Nonlinear Dynamics for 3 years.

8. Dr. Anindya Chatterjee (ME), Associate Editor, Journal of Computational and Non-linear dynamics, Transactions of ASME, American Society of Mechanical Engineers.

9. Dr. P. Venkitanarayanan (ME), Associate Editor, Journal of Dynamic Behavior of Materials, Society for Experimental Mechanics and Springer.

2016

1. Dr. P. S. Ghoshdastidar (ME), Editorial Board Member, Engineering Science and Technology, an International Journal (JESTECH), Elsevier.

2. Dr. P. Venkitanarayanan (ME), Associate Editor, Experimental Mechanics, Springer for Society for Experimental Mechanics, USA.

3. Dr. Bishakh Bhattacharya (ME), Editorial Board Member, The Journal of the Institute of Smart Structures and Systems, Springer.

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Books published by faculty in the past seven years

2021

1. Handbook of Nanocomposite Supercapacitor Materials: III Selection, Kamal K. Kar (ME), Springer Nature, ISBN: 978-3-030-68363-4.

2. Acoustic analysis and design of short elliptical end-chamber mufflers, Akhilesh Mimani (ME), Springer Nature, Singapore, 2021, ISBN: 978-981-10-4828-9.

3. Build and Sustain a Career in Engineering, Anidya Chatterjee (ME), Notion Press, ISBN 978-137816233, 2021.

4. Carbon Nanostructures: Fundamentals to applications, Rajgopalan T., Roy, S.C., Sundriyal P., Bhattacharya, Shantanu (Ed.), ISBN9870735423114, American Institute of Physics, Melville, NY, 2021.

5. MEMS Application in Biology and Healthcare, Basu A.K., Basu, A., Ghosh S., Bhattacharya, Shantanu (Ed.), ISBN9780735423923, American Institute of Physics, Melville, NY, 2021.

6. Trends in Fabrication of Polymer and Polymer Composites, Patel V.K., Kant Rishi, Chauhan P.S., Bhattacharya, Shantanu (Ed.), ISBN 9780735423916, American Institute of Physics, Melville, NY, 2021.

7. Gas sensors: Manufacturing, Materials and Technologies, Gupta A., Kumar M., Singh R.K., Bhattacharya, Shantanu (Ed.), CRC press, Taylor and Francis, 2021.

2020

1. Drop dynamics and dropwise condensation over textured surfaces, Sameer Khandekar (ME) and K. Muralidhar (ME), Springer (New York), 2020, ISBN 978-3-030-48463-7.

2. Simulations and Optical Diagnostics for Internal Combustion Engines Current Status and Way Forward, Avinash Kumar Agarwal (ME), Springer, Singapore, 2020, ISBN 978-981-15-0335-1.

3. Liquid Crystalline Polymers, Kamal K. Kar (ME), Lie Zhu (Case Western Reserve University, USA), Springer Nature, Switzerland AG, 2020, ISBN: 978-3-030-43350-5.

4. Handbook of Nanocomposites Supercapacitor Materials: II Performance, Kamal K. Kar (ME), Springer Nature Switzerland AG, 2020, ISBN 978-3-030-52359-6.

2019

1. Fundamentals of Convective Heat Transfer, Biswas Gautam (ME), Dalal Amaresh and Dhir Vijay K., CRC Press-Boca Raton, London, New York, 2019, ISBN: 978-1-138-10329-0.

2. Simulations and Optical Diagnostics for Internal Combustion Engines Current Status and Way Forward,Akhilendra Pratap Singh, Pravesh Chandra Shukla, Joonsik Hwang, Avinash Kumar Agarwal (ME),Springer-Singapore, 2019, ISBN: 978-981-15-0335-1.

3. Advanced Combustion Techniques and Engine Technologies for the Automotive Sector, Akhilendra Pratap Singh, Nikhil Sharma, Ramesh Agarwal, Avinash Kumar Agarwal (ME), Springer-Singapore, 2019, ISBN:978-981-15-0368-9.

4. Alternative Fuels and Their Utilization Strategies in Internal Combustion Engines, Akhilendra Pratap Singh, Yogesh C. Sharma, Nirendra N. Mustafi, Avinash Kumar Agarwal (ME), Springer-Singapore, 2019, ISBN: 978-981-15-0417-4.

5. Solar Energy Systems, Challenges, and Opportunities, Himanshu Tyagi, Prodyut Chakraborty, Satvasheel Powar, Avinash Kumar Agarwal (ME), Springer-Singapore, 2019, ISBN: 978-981-15-0675-8.

6. Measurement, Analysis and Remediation of Environmental Pollutants, Tarun Gupta (CE), Swatantra Pratap Singh, Prashant Rajput, Avinash Kumar Agarwal (ME), Springer-Singapore, 2019, ISBN: 978- 981-15-0540-9.

7. Paper Microfluidics Theory and Applications, Shantanu Bhattacharya (ME), Sanjay Kumar, Avinash Kumar Agarwal (ME), Springer- Singapore, 2019, ISBN: 978-981-15-0489-1.

8. Design and Development of Heavy-Duty Diesel Engines, P. A. Lakshminarayanan, Avinash Kumar Agarwal (ME), Springer-Singapore, 2019, ISBN: 978-981-15-0970-4.

9. Modeling Transport Phenomena in Porous Media with Applications, Malay K Das, PP Mukherjee, K. Muralidhar (ME), Springer International Publishing, ISBN 978-3-319-69864-9.

10. Air Pollution and Control, Nikhil Sharma, Avinash K Agarwal, Peter Eastwood, Tarun Gupta, Akhilendra P Singh (ME), Springer, Singapore.

11. Coal and Biomass Gasification, Santanu De, Avinash K Agarwal, V S Moholkar, Thallada Bhaskar (ME), Springer, Singapore., 2019.

12. Automotive Tribology, Jitender Katiyar, Vinay Kumar Patel, Shantanu Bhattacharya (ME), Springer-Singapore, 2019, ISBN: 978-981-15- 0433-4.

2018

1. Innovation, Incubation and Entrepreneurship: Case Studies from IIT Kanpur, Phani B. V. (IME), Khandekar S. (ME), Springer, ISBN: 978-981-10-3333-9 (P) 78-981-10- 3334-6 (O).

2. Modeling and Simulations of Turbulent Combustion, Santanu De, Avinash K Agarwal, (ME), Springer, Singapore, 2018, ISBN: 978-981-10-7409-7.

3. Shapes and Dynamics of Granular Minor Plants, Ishan Sharma (ME), Springer International Publishing, 2018.

4. Fluid Mechanics and Fluid Power- Contemporary Research, A. K. Saha, D. Das, R. Srivastava, P.K. Panigrahi, K. Muralidhar (ME), Springer.

5. Pipe Inspection Robots for Structural Health and Condition Monitoring, co-authored by Bishakh Bhattacharya (ME), Springer.

6. Environmental Contaminants, Tarun Gupta, Avinash K Agarwal (ME), Rashmi A Agarwal, Nitin K Labhsetwar, Springer, Singapore, 2018, ISBN: 978-981-10-7332-8.

7. Air Pollution and Control, Nikhil Sharma, Avinash K Agarwal (ME), Peter Eastwood, Tarun Gupta, Akhilendra P Singh, Springer, Singapore, 2018, ISBN: 978-981-10-7184-3.

8. Coal and Biomass Gasification, Santanu De, Avinash K Agarwal (ME), V S Moholkar, Thallada Bhaskar, Springer, Singapore, 2018, ISBN: 978-981-10-7334-2.

9. Droplets and Sprays, Saptarshi Basu, Avinash K Agarwal (ME), Achintya Mukhopadhyay, Chetan Patel, Springer, Singapore, 2018, ISBN: 978-981-10-7448-6.

10. Advances in Internal Combustion Engine Research, 345 pages, Published by Springer, Singapore (2018), (Eds.) Dhananjay K Srivastava, Avinash K Agarwal (ME), Amitava Datta, Rakesh K Maurya (ISBN # 978-981-10-7574-2) DOI: 10.1007/978-981-10-7575-9.

11. Prospects of Alternative Transportation Fuels, Akhilendra P Singh, Avinash K Agarwal (ME), Rashmi A Agarwal, Atul Dhar, Mritunjay Kumar Shukla, Springer, Singapore, 2018, ISBN: 978-981-10-7517-9.

12. Environmental, Chemical and Medical Sensors, Shantanu Bhattacharya (ME), Avinash K Agarwal (ME), Nripen Chanda, Ashok Pandey, Ashis Kumar Sen, Springer, Singapore, 2018, ISBN: 978-981-10-7750-0.

13. Applications of Solar Energy, Himanshu Tyagi, Avinash K Agarwal (ME), Ashok Pandey, Prodyut R Chakraborty, Satvasheel Powar, Springer, Singapore, ISBN: 978- 981-10-7205-5.

14. Bioremediation: Applications for Environmental Protection and Management, Sunita J Varjani, Avinash K Agarwal (ME), Ashok Pandey, Edgard Ghansounou, Baskar Gurunathan, Springer, Singapore, 2018, ISBN: 978-981-10-7484-4.

15. Applications Paradigms of Droplet and Spray Transport: Paradigms and Applications, Saptarshi Basu, Avinash K Agarwal (ME), Ashok Pandey, Achintya Mukhopadhyay, Chetan Patel, Springer, Singapore, 2018, ISBN: 978-981-10-7232-1.

16. Water Remediation, Bhattacharya Shantanu, Akhilen Bhushan Gupta, Ankur Gupta, and Ashok Pandey (Eds.), Springer, ISBN9789811075506, Published, 23 January 2018.

17. Nanoenergetic Materials, Bhattacharya, Shantanu, Avinash Kumar Agarwal, T. Rajgopalan, Vinay Kumar Patel, "", ISBN 978-981-13-3289-0, Springer, 2018.

18. Sensors for Aerospace and Automotive Applications, Bhattacharya, Shantanu, Avinash Kumar Aggarwal, Shailendra Singh, Om Prakash, ISBN 978-981-13-3269-2, Springer, 2018.

2017

1. Combustion for Power Generation and Transportation: Technology, Challenges and Prospects, Avinash Kumar Agarwal (ME), Santanu De, Ashok Pandey, Akhilendra Pratap Singh, Springer, New Delhi.

2. Modeling Transport Phenomena in Porous Media with Applications, Malay K. Das (ME), Springer, 2017, ISBN: 978- 3-319-69864-9 (Print) 978-3-319-69866-3 (Online).

3. Locomotives and Rail Road Transportation: Technology, Challenges and Prospects, Avinash Kumar Agarwal (ME), Atul Dhar, Anirudh Gautam, Ashok Pandey, Springer, New Delhi.

4. The proceedings of the 17th International Heat Pipe Conference published as Science and Technology of Heat Pipes: Historical Perspective to Contemporary Developments, edited by Sameer Khandekar (ME), Begell House.

5. Biofuels: Technology, Challenges and Prospects, Avinash Kumar Agarwal (ME), Rashmi Avinash Agarwal, Tarun Gupta, Bhola Ram Gurjar, Springer, New Delhi.

6. Technology Vision 2015: Technology Roadmap Transportation, Avinash Kumar Agarwal (ME), S Thipse, Akhilendra P Singh, Gautam Goswami, Mukti Prasad, TIFAC, New Delhi.

7. Computational Fluid Dynamics and Heat Transfer, P. S. Ghoshdastidar (ME), Cengage Learning India Pvt. Ltd., New Delhi.

8. Composite materials: processing, application, characterizations, Kamal K. Kar (ME) Berlin – Heidelberg.

2016

1. Nanoscale and Microscale Phenomena: Fundamentals and Applications, Springer Tracts in Mechanical Engineering, Joshi, Y. M. (CHE) and Khandekar S. (ME) (Editors), Springer, Delhi, 2016.

2. Transport Phenomena in Microfluidic Systems, P K Panigrahi (ME), John Wiley and Sons, ISBN: 978-1-118- 29841-1, 507 pages, (2016).

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Membership in major national / international committees in past seven years

#	Name	Name of the Committee	National/ International	Year
1	Agarwal, Avinash Kumar	Member of IIT Council, the highest policy making body of IITs.	National	2022 - 2025
		Member of Board of Governors of Kamala Nehru Institute of Technology (KNIT), Sultanpur	National	2022 - 2025
		AICTE Nominee Member of Selection Committee for Bihar Public Service Commission, Patna	National	2022 - 2025
		Member of PAC for Technology Development Programme (TDP) under TDT Division of DST	National	2022 - 2025
		Member, Board of Studies, Department of Mechanical Engineering, USJM, Kanpur	National	2022 - 2023
		Member of PMRC for Industry Relevant R&D (IRRD) Program: SERB-GE India FIRE	National	2021 - 2022
		Chairman of the Engineering Sciences Committee of CSIR SRA selection	National	2021 - 2024
		Member of the AICTE Technical Book Writing Committee for UG and Diploma model Curriculum and Indian Languages	National	2021 - 2022
		Member of Research Council of CSIR-CMERI, Durgapur	National	2021 - 2024
		Member of DST Subject Expert Committee (SEC) for "Women Scientist Scheme–B (WOS-B)	National	2020 - 2023
		Member of SERB's ABHYAAS Expert Committee (AEC) for Accelerate Vigyan (AV) Scheme	National	2020 - 2023
		Member of SERB's Core Research Grant (CRG) PAC Mechanical	National	2020 - 2023

		Engineering		
		Member, Board of Studies, Mechanical Engineering, HBTU, Kanpur	National	2020 - 2021
		Chair of CPCB Sub-committee Responsible for Making Locomotive Emission Norms for India	National	2019 - 2020
		Member of CPCB Standing Committee on Emissions for Off-Road Applications	National	2018 - onwards
		Member of the Electric and Hybrid Vehicles Sectional Committee of BIS (TED 27)	National	2018 - 202020
		Member of SERB's EMEQ Task Force Committee	National	2018, 2019, 2020 and 2021
		Member of NITI Ayog's Task Force for Conversion / Design of Methanol/ DME based engines	National	2017 - 2019
		Member of Task force on Methanol / DME, Department of Science and Technology	National	2017 - 2019
		Member of Expert Group on R&D issues related to Production and Utilization of Methanol / DME, DST	National	2016 - 2019
		Member of National Committee IE(I) Mechanical Engg for PE Certification of Engineers	National	2016 - onwards
2	Basu, Sumit	Member, Expert Committee, Teachers Associateship For Research Excellence (TARE)	National	2021
		Editorial Board, Sadhana	National	2011

3	Bhattacharya, Bishakh	Joint Secretary, Institute for Smart Structures & Systems	National	2022 - ongoing
		Panel Member AR & DB, Systems Panel	National	2018 - ongoing
		Faculty Selection Committee Member - IIT Mandi, IIT Patna, HBTU	National	2018 - ongoing
		Academic Representative, Mentor Council of DGET, Industrial Automation & Instrumentation	National	2014 - ongoing
		Empanelled Eminent Expert, National Manufacturing Competitiveness Program	National	2013 - ongoing
		Board of Studies: CSJMU, UPES	National	2021
4	Bhattacharya, Shantanu	Expert member on Indo-Dutch Roundtable organized by DST	National	2021
		Theme lead at the IITK-LaTrobe academy, "Health and well-being theme"	National	2021
		Panelist, VAIBHAV SUMMIT, Advanced Manufacturing Technologies (AMT) Vertical - Additive Manufacturing	International	2020
		Member of DST, WTI, PAC nominated by DST	National	2019 - 2020
		Member of Board of studies DIAT, UPID	National	2018 - 2019
		In Faculty/ Scientists/ Management professionals Selection Committees of IIT Delhi, Institute of Infrastructure Technology Research and Management (IITRAM), Delhi Skill and Entrepreneurship University (DSEU), Artificial limb manufacturing company (ALIMCO)	National	2017 - onwards
		Nominated member in Modernization Board of Artificial limb manufacturing company (ALIMCO), Kanpur	National	2017 onwards

		Scientific council member of Indo-German Science and technology council, DST	International	2015 - 2016
5	De, Santanu	Expert, Technology Development Fund (TDF), Defense Research and Development Organization (DRDO)	National	2017 - present
6	Dutta, Ashish	Project Coordinator Rural Technology Action Group, PSA Office, RuTAG @ IITK	National	2022 - present
		Member of SERB, Mechanical Board	National	2021 - present
		Member - Bureau of Indian Standards (BIS) section on drilling	National	2020 - present
		Board of Studies: APJ Abdul Kalam Technical University, Lucknow	National	2020 - present
		Grand Project Coordinator of the IHFC (DST) national projects and IHFC (DST) - NSF (USA) international projects on "Rehabilitation Robotics".	National and International	2020 - present
		Chairman, IE (I) Kanpur Local Chapter	National	2018 - 2020
		Visiting Faculty, Department of Life Science and Systems Engineering, Kyushu Institute of Technology, Japan.	International	2018 - present
		Advisory board member The Robotics Society (India)	National	2018 - present
		Chairman IEEE Robotics and Automation Society - UP, UK state section	National	2018 - present
		Selection committee members in various IIT, NIT and IIIT's	National	2017 - present
		Board of Studies: NITS, IIITDMS	National	2017 - present
		Member - Bureau of Indian Standards (BIS) section on production automation systems and robotics (BIS- PGD 18).	National	2017 - present

		External member of senate, IIIT Allahabad	National	2017 - 2019
		Board of Studies: APJ Abdul Kalam Technical University, Lucknow	National	2016 - present
		Member of ISO international standards committee on collaborative robotics	International	2015 - 2016
7	Kar, K. Kamal	Several faculty selection committees (all CFTs)	National	
		Member of SERB, Condensed Matter Physics/Materials Science	National	
		Member, New Raw Materials Development, ASPIRE, International Centre for Automotive Technology (ICAT)	National	
		Member, board of XIth Five Year Plan of DMSRDE on Development of Smart Polymers/Materials, Elastomers and Nanomaterial Based Fluids (DRDO)	National	
		Member of Academic Council, DIT University, Dehradun	National	
		Board of Studies - Chhatrapati Shahu Ji Maharaj University, Kanpur; GLA University, Mathura	National	
		Member of Expert Committee for 6th National Awards for Technology Innovation in Petrochemicals and Downstream Plastics Processing Industry	National	
8	Khandekar, Sameer	Chairperson, International Heat Pipe Committee	International	2022 - ongoing
		Member, International Heat Pipe Committee	International	2007 - ongoing
		Visitors Nominee for faculty selection committees (all CFTIs)	National	2018 - ongoing
		AICTE: All India Board of Undergraduate Studies in Engineering & Technology (AIB-	National	2020 - ongoing

		UGET)		
		Consultant to UT Ladakh (for Kargil Engineering College)	National	2021 - ongoing
		Board of studies - KIIT University	National	2021 - ongoing
		Board of Studies - UPTTI, Kanpur	National	2021 - ongoing
		Member of task force setup to install PSA Oxygen Plants in hospitals	National	2021 - 2022
		Member, ME Department Review Committee (IIT Palakkad)	National	2021 (Completed)
		Board of Studies (ME), LNMIIT Jaipur	National	2020 - ongoing
		Several selection committees of INAE awards	National	2019 - ongoing
		DST SERB PAC/ECA (Civil, Mechanical, Aerospace Engineering)	National	2015 - ongoing
		DST SERB PAC (Materials, Energy	National	2022 - ongoing
9	Kumar, Arvind	Advisory Board Member, First International Conference on Advances in Renewable and Sustainable Energy Systems - 2020 (ICARES 2020), organized by SRM Institute of Science and Technology, Chennai, India	National	2020
10	Muralidhar, K.	Editorial advisory board, Mechanical Engineering Series, Springer, New York	International	2017 - 2022
		Visitor's nominee, IIT Bombay	National	2015 - 2020
		Member, International Advisory Board, Asian Computational Flow and Heat Transfer Conference	International	2015 - 2019
		President, National Fluid Mechanics and Fluid Power Society	National	2014 - 2016

11	J., Ramkumar	Program Chair - International Conference "Advances in Robotics" 2021	International	2021
		Member - ISRO Committee on "Space robotics experiment for Gaganyaan program."	National	2019
		External expert committee member for review of DRDO, R&D Engineers laboratories	National	2019
		Member - "Task force on AI for India's economic transformation" - Ministry of Commerce and Industry, Govt. of India.	National	2018
		Secretary - Robotics Society of India.	National	2014 - 2017
		Selection committee member for faculty selection of several IITs, NITs and private engineering colleges.	National	2015
12	Sarkar, Subrata	External member of the Academic Senate, NIT Kurukshetra	National	2015 - 2017
		Member of the Academic Review Committee, NIT Allahabad	National	2014 - 2015
		Coortinator, Multicentric Gas Turbine Technology (GATET) Initiative in India	National	2007 - 2013
		Member of the Propulsion Panel, AR&DB, Govt. of India	National	2010 - 2012
		Coordinator, Unman Air Vehicle (UAV) Initiative in India	National	2009 - 2012
		Review Chair, ASME Gas Turbine India	International	2014
		Member of Faculty Selection Committee, IIT, NIT	National	Ongoing

13	Vyas, Nalinaksh S.	Member Advisory Comm Common Res & Tech Development Hubs (CRTD-Hubs), DSIR	National	2020
		Member Expert Task Force on IVHM of LCA (Light Combat Aircraft)	National	2021 - Ongoing
		Chairman PARC AGRO-Tech Program, DST	National	2019 – 2022
		Chairman Technology Mission for Indian Railways (TMIR)	National	May, 2015- April 2022
		Member, Governing Council, TIFAC, DST	National	2018-2021
		Member Board of Governors MNIT (Malaviya National Institute of Technology) Jaipur	National	2018 - Ongoing
		Chairman PARC Technology Enabling Centres, DST	National	2018 - Ongoing
		Member Science & Technology Research Initiative (SHRI), DST	National	2017 - Ongoing
		Member Board of Governors JNARDDC (J L Nehru Aluminum Research, Des. & Dev. Centre)	National	2016 - Ongoing
		Chairman PARC Technology Systems Development Program (TSDP), DST	National	2016 - 2022
		Member Board of Governors IIT (Indian Institute of Technology) Jodhpur	National	2014-18
		Member Executive Committee AICTE (All India Council for Technical Education)	National	2014-18
		Vice Chancellor Rajasthan Technical University	National	2013- 15
		Project Coordinator Rural Technology Action Group, PSA Office, RuTAG @ IITK	National	2012-2022
		Chairman NPMASS, DRDO, Automotive Parc, National Program	National	2009-15

		on Micro & Smart Structures		
		Project Coordinator Nano-Satellite, JUGNU Project with ISRO	National	2009 – 2011
		Consortium Leader Electronic Stability Program, CAR, Core Group on Automotive Research, TIFAC	National	2005-2008
		National Coordinator Technology Mission on Railway Safety, Govt of India	National	2005-09
		Member Indo-US Task Force on Embedded Systems, Planning Commission	National	2012
		Member Working Group on Energy Res., Planning Comm., Govt of India	National	2012

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Faculty Profile

Department of Mechanical Engineering
Indian Institute of Technology Kanpur
Kanpur (UP) 208016 India

As on August 15, 2022

List of Faculty members as on August 15, 2022			
#	PF No.	Name	Designation
1	4560	Dr. Gautam Biswas	Emeritus Professor
2	4288	Dr. Partha Sarathi Ghoshdastidar	Emeritus Professor
3	4398	Dr. Krishnamurthy Muralidhar	Professor (HAG)
4	4459	Dr. Nalinaksh Sharadchandra Vyas	Professor (HAG)
5	4788	Dr. Subrata Sarkar	Professor (HAG)
6	4801	Dr. Pradipta Kumar Panigrahi	Professor (HAG)
7	5455	Dr. Anindya Chatterjee	Professor (HAG)
8	*4928	Dr. Kamal Krishna Kar	Professor (HAG)
9	4931	Dr. Avinash Kumar Agarwal	Professor (HAG)
10	4890	Dr. Bishakh Bhattacharya	Professor (HAG)
11	5022	Dr. Ashish Dutta	Professor (HAG)
12	5054	Dr. Venkitanarayanan Parameswaran	Professor (HAG)
13	5120	Dr. Sameer Khandekar	Professor (HAG)
14	4779	Dr. Bhaskar Dasgupta	Professor
15	5014	Dr. Sumit Basu	Professor
16	5122	Dr. Arun Kumar Saha	Professor
17	4956	Dr. Anupam Saxena	Professor
18	5199	Dr. Ishan Sharma	Professor
19	5234	Dr. Shantanu Bhattacharya	Professor
20	5299	Dr. Pankaj Wahi	Professor
21	5294	Dr. Malay Kumar Das	Professor
22	5300	Dr. Anurag Gupta	Professor
23	5399	Dr. Shakti Singh Gupta	Professor

24	5447	Dr. Arvind Kumar	Associate Professor
25	5518	Dr. Niraj Sinha	Associate Professor
26	5622	Dr. Jishnu Bhattacharya	Associate Professor
27	5628	Dr. Santanu De	Associate Professor
28	5713	Dr. Mohit S. Law	Associate Professor
29	6166	Dr. K. R. Guruprasad	Associate Professor
30	5267	Dr. Basant Lal Sharma	Assistant Professor Grade I
31	5901	Dr. Akhilesh Mimani	Assistant Professor Grade I
32	5701	Dr. Sachin Y. Shinde	Assistant Professor Grade I
33	5872	Dr. Pranav Ramkrishna Joshi	Assistant Professor Grade I
34	5894	Dr. Supratik Mukhopadhyay	Assistant Professor Grade I
35	5965	Dr. Manjesh Kumar Singh	Assistant Professor Grade I
36	5960	Dr. Anikesh Pal	Assistant Professor Grade I
37	5910	Dr. Aditya Saurabh	Assistant Professor Grade I
38	5862	Dr. Chandraprakash Chindam	Assistant Professor Grade I
39	6119	Dr. Abhishek Sarkar	Assistant Professor Grade I
40	6155	Dr. Shyam Sunder Gopalakrishnan	Assistant Professor Grade I
41	6027	Dr. Umesh Madanan	Assistant Professor Grade I
42	6084	Dr. Ushasi Roy	Assistant Professor Grade II
43	6167	Dr. Keval Shrihari Ramani	Assistant Professor Grade II
44	6170	Dr. Virkeshwar Kumar	Assistant Professor Grade II
45	6172	Dr. Sarvesh Kumar Mishra	Assistant Professor Grade II

Note: Prof. Janakrajan Ramkumar and Prof. Nachiketa Tiwari are presently serving the Department of Design, which is newly formed in the year 2022.

The details of all the faculty members are given hereunder (alphabetical order).

Faculty profile

Name: Avinash Kumar Agarwal **Academic Degree:** • B.E. (Mech. Eng.), 1994, Malviya REC, Jaipur (Rajasthan) • M. Tech. (Energy), 1996, Centre for Energy Studies, Indian Institute of Technology Delhi • Ph. D. (Energy), 1999, Centre for Energy Studies, IIT Delhi **Specialization**: IC engines, biofuels, emissions, laser diagnostics **Date of Joining**: 20th March, 2001 **No of PhD Graduated:** 14 (8 Ongoing) **No of MTech Graduated:** 56 (2 Ongoing)	

Five Best Contributions:

1. An Electronic Fuel Injection System for a Locomotive Diesel Engine of Indian Railways: An electronic fuel injection system for a 4-stroke, 16 cylinders, V-configuration, medium speed, large bore loco-engine was developed and successfully retrofitted on a rebuilt diesel locomotive in collaboration with RDSO, Lucknow. A savings of 4% fuel consumption and 70% smoke reduction over the duty cycle.
2. Edited “Handbook of combustion” (3200 pages of combustion), the most updated reference in Combustion globally. Springer Book Series Editor on Energy, Environment, and Sustainability.
3. Amir F.N. Abdul-Manan, V. Gordillo Zavaleta, A. K. Agarwal, G. Kalghatgi, A. A. Amer, “Electrifying passenger road transport in India requires near-term electricity grid decarbonization” NATURE Communications, 13, 2095 (2022) - IF 2022: 17.7; Four papers published in Progress in Energy and Combustion Science (IF 35.34).
4. In top 2% list of Scientists Prepared by Stanford University, 2021. First in Energy Domain out of 136 Indian Researchers in this list in 2019, 2020, 2021.
5. Six students are faculty in the IIT system (IIT KGP, Ropar, Bhilai, IITBHU, and 2 in Mandi), few more are likely to join soon. 56 MT students in R&D in Indian Automotive Industries.

Five best Recognitions:

- Elected Fellow of CI (Combustion Institute, USA), 2022; AAAS (Am. Ass. Advancement of Science), 2020; WSSET (World Society for Sustainable Energy Tech.), UK, 2020; RSC (Royal Society of Chemistry, UK) 2018, NASI (National Academy of Sciences India), 2018, INAE, 2015, ISEES (Int. Soc. of Energy, Env. Sustainability), 2015, ASME, 2013, and SAE, USA), 2012.
- Sir J C Bose National Fellow (Science and Engineering Research Board, GoI), August 2019.
- Featured in DST Golden Jubilee Coffee Table Book “75 under 50 Scientists Shaping Today’s INDIA,” released by Vigyan Prasar, GOI, on National Science Day, February 28th, 2022.
- CSIR’s Shanti Swarup Bhatnagar Prize-2016 was awarded by the Prime Minister of India.
- Distinguished Alumnus Award-2021 from Malviya National Institute of Technology, Jaipur and India Research Excellence - Clarivate Analytics Citation Award-2017, Rajib Goyal Prize-2017 by Kurukshetra University, Er. M P Baya National Award in Mechanical Engineering-2017, NASI-Reliance Industries Platinum Jubilee Award -2012 for Application Oriented Innovations in Physical Sciences, INAE Silver Jubilee Young Engineer Award-2012, Dr C. V. Raman Young Teachers Award-2011 for Excellence in Engineering Education, SAE Internationals’ Ralph R. Teetor Educational Award-2008, INSA Young Scientist Award-2007, UICT Alkyl Amine Young Scientist Award-2007, INAE Young Engineer Award-2005, and AICTE Career Award for Young Teachers-2004.

Faculty profile

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Name: Sumit Basu

Academic degree:

1. B.E. Jadavpur University 1991 Honours
2. M.E. I. I. Sc-Bangalore 1994 Distinction
3. PhD I. I. Sc-Bangalore 1999

Specialization: Multiscale and multi-physics based studies of deformation and failure of soft, natural, heterogenous and polymeric materials.

Date of joining: August, 2002

No of PhD Graduated: 16

No of MTech Graduated: ~ 60

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Five Best Contributions:

1. MR Zafar, S Basu (2022) Stiffness and toughness of soft, liquid reinforced composites, Journal of the Mechanics and Physics of Solids 159, 104714
2. AK Srivastava, S Basu (2020) Mechanics of reversible wrinkling in a soft dielectric elastomer, Physical Review E 101 (4), 040501
3. Prabhat K Agnihotri, Kamal K. Kar, Sumit Basu, (2011) Effect of Carbon Nanotube Length and Density on the Carbon Nanotube Coated Carbon fibre / Polyester Composites. Carbon, v49, p3098-3106
4. Dhiraj K Mahajan, Rafael Estevez and Sumit Basu, (2010) Ageing and rejuvenation in glassy amorphous polymers, Journal of the Mechanics and Physics of Solids, v 58, n 10, p 1474-88, Oct. 2010
5. Majumder, Manoj K.; Ramkumar, S.; Mahajan, Dhiraj K.; Basu, Sumit, (2010) Coarse-graining scheme for simulating uniaxial stress-strain response of glassy polymers through molecular dynamics, Physical Review E: Statistical, Nonlinear, and Soft Matter Physics, v81, n1, 011803.
6. Parimal Maity, P. Venkitanarayanan, Sumit Basu, Nandini Gupta (2007), Degradation of Polymer Dielectrics with Nanometric Metal-oxide Fillers due to Surface Discharges, IEEE Transactions on Dielectrics and Electrical Insulation, v15, pp52-62

Faculty profile

Name: Bishakh Bhattacharya **Academic Degree:** • Bachelor of Civil Engineering, Department of Civil Engineering, Jadavpur University, 1988 • Master of Engineering (Applied Mechanics), Deptt. Mech. Engineering, Jadavpur University, 1991 • PhD, Aerospace Engineering, Indian Institute of Science Bangalore, 1998 **Specialization**: Vibration and Control, Smart materials, Health-care Robotics, Sensors & Actuators **Date of joining**: June, 2000 **No of PhD Graduated:** 14 **No of MTech Graduated:** 76**; No of M Des Graduated**: 28 **No of MS Graduated: 3**	

Five Best Contributions:

1. Development of Hour-glass based latticed meta-structure for vibration control
2. Development of Shape Memory Alloy (SMA) based bi-pennate actuation system for medical robots
3. Active Shape Control of Flexible Parabolic Antenna System for Space Application
4. Pipe Health Monitoring Robot for Defect Detection of Gas-pipelines
5. Autonomous Aquatic Observatory for River health monitoring

Five Best Recognitions:

- Associate Editor of Journal of Low Frequency Noise, Vibration and Active Control
- Associate Editor of Journal of Vibration Engineering and Technology
- Associate Editor of Journal of Systems Science and Engineering
- HAL Chair Professor Award, Hal Lucknow, 2021
- Young Scientist Award 2006 by Systems Society India

Faculty profile

Name: Jishnu Bhattacharya

Academic Degree:

Doctor of Philosophy (ME)	University of Michigan, Ann Arbor	2010
MS Engineering (ME)	Indian Institute of Science, Bangalore	2005
Bachelor of Engineering (ME)	Bengal Engineering College, Shibpur	2002

Specialization: Fluid Mechanics, Thermal Sciences

Date of joining: October, 2014

No. of PhD Graduated: 3

No. of M. Tech. Graduated: 13

Five Best Contributions:

1. Jishnu Bhattacharya, A Van der Ven, Mechanical instabilities and structural phase transitions: The cubic to tetragonal transformation, Acta Materialia, 56 (16), 4226-4232 (2008)
2. Jishnu Bhattacharya, A Van der Ven*, Phase stability and nondilute Li diffusion in spinel Li1+xTi2O4, Physical Review B, 81 (10), 104304 (2010)
3. N. Chintapalli, MK Sharma, J Bhattacharya*, Linking spectral, thermal and weather effects to predict location-specific deviation from the rated power of a PV panel, Solar Energy, 208, 115-123 (2020)
4. P Jindal, BS Kumar, J Bhattacharya*, Coupled electrochemical-abuse-heat-transfer model to predict thermal runaway propagation and mitigation strategy for an EV battery module, Journal of Energy Storage, 39, 102619 (2021)
5. M Singh, MK Sharma, J Bhattacharya*, Design methodology of a parabolic trough collector field for maximum annual energy yield, Renewable Energy, 177, 229-241 (2021).

Faculty profile

Name: Shantanu Bhattacharya

Academic Degree:

B.E., (Ind./Prod.)	Delhi College of Engineering	1996
M.S. (ME)	Texas Tech University, USA	2003
Ph. D.	Uni-Missouri, Columbia, USA	2006

Specialization: Microsystem design, fab., BioMEMS, Lab on chip, Sensors, Nano-energetics, Acoustic Metamaterials, Printable manufacturing, Water remediation, Energy storage, Microfluidics

Date of joining: July, 2007

No of PhD Graduated: 14 (Comp.) + 03 (Submitted)

No of M. Tech. Graduated: 20 (ME) + 11 (Design)

Five Best Contributions:

1. Poonam Sundriyal, Shantanu Bhattacharya, 2017, Inkjet-Printed Electrodes on A4 Paper Substrates for Low-Cost, Disposable, and Flexible Asymmetric Supercapacitors, ACS applied materials and interfaces, Vol. 9, No. 44, pp. 38507–38521
2. Om Prakash, Shantanu Bhattacharya, Sanjay Kumar, Pulak Bhushan, 2019, Composite sound absorption panel assembly, US 2019/0103089A1, Technology transferred to Boeing
3. Megha Sahu, Om Prakash, Shantanu Bhattacharya, Poonam Sundriyal, 2021, Method for enhanced bonding of thermoplastic composites, US 2021/0269608 A1, Pub. 02/09/2021, Technology Transferred to Boeing
4. Aviru Kumar Basu, Amar Nath Sah, Mayank Manjul Dubey, Prabhat K. Dwivedi, Asima Pradhan, Shantanu Bhattacharya, 2020, MWCNT and α-Fe_2O_3 embedded rGO-nanosheets based hybrid structure for room temperature chloroform detection using fast response/ recovery cantilever-based sensors, Sensors Actuators, B: Chemical, Vol. 305, 127457, 2020
5. Shantanu Bhattacharya, A. Dutta, J.M. Berg, S. Gangopadhyay, 2005, Studies on surface wettability of PDMS and glass under oxygen plasma treatment and correlation with bond strength, Journal of Microelectromechanical Systems, Vol. 14, No.3, June 2005.

Five Best Recognitions:

- Abdul Kalam Technology Innovation National Fellow, Conferred by Indian National Academy of Engineering (INAE), 2020. (Contribution in the fields of Micro-Fabrication, Nano-Materials Synthesis and Applications, Micro-fluidic Systems as well as overall contribution in the growth of the engineering profession within the country.)
- Fellow of The Royal Society of Chemistry, 2021.
- Senior Member, IEEE, 2019.
- NASI Reliance Platinum Jubilee Award, Conferred by National Academy of Sciences of India, 2019. (For Application driven innovations in Physical Sciences.)
- Er. M.P. Baya National Award-2019. Conferred by Institution of Engineers of India (For Excellence in Engineering)

Faculty profile

Name: Gautam Biswas **Academic Degree:** BE, (Calcutta University, 1979) PhD, (IIT Kharagpur, 1985) **Specialization**: Fluid and Thermal Sciences **Date of joining**: May, 1990 **No of PhD Graduated:** 23 **No of MTech Graduated:** 63	

Five Best Contributions:

1. B. Ray, G. Biswas and A. Sharma, Generation of secondary droplets in coalescence of a drop at a liquid/ liquid interface, Journal of Fluid Mechanics, Vol. 655, pp. 72-104, (2010). https://doi.org/10.1017/S0022112010000662
2. B. Ray, G. Biswas and A. Sharma, Regimes during liquid drop impact on a liquid pool, Journal of Fluid Mechanics, Vol. 768, pp. 492-523, (2015). https://doi.org/10.1017/jfm.2015.108
3. H. Deka, B. Ray, G. Biswas, A. Dalal, P.-H. Tsai, and A.-B. Wang, The regime of large bubble entrapment during a single drop impact on a liquid pool, Physics of Fluids, Vol. 29, (Issue 9) pp. 092101-1- 092101-13, (2017). https://aip.scitation.org/doi/10.1063/1.4992124
4. H. Deka, G. Biswas, K. C. Sahu, Y. Kulkarni, A. Dalal, Coalescence dynamics of a compound drop on a deep liquid pool, Journal of Fluid Mechanics, (JFM Rapids), Vol. 866, pp. R2-1 –R2-11, (2019). https://doi.org/10.1017/jfm.2019.137
5. G. S. Chaitanya, K. C. Sahu and G. Biswas, A study of two unequal-sized droplets undergoing oblique collision, Physics of Fluids, Vol. 33, pp. 022110-1 -- 022110-15, (2021). https://doi.org/10.1063/5.0038734

Five Best Recognitions:

- Fellow of the Indian National Science Academy (INSA), New Delhi, India
- J C Bose National Fellowship by SERB (DST), Govt of India
- Fellow of the Indian Academy of Sciences (Bangalore), India
- Fellow of the National Academy of Sciences, India
- Fellow of the Indian National Academy of Engineering, India
- Fellow of the American Society of Mechanical Engineers (ASME), USA

Faculty profile

Name: C. Chandraprakash

Academic Degree:

PhD in Engineering Science and Mechanics	Penn. State	2017
B. Tech and M. Tech in Mechanical Engineering	IIT Madras	2010

Specialization: Solid Mechanics and Design

Date of joining: December, 2017

No. of Ph. D. Graduated: 0

No. of M. Tech. Graduated: 9

Five Best Contributions:

1. S Kumar, K Jahan, A Verma, M Agarwal, and C Chandraprakash, Agar-based composite films as effective biodegradable sound absorbers, *ACS Sustain. Chem. Engg.*, 10 (26), 8242-9253 (2022).
2. V Sharma and C Chandraprakash. Quasi-superhydrophobic microscale two-dimensional phononic crystals of stainless steel 304, *Journal of Applied Physics*, 131 (18), 184901 (2022)
3. C Chandraprakash, N M Wonderling, A Lakhtakia, O Awadelkarim, and W Orfali. Microfiber inclination, crystallinity, and water wettability of microfibrous thin-film substrates of Parylene C in relation to the direction of the monomer vapor during fabrication, *Applied Surface Science*, 345, 145-155 (2015).
4. C Chandraprakash, N Nama, M I Lapsley, F Costanzo, and T J Huang. Theory and experiment on resonant frequencies of liquid-air interfaces trapped in microfluidic devices, *Journal of Applied Physics*, 114 (19), 194503 (2013).
5. C Chandraprakash, C V Krishnamurthy, K Balasubramaniam, and R V Prakash. Thermo-mechanical response of metals: Maxwell vs. Kelvin-Voigt models, *Materials Science and Engineering: A*, 560, 54{61 (2013).

Five Best Recognitions:

- Work by S Kumar et al. has been picked by ACS editors for the ACS News - also highlighted in the international and national science news: Phys.org, ScienceDaily, Technology networks, Eurekalert, and Nature world. Attracted attention to seaweed and music communities. 2022
- Paul A. Lester Memorial Award for best PhD research in microelectronics in Department of Engineering Science and Mechanics, Penn State University 2017
- Distinguished Teaching Fellow in College of Engineering, Penn State for 2015-16
- Won 3rd prize for poster presentation in ESM Today, graduate research symposium of Department of Engineering Science and Mechanics, Penn State University 2017
- Won 2nd prize for poster presentation in ESM Today 2013

Faculty profile

Name: Anindya Chatterjee **Academic Degree:** • B. Tech., Mechanical Engg, IIT Kharagpur, 1989 • M.S, Engineering Mechanics, University of Florida, 1993 • M.S, Applied Mathematics, University of Florida, 1993 • Ph. D, Theoretical & Applied Mechanics, Cornell University, 1997 **Specialization**: Applied mechanics, Dynamics **Date of joining**: July, 2012 **No of Ph. D Graduated:** 12 No of M. Tech. Graduated: Not sure. More than 25.	

Five Best Contributions:

1. S. Tiwari, C. P. Vyasarayani and A. Chatterjee. Data suggest COVID-19 affected numbers greatly exceeded detected numbers, in four European countries, as per a delayed SEIQR model. Scientific Reports, 2021, vol. 11, article no. 8106.
2. A. Kumar and A. Chatterjee. Unequivocally nonconservative results from one method of imperfection quantification in RCC-MR. ASME Journal of Nuclear Engineering and Radiation Science, 2021, vol. 7(1), 011801.
3. S. Tiwari and A. Chatterjee. Basis functions for residual stresses. Applied Mathematics and Computation, 2020, vol. 386, 125468.
4. S. Rakshit and A. Chatterjee. Scalar generalization of Newtonian restitution for simultaneous impact. Int. Journal of Mechanical Sciences, vol. 103, 2015, 141-157.
5. S. Biswas and A. Chatterjee. A reduced-order model from high dimensional frictional hysteresis. Proceedings of the Royal Society of London A, vol. 470, 2014, 20130817.

Five Best Recognitions:

- Fellow of Indian National Academy of Engineering (FNAE).
- Fellow of National Academy of Sciences India.
- Associate Editor, ASME Journal of Compuational and Nonlinear Dynamics, 2016-19.
- Subject Editor, Nonlinear Dynamics, presently.
- Excellence in teaching award, IIT Kanpur, 2021

Faculty profile

Name: Malay Kumar Das **Academic Degree:** B.E., Uni. of Calcutta (Bengal Engg. College, Shibpur), 1989 M. Tech., I. I. T. Kanpur, 2003 Ph. D, Pennsylvania State University, 2008 **Specialization:** Thermal Science **Date of joining:** May, 2008 **No of Ph.D Graduated:** 08 **No of M. Tech. Graduated:** 38	

Five Best Contributions:

1. Yadav R., Gupta A. K., Das M. K., Panigrahi P. K., "Investigations on a controlled microwave heating technique for efficient depressurization in methane hydrate reservoirs", Energy Reports, Vol 8, 7825-7839, 2022
2. Pandey P K., Das M. K., "Effect of foam insertion in aneurysm sac on flow structures in parent lumen: relating vortex structures with disturbed shear", Physical and Engineering Sciences in Medicine, Vol 44(4), 1231-1248, 2021
3. Bharti O. S., Rajan D., Saha A. K., Das M. K., "Simultaneous Estimation of Pr and Ra in a Natural Convective Flow Using Inverse Technique", Journal of Heat Transfer, Vol 142(2), 022601, 2020.
4. Babu R., Das M. K., "Experimental studies of natural convective mass transfer in a water-splitting system", International Journal of Hydrogen Energy, Vol. 44(29), 14467-14480, 2019.
5. Jithin M., Kumar N., De A., Das M. K., "Pore-scale simulation of shear-thinning fluid flow using lattice Boltzmann method", Transport in Porous Media, Vol 121(3), 753-782, 2018.

Faculty profile

Name: Bhaskar Dasgupta **Academic Degree:** B. Sc. Engg. (1991) Patna University, Patna (India) M. E. (1993) Indian Institute of Science, Bangalore (India) Ph. D. (1997) Indian Institute of Science, Bangalore (India) **Specialization**: Robotics, CAD, Optimization **Date of joining**: August, 1997 **No of PhD Graduated:** 6 **No of MTech Graduated:** 60 (approx)	

Five Best Contributions:

1. PG Textbook on Applied Mathematical Methods (Pearson Education).
2. NPTEL course on "Mathematical Methods in Engineering and Science".
3. Analytical Formulation of Algorithms for Analysis, Synthesis, Planning and Control of Redundant Manipulators.
4. A new scoring function "Normalized Volume Mismatch" for shape complementarity analysis in protein docking.
5. Domain Mapping algorithm with potential applications in solid and surface modelling for motion planning, docking and mesh generation.
6. English Proficiency Programme: A framework for learning and teaching English in a constrained timeframe, documented in the NPTEL course "Practical English: Learning and Teaching".

Five Best Recognitions:

- Two gold medals for best PhD thesis (1997)
- Humboldt Fellowship (2001)
- INAE Young Engineer Award (2003)
- Mercator Guest Professorship at TU Berlin (2005)
- TWO "Mechanism and Machine Theory Awards" for Excellence for the papers "The Stewart platform manipulator: a review" (2000) and "A Newton-Euler formulation for the inverse dynamics of the Stewart platform manipulator" (1998), as among the top 10 most cited papers during the journal's history of half a century (2017).

Faculty profile

Name: Santanu De

Academic Degree:

Ph. D. (Aerospace Engg.)	IISc Bangalore	2012
M. Tech. (Mech. Engg.)	IIT Kanpur	2004
B. E. (Mech. Engg.)	North Bengal University	2002

Specialization: Fluid Mechanics, Thermal Sciences

Date of joining: December, 2014

No. of PhD Graduated: 2

No. of M. Tech. Graduated: 23

Five Best Contributions:

1. Fluidized bed gasifier for high-ash coal: S Gupta, S De, An experimental investigation of high-ash coal gasification in a pilot-scale bubbling fluidized bed reactor, Energy 244, 122868, https://doi.org/10.1016/j.energy.2021.122868
2. Mixing timescale model development in a turbulent spray combustion solver (MMCFoam) based on transported PDF approach: E Sharma, S De, MJ Cleary, A fully dynamic mixing time-scale model for the sparse Lagrangian multiple mapping conditioning approach, Combustion and Flame 238 (4), 17, https://doi.org/10.1016/j.combustflame.2021.111872
3. RANS-MMC modeling of multi-regime combustion model: SK Ghai, S De, Numerical investigation of auto-igniting turbulent lifted CH_4/air jet diffusion flames in a vitiated co-flow using a RANS based stochastic multiple mapping conditioning approach, Combustion and Flame 203, 362-374, https://doi.org/10.1016/j.combustflame.2019.02.024
4. Development of a spray combustion solver: S De, SH Kim, Large eddy simulation of dilute reacting sprays: Droplet evaporation and scalar mixing, 2013, Combustion and Flame 160 (10), 2048-2066, https://doi.org/10.1016/j.combustflame.2013.04.024
5. S Gupta, S De, Investigation of hydrodynamics and segregation characteristics in a dual fluidized bed using the binary mixture of sand and high-ash coal, Advanced Powder Technology 32 (8), 2690-2702, https://doi.org/10.1016/j.apt.2021.04.023

Faculty profile

Name: Ashish Dutta **Academic Degree:** • B. Tech, R.E.C. Calicut, India. 1989 • M. E., Jadavpur University, India. 1994 • Ph. D., Akita University, Japan. 2002 **Specialization**: Robotics and intelligent control systems **Date of joining**: November, 2002 **No of Ph. D. Graduated**: 10 **No of M. Tech. Graduated**: 55	

Five Best Contributions:

1. A Chowdhury, YK Meena, H Raza, B Bhushan, AK Uttam, N Pandey, Ashish Dutta, Girijesh prasad. Active physical practice followed by mental practice using BCI-driven hand exoskeleton: a pilot trial for clinical effectiveness and usability. IEEE journal of biomedical and health informatics 22 (6), 2018, pp.1786-1795
2. A Chowdhury, H Raza, YK Meena, A Dutta, G Prasad An EEG-EMG correlation-based brain-computer interface for hand orthosis supported neuro-rehabilitation. Journal of neuroscience methodsvol. 312,2019, pp. 1-11.
3. D Rathee, A Chowdhury, YK Meena, A Dutta, S McDonough, G Prasad. Brain–machine interface-driven post-stroke upper-limb functional recovery correlates with beta-band mediated cortical networks. IEEE Transactions on Neural Systems and Rehabilitation Engineering 27 , 2019, pp. 1021-1031.
4. R Raja, A Dutta, KS Venkatesh, New potential field method for rough terrain path planning using genetic algorithm for a 6-wheel rover. Robotics and Autonomous Systems 72, 2015, 295-306
5. RK Jain, S Majumder, A Dutta. SCARA based peg-in-hole assembly using compliant IPMC micro gripper. Robotics and Autonomous Systems 61 (3), 2013, 297-311.

Faculty profile

Name: P. S. Ghoshdastidar

Academic Degree:

B. M. E. Hons (Jadavpur University, 1978)
M. S. (University of South Carolina, Columbia, USA, 1981)
Ph. D. (University of South Carolina, Columbia, USA, 1984)

Specialization: Computational Heat Transfer

Date of joining: May 24, 1985

No of Ph.D Graduated: 10

No of MTech Graduated: 75

Five Best Papers:

1. Sayan Sadhu and P.S. Ghoshdastidar, "Heat Flux Controlled Pool Boiling of Zirconia-Water and Silver-Water Nanofluids on a Flat Plate: A Coupled Map Lattice Simulation", ASME Journal of Heat Transfer, Vol. 137, p. 021503, 2015.
2. Ashish Agrawal and P.S. Ghoshdastidar, "Numerical Simulation of Heat Transfer during Production of Rutile Titanium Dioxide in a Rotary Kiln", Int. J. Heat Mass Transfer, Vol. 106, pp. 263-279, 2017.
3. Dileep V. Nair and P.S. Ghoshdastidar, "A Comparative Study of 2-D and 3-D Conjugate Natural Convection from a Vertical Rectangular Fin Array with Multilayered Base Subjected to Distributed High Heat Flux", Int. J. Heat and Mass Transfer, Vol. 121, pp. 1316-1334, 2018.
4. Saptarshi Mandal and P.S. Ghoshdastidar, "Laminar Forced Convection of Nanofluids in a Circular Tube: A New Nonhomogeneous Flow Model", ASME J. Heat Transfer, Vol. 142, p.022502, 2020.
5. Atinder Pal Singh and P.S. Ghoshdastidar, "Computer Simulation of Heat Transfer in Alumina and Cement Rotary Kilns", ASME Journal of Thermal Science and Engineering Applications, Vol. 14, p. 031001, 2022.

Five Best Recognitions:

- Recipient of the Institution Prize of the Institution of Engineers (I) by the President of India on December 20, 1995 during the inaugural session of 10th Indian Engineering Congress held in Jaipur, for the paper, “Numerical Modelling of Enhanced Oil Recovery Using Water Injection Method” (K. M. Pillai, K. Muralidhar and P. S. Ghoshdastidar), 1994 in the institution journal.
- 2012 A. M. Strickland Prize of the Manufacturing Industries Division of the IMechE, U.K., for the paper entitled, “Computational Fluid Dynamics Simulation and Experimental Investigations into the Magnetic-field-assisted Nano-finishing Process”, published in the Journal of Engineering Manufacture, Proceedings of the Institution of Mechanical Engineers, U.K., Part B in 2012.
- Associate Editor, Heat Transfer Research (since May 1, 2011).
- Outstanding Reviewer Award, Int. Journal of Heat and Mass Transfer in January, 2018.
- Recipient of the Excellence-in-Teaching Award 2021 of IIT Kanpur. The prize was given away by the Director, IIT Kanpur, on Teacher's Day (5.9.21).

Faculty profile

Name: Shyam Sunder Gopalakrishnan

Academic Degree:

Ph. D. (Fluid Mech.)	Universite de Lyon 1, France	2014
M. S. (Fluid Mech.)	Ecole Polytechnique (Paris)	2010
B. Tech. (ME)	NIT, Suratkal	2008

Specialization: Fluid Mechanics, Thermal Sciences

Date of joining: June, 2022

No. of PhD Graduated: Nil

No. of M. Tech. Graduated: Nil

Five Best Contributions:

1. S. S. Gopalakrishnan, On the instability of buoyancy-driven flows in porous media, Journal of Fluid Mechanics, 892, A13, 2020
2. S. S. Gopalakrishnan, K. Panajotov, M. Taki, and M. Tlidi, Dissipative light bullets in Kerr cavities: Multistability, clustering, and rogue waves, Physical Review Letters, 126, 153902, 2021
3. S. S. Gopalakrishnan, B. Pier, and A. Biesheuvel, Dynamics of pulsatile flow through model abdominal aortic aneurysms, Journal of Fluid Mechanics, 758, 150—179, 2014
4. S. S. Gopalakrishnan, B. Pier, and A. Biesheuvel, Global stability analysis of flow through a fusiform aneurysm: steady flows, Journal of Fluid Mechanics, 752, 90—106, 2014
5. S. S. Gopalakrishnan, B. Knaepen, and A. De Wit, Scalings of the mixing velocity for buoyancy-driven instabilities in porous media, Journal of Fluid Mechanics, 914, A27, 2021

Five Best Recognitions:

- CNRS Post-doctoral fellowship (2021): Two-year scholarship for research and education at Laboratoire de Physique des Lasers, Atomes et Molecules (PhLAM), Universite de Lille
- ARC Post-doctoral fellowship (2014): Three-year scholarship for research and education in the Nonlinear Physical Chemistry Unit, Universite Libre de Bruxelles
- Thales Academia scholarship (2009): Won the Thales Academia scholarship from the French Embassy for pursuing Master’s studies at Ecole Polytechnique, Paris (1 out of 9 people selected from all over India)
- CBSE (2004): Was awarded a certificate of merit by the Central Board of Secondary Education for achieving a score within the top 0.1% of students all over India in Chemistry
- Member of the Brussels Writers’ Circle: Part of the Anthology, ‘The Circle’ published by the Harvard Square Editions, with an honourable mention

Faculty profile

Name: Anurag Gupta **Academic Degree:** B. Tech. IIT Roorkee 2002 M. S. UC Berkeley 2003 Ph. D. UC Berkeley 2008 **Specialization:** Continuum Mechanics; Interfaces in Solids; Plasticity; Defects in solids. **Date of joining:** October, 2008 **No of PhD Graduated:** 5 **No of MTech Graduated:** 21	

Five Best Contributions:

1. Manish Singh, Ayan Roychowdhury, and Anurag Gupta. Defects and metric anomalies in Föppl-von Kármán surfaces. Proceedings of the Royal Society London A, 478, 20210829, 1-23, 2022.

2. Animesh Pandey and Anurag Gupta. Point singularities in incompatible elasticity. Journal of Elasticity, 147, 229-256, 2021.

3. Digendranath Swain and Anurag Gupta. Biological growth in bodies with incoherent interfaces, Proceedings of the Royal Society London A, 474, 20170716, 2018.

4. Ayan Roychowdhury and Anurag Gupta. Non-metric connection and metric anomalies in materially uniform elastic solids, Journal of Elasticity, 126, 1-26, 2017.

5. Anurag Gupta and David Steigmann, Plastic flow in solids with interfaces, Mathematical Methods in the Applied Sciences, 35, 1799-1824, 2012.

Five Best Recognitions:

- Lawrence scholar, Lawrence Livermore National Laboratory (LLNL), Dec. 2006-Aug. 2008.
- Member of the editorial board, Mathematics and Mechanics of Solids (since 2017).
- P. K. Kelkar research fellow, IIT Kanpur, May, 2017 - Apr, 2020.

Faculty profile

Name: Shakti S Gupta **Academic Degree:** B. E. (Mechanical), NIT Raipur (formerly GCE&T), 1993 M. E. (Mechanical), IISc Bangalore, 2001 Ph. D. (Engineering Mechanics), Virginia Tech, 2009 **Specialization**: Engineering Mechanics. **Date of joining**: March 2011 **No. of Ph. D. Graduated:** 03 **No. of M. Tech. Graduated:** 40	

Five Best Contributions:

1. Comparing quantum, molecular and continuum models for graphene at large deformations, A. Mokhalingam, R. Ghaffari, R. A. Sauer, and S. S. Gupta, 2020, Carbon, Vol. 159, 478-494.
2. Vibroacoustics study of a point-constrained plate in a duct, S. Sapkale, M. M. Sucheendran, S. S. Gupta, and S. Kanade, 2018, Journal of Sound and Vibration, Vol. 420, 204-226.
3. Instabilities in carbon nanocone stacks, A. Raj, A. Mokhalingam, and S. S. Gupta, 2017, Carbon, Vol 127, 404-411.
4. Buckling of single-walled carbon nanotubes using two criteria, S. S. Gupta, P. Agrawal, and R. C. Batra, 2016, Journal of Applied Physics, Vol. 119, Art. No. 245106.
5. Elastic properties and frequencies of free vibrations of single- layer graphene sheets, S. S. Gupta, and R. C. Batra, 2010, Journal of Computational and Theoretical Nanoscience, Vol. 7, 1-14.

Five Best Recognitions:

- DRDO's Mechanical Engineering Fellowship, Sept 1994 to Aug 1995, to undergo training in advanced technology areas of mechanical engineering at IAT, Pune.
- Teaching Fellowship to teach UG students, 2008, Virginia Tech, Blacksburg, USA.
- Daniel Fredrick Scholarship for excellent performance in the graduate program in the Department of Engineering Science and Mechanics, Virginia Tech, 2009, Blacksburg, USA.
- DRDO's Silicon Medal for National Science Day oration in 2010.
- Commendation letters from Senate Chairman, IIT Kanpur for performance in teaching/tutoring: Introduction to Solid Mechanics (ME621), Applied Dynamics and Vibrations (ME625), Vibration of Continuous Systems (ME626), Introduction to Solid Mechanics (ESO202).

Faculty profile

Name: K. R. Guruprasad

Academic Degree:

Ph. D. (Aerospace)	Indian Institute of Science, Bengaluru	2009
M. Sc. (Engg) - ME	Indian Institute of Science, Bengaluru	1997
B. E. (ME)	Karnataka REC, Surathkal	1993

Specialization: Robotics and Automation

Date of joining: July, 2022

No. of Ph. D. Graduated: 3 (Prior to joining IITK)

No. of M. Tech. Graduated: 22 (Prior to joining IITK)

Five Best Contributions:

1. Authored a text book: K.R. Guruprasad, Robotics: Mechanics and Control, PHI, Delhi 110092, 2019
2. K. R. Guruprasad and D. Ghose, Automated multi-agent search using centroidal Voronoi configuration, *IEEE Transactions on Automation Science and Engineering*, vol. 8, issue 2, pp. 420-423, 2011
3. Jeane M D'Souza, Venkat Varun Velpula, and K.R Guruprasad, "On effectiveness of camera as an UAV mounted search sensor," International Journal of Control, Automation, and Systems, 19(7), pp 2557–2568, 2021.
4. K. R. Guruprasad and T.D Ranjitha, "CPC algorithm: Exact area coverage by a mobile robot using approximate cellular decomposition", Robotica, vol 39, pp. 1141–1162, 2021
5. Soumya S. and K.R Guruprasad, "Distributed nonlinear control of planar serial-link manipulators", Int. J. Control, Automation, and Systems, 19(2), pp. 850-863, 2021

Five Best Recognitions:

- Invited Expert Member, Board of Studies, School of Robotics, Defence Institute of Advanced Technology, Pune
- Senior Member, IEEE
- Best presentation: K. R. Guruprasad, Multi-Agent Search using Sensors with Heterogeneous Capabilities, Presented in the Doctoral Symposium, IISc-IBM Research Third Operations Research and Data Analytics Workshop, March 2008.
- Best paper award finalist - K. Hungerford, P. Dasgupta, and K.R. Guruprasad, A Repartitioning Algorithm to Guarantee Complete, Non-overlapping Planar Coverage with Multiple Robots, Distributed Autonomous Robots and Systems (DARS) 2014.
- Fellowship from the Indian National Academy of Engineering (INAE) (June-July 2010) Under scheme of "mentoring of Engineering Teachers by INAE Fellows". Mentor: Professor Debasish Ghose, Department of Aerospace Engineering, Indian Institute of Science, Bengaluru, India.

Faculty profile

Name: Pranav Ramkrishna Joshi

Academic Degree:

B. E.	Shivaji University, Kolhapur	2003
M. Sc. (Engg.)	IISc, Bangalore	2006
M. S.	Johns Hopkins University, U.S.	2009
Ph. D.	Johns Hopkins University, U.S.	2013

Specialization: Fluid Mechanics and Thermal Sciences

Date of joining: April, 2018

No. of PhD Graduated: 0

No. of M. Tech./M.S.R. Graduated: 05

Five Best Contributions:

1. Abhilash Ojha, Mohammad Anas, Avishek Ranjan, Pranav Joshi, and Mahendra K. Verma. "Helicity segregation by Ekman pumping in laminar rotating flows with gravity orthogonal to rotation." Physical Review Fluids 7, no. 3 (2022): 034801.
2. Mohammad Anas, Pranav Joshi, and Mahendra Verma (2020) "Freely decaying turbulence in a finite domain at finite Reynolds number". Physics of Fluids, 32, 095109.
3. Pranav Joshi, Hadi Rajaei, Rudie Kunnen and Herman Clercx (2017) "Heat transfer in rotating Rayleigh–Bénard convection with rough plates". Journal of Fluid Mechanics, 830, R3.
4. Hadi Rajaei, Pranav Joshi, Kim Alards, Rudie Kunnen, Federico Toschi and Herman Clercx (2016) "Transitions in turbulent rotating convection: A Lagrangian perspective". Physical Review E, 93, 043129. doi:10.1103/PhysRevE.93.043129.
5. Pranav Joshi, Xiaofeng Liu and Joseph Katz (2014). "Effect of mean and fluctuating pressure gradients on boundary layer turbulence". Journal of Fluid Mechanics, 748, pp 36-84.

Five Best Recognitions:

- Winner, Graduate Student Presentation Competition at the AIAA Region I Young Professional, Student and Education Conference (YPSE-12), November 2, 2012.
- Recipient of JHU ME Department Graduate Student Fellowship, 2006-2007.
- Awarded the ME Department Alumni Medal for the best M.Sc. (Engg.) thesis of the year 2006-2007 in the Department of Mechanical Engineering at IISc, Bangalore.
- Twice recipient of Shivaji University Merit Scholarship awarded to first few meritorious students in the University at the undergraduate level.
- Received the National Talent Search Scholarship awarded by the National Council of Educational Research and Training to 750 students all over India at the 10th level.

Faculty profile

Name: Kamal K Kar

Academic Degree:

B. Tech.: Calcutta University, 1992
M. Tech.: IIT-Kharagpur, 1994
Ph. D.: IIT-Kharagpur, 1999

Specialization: Materials

Date of joining: January, 2001

No. of PhD Graduated: 30

No. of MTech Graduated: 20

Five Best Contributions:

1. Title: Enhanced thermoelectric performance of PbSe-graphene nanocomposite manufactured with acoustic cavitation induced defects Authors: Chhatrasal Gayner, Raghunandan Sharma, Iram Malik, Mukesh Kumar, Sugandha Singh, Kiran Kumar, Jitendra Tahalyani, Tulika Srivastava, K. K. Kar, H. Yokoi, and A. K. Naskar, Nano Energy, ISSN: 2211-2855, Vol.: 94, pp.: 106943, Year: 2022, (IF: 19.069) https://doi.org/10.1016/j.nanoen.2022.106943
2. Title: Heteroatom doped graphene engineering for energy storage and conversion Authors: Rajesh Kumar Sumanta Sahoo, Ednan Joanni, Rajesh K. Singh, Keiichiro Maegawa, Wai Kian Tan, Go Kawamura, Kamal K. Kar, Atsunori Matsuda References: Materials Today, Vol.: 39, Pages: 47-65, Year: 2020, ISSN: 1369-7021, (IF-26.943), https://doi.org/10.1016/j.mattod.2020.04.010
3. Title: Laser processing of graphene and related materials for energy storage: State of the art and future prospects Authors: Rajesh Kumar, Angel Perez del Pino, Sumanta Sahoo, Rajesh. K. Singh, Wai K. Tan, Kamal K Kar, Atsunori Matsuda, Ednan Joanni, References: Progress in Energy and Combustion Science, Vol.: 89, Year: 2022, ISSN: 0360-1285, (IF-35.339), https://doi.org/10.1016/j.pecs.2021.100981
4. Title: Recent progress in the synthesis of graphene and derived materials for next generation electrodes of high performance lithium ion batteries Authors: Rajesh Kumar, Sumanta Sahoo, Ednan Joanni, Rajesh Kumar Singh, Wai Kian Tan, Kamal Krishna Kar and Atsunori Matsuda References: Progress in Energy and Combustion Science, Vol.: 75, Pages: 100786, Year:2019, ISSN: 0360-1285, (IF-35.339), https://doi.org/10.1016/j.pecs.2019.100786
5. Title: Recent advances in thermoelectric materials Authors: Chhatrasal Gayner, Kamal K. Kar References: Progress in Materials Science, Vol.:83, Pages: 330-382, Year:2016, ISSN 0079-6425, (IF-48.165), https://doi.org/10.1016/j.pmatsci.2016.07.002

Five Best Recognitions:

- Editor-in-Chief, Polymers and Polymeric Composites: A Reference Series, Springer
- Associate Editor, Applied Nanoscience, Springer Nature
- Member of editorial board of Advanced Manufacturing: Polymer & Composites Science, T&F
- Member of the editorial boards of International J. Plastic Technology Springer Nature
- Member of the editorial boards of SPE POLYMERS, WILEY

Faculty profile

Name: Sameer Khandekar

Academic Degree:

B. E. (ME) – Govt. Engg. College, Jabalpur (MP), 1993.
M. Tech. (FTS) – IIT Kanpur, 2000.
Ph. D. - University of Stuttgart, Stuttgart, Germany, 2004.

Specialization: Thermal - Fluid Engineering Sciences, Boiling, Condensation, Evaporation, Heat Pipes

Date of joining: September, 2004

No of PhD Graduated: 11

No of MTech Graduated: 57

Five Best Contributions:

1. Jaiswal A. and Khandekar S., Drop-on-drop Impact Dynamics on a Superhydrophobic Surface, Langmuir, Vol. 37, 43, pp. 12629–12642, 2021. DOI: 10.1021/acs.langmuir.1c01779
2. Khandekar S., Sahu G. N., Muralidhar K., Gatapova E. Ya., Kabov O., Hu R., Luo X., Zhao L., Cooling of High-Power LEDs by Liquid Sprays: Challenges and Prospects, Applied Thermal Engineering, Vol. 184, pp. 115640, 2021. DOI: 10.1016/j.applthermaleng.2020.115640
3. Shah R. K., Khandekar S., Manipulation of Taylor-Bubble Flow in a Magneto-Fluidic System, Colloids and Surfaces A: Physicochemical and Engineering Aspects, Vol. 593, 124589 (1-15), 2020. DOI: 10.1016/j.colsurfa.2020.124589
4. Khandekar S., Dollinger N. and Groll M., Understanding Operational Regimes of Pulsating Heat Pipes: An Experimental Study, Applied Thermal Engineering, Elsevier Science, ISSN 1359-4311, Vol. 23, Issue 6, pp. 707-719, 2003. DOI: 10.1016/S1359-4311(02)00237-5
5. Books published: (i) Khandekar S. and Muralidhar K., Drop Dynamics and Dropwise Condensation on Textured Surfaces, ISBN 978-3-030-48460-6, Mechanical Engineering Series, Springer, 2020. and (ii) Joshi Y. M. and Khandekar S. (Eds.), Microscale and Nanoscale Phenomena: Fundamentals and Applications, Springer Tracts in Mechanical Engineering, ISBN 978-81-322-2288-0, June 2015.

Five Best Recognitions:

- Chairperson, International Heat Pipe Committee, 2022-onging
- Fellow of Indian National Academy of Engineering, 2019; Institution of Engineers (I), 2016
- Sir M. Visvesvaraya Chair Professor (2017 - ongoing) and P. K. Kelkar Research Fellowship (October 2009 - September 2012).
- Prof. K. N. Seetharamu Young Researcher Medal and Prize from the Indian Heat and Mass Transfer Society, 2010.
- George Grover Young Scientist Medal from International Heat Pipe Committee, 2007.

Faculty profile

Name: Arvind Kumar **Academic Degree:** B. Tech.: NIFFT, Ranchi (2001) M. Sc. (Engg): IISc Bangalore (2003) Ph. D.: IISc Bangalore (2009) **Specialization:** Solidification; Additive manufacturing; 3D printing; Laser materials processing; Thermal energy storage and Waste heat recovery **Date of joining**: June, 2012 **No of PhD Graduated:** 5 **No of MTech Graduated:** 43	

Five Best Contributions:

1. A. Kumar, M. Založnik, H. Combeau, G. Lesoult, A. Kumar, Channel segregation during columnar solidification: Relation between mushy zone instability and mush permeability, Int. Journal Heat Mass Transfer, 164, 2021, 120602. IF-5.584.
2. A. Chouhan, A. Aggarwal, A. Kumar, Role of melt flow dynamics on track surface morphology in the L-PBF additive manufacturing process, International Journal of Heat and Mass Transfer, 178, 2021, 1216022021. IF-5.584.
3. V. Soni, A. Kumar, V.K. Jain, Performance evaluation of nano-enhanced phase change materials during discharge stage in waste heat recovery, Renewable Energy, 127, 2018, 587-601. IF-8.001.
4. EU-Indo project in the New INDIGO Partnership Programme (NPP) of the European Member States and Associated States and the Indian Department of Science and Technology on New INDIGO, NPP Call on Energy, 2014.
5. Paper on DC casting (Coupling macro-segregation and grain structure formation in direct chill cast aluminium alloy ingots, Light Metals, 2011, pp. 699-704.) is featured in a collection of best research papers on aluminium cast shop (1971-2011) in, Essential Readings in Light Metals, 3, Cast Shop for Al Production, J.F. Grandfield, D.G. Eskin (Ed)

Five Best Recognitions:

- Marie Curie Fellow, European Commission, FP7 framework (Uni. Southampton, UK, 2011-12).
- Selection in Britain's Young Engineers to present research in the House of Commons, 2012.
- IEI Young Engineers Award, 2014.
- Best Research Paper Award in the 12th IIR Conference on Phase Change Material and Slurries for Refrigeration and Air Conditioning, 2018, Canada.
- PK Kelkar Young Faculty Research Fellowship Position, IIT Kanpur (2018 - 2021).

Faculty profile

Name: Virkeshwar Kumar

Academic Degree:

B. Tech.	NIFFT Ranchi	2014
Ph. D.	IIT Bombay	2020

Specialization: Fluid Mechanics and Thermal Sciences, and Manufacturing Sciences

Date of joining: July, 2022

No. of PhD Graduated: 0

No. of M. Tech. Graduated: 0

Five Best Contributions:

1. Virkeshwar Kumar, Atul Srivastava, Shyamprasad Karagadde, "Role of microstructure and composition on the natural convection during ternary alloy solidification" Journal of Fluid Mechanics, 913, A41, 2021. DOI: doi.org/10.1017/jfm.2021.1
2. Virkeshwar Kumar, G. S. Abhishek, Atul Srivastava, Shyamprasad Karagadde, "On the mechanism responsible for unconventional thermal behaviour during freezing" Journal of Fluid Mechanics, 903, A32, 2020. DOI: doi.org/10.1017/jfm.2020.630
3. Virkeshwar Kumar, Atul Srivastava, Shyamprasad Karagadde, "Compositional dependency of double-diffusive layers during binary alloy solidification: Full-field measurements and quantification" Physics of Fluids, 29, 113603, 2018. DOI: doi.org/10.1063/1.5049135 (Featured Article doi.org/10.1063/1.5049135 in Physics of Fluid journal, with AIP media coverage via SciLight doi.org/10.1063/1.5081144 to showcase the most interesting research)
4. Virkeshwar Kumar, Ketan S., Shyamprasad Karagadde, "Convection-induced bridging during alloy solidification" Physics of Fluids, 34, 053605, 2022. DOI: doi.org/10.1063/5.0088590
5. Virkeshwar Kumar, Susmita Dash, "Patterns during Evaporative Crystallization of a Saline Droplet" 2022, Langmuir. (In press)

Five Best Recognitions:

- Excellence in Ph. D. Research Award for 2018-2020, IIT Bombay (58th Convocation, 2020).
- C V Raman Post-Doc Fellowship, IISc Bangalore, 2020.
- Won 2nd Prize in image contest, Mechanical Department Annual Research Student Symposium, IISc Bangalore, July 2021.
- Ph. D. Annual Progress Seminar Award (2017-18), Department of Mechanical Engineering IIT Bombay.
- International Travel Support (ITS) grant to attend ICASP-5 & CSSCR-5 conference at Salzburg Austria: 2019

Faculty profile

Name: Mohit S. Law

Academic Degree:

Ph. D. (ME)	The University of British Columbia, Canada	2013
M. S. (ME)	Michigan Technological University, USA	2008
B. E. (ME)	BVCOE, Pune University	2003

Specialization: Manufacturing Sciences

Date of joining: November, 2015

No. of PhD Graduated: 2

No. of M. Tech. Graduated: 20

Five Best Contributions:

1. Law M, Lambora R, Nuhman A P, and Mukhopadhyay S, Modal parameter recovery using temporally aliased video recordings of cutting tools, CIRP Annals. Vol. 71, 2022
2. Bari P, Kilic Z M, Law M., and Wahi P., Rapid stability analysis of serrated end mills using graphical-frequency domain methods, International Journal of Machine Tools and Manufacture. 171, 2021.
3. Patel A, Talaviya D, Law M and Wahi P., Optimally tuning an absorber for a chatter-resistant rotating slender milling tool holder. Journal of Sound and Vibration. 2021
4. Gupta, P., Rajput, H., and Law, M., Vision-based modal analysis of cutting tools, CIRP Journal of Manufacturing Science and Technology, 32 2021.
5. Sahu, G., Pulkit. J., Wahi, P., and Law, M., Emulating bistabilities in turning to devise gain tuning strategies to actively damp them using a hardware-in-the-loop simulator, CIRP Journal of Manufacturing Science and Technology, 32 2021.

Five Best Recognitions:

- Gopal Das Bhandari Memorial Distinguished Teacher Award – 2020
- Best paper award at the 8th International and 29th All India Manufacturing Technology, Design and Research Conference 2018 (AIMTDR 2018). Paper co-authored with a student and a colleague.
- Two best paper awards at the 2nd International Conference on Computational Methods in Manufacturing (IIT Guwahati). Papers co-authored with students and a colleague.
- Best paper award at 7th International and 28th All India Manufacturing Technology, Design and Research Conference 2018. Paper co-authored with students and a colleague.
- Award for best exhibit on 'Active damping and isolation of machine tool vibrations' at the IMTEX 2017 Academic Pavilion.

Faculty profile

Name: Umesh Madanan

Academic Degree:

Ph. D. (Mech. Engg.)	Uni. Minnesota Twin Cities	2019
M. Tech. (Mech. Engg.)	IIT, Madras	2012
B. Tech. (Honors - ME)	University of Calicut	2007

Specialization: Fluid and Thermal Sciences

Date of joining: 18th June 2020

No. of Ph. D. Graduated: NIL

No. of M.Tech. Graduated: 2

Five Best Contributions:

1. Madanan, U. and Goldstein, R. J., 2020. High-Rayleigh-number thermal convection of compressed gases in inclined rectangular enclosures. Physics of Fluids, Vol. 32(1), p. 017103.
2. Madanan, U. and Goldstein, R. J., 2019. Effect of sidewall conductance on Nusselt number for Rayleigh-Bénard convection: a semi-analytical and experimental correction. ASME Journal of Heat Transfer, Vol. 141(12), p. 122504.
3. Madanan, U. and Goldstein, R. J., 2019. Experimental investigation on very-high-Rayleigh-number thermal convection in tilted rectangular enclosures. International Journal of Heat and Mass Transfer, Vol. 139, pp. 121-129.
4. Madanan, U. and Goldstein, R. J., 2019. Thermal convection in horizontal rectangular enclosures at moderate Rayleigh numbers: effect of sidewall conductance and aspect ratio. International Journal of Heat and Mass Transfer, Vol. 136, pp. 178-185.
5. Madanan, U., Chatterjee, D. and Das, S. K., 2018. A note on adiabatic two-phase flow maldistribution in a set of horizontal parallel mini-channels with I-type and Z-type configurations. Chemical Engg. Processing: Process Intensification, Vol. 132, pp. 34-41.

Five Best Recognitions:

- Graduate Teaching Fellowship, Department of Mechanical Engineering, University of Minnesota Twin Cities, USA (2018-19)
- Graduate Student Fellowship, Department of Mechanical Engineering, University of Minnesota Twin Cities, USA (2014-15)
- Prof. B. Sengupto Prize and Institute Medal, 1st rank in the Department of Mechanical Engineering, Indian Institute of Technology Madras, India (2012)
- Prof. N. Venkatarayulu Memorial Prize and Institute Medal, 1st rank in the Thermal Engineering Stream, Indian Institute of Technology Madras, India (2011)
- Ramanan Ramamurthy Memorial Prize and Institute Medal, 1st rank in the Department of Mechanical Engineering, Indian Institute of Technology Madras, India (2011)

Faculty profile

Name: Akhilesh Mimani

Academic Degree:

B. E. Mechanical Engg.	RV College of Engg., Bangalore	2006
Mechanical Engineering (Acoustics)	Indian Institute of Science, Bangalore	2012

Specialization: Solid Mechanics and Design Acoustics

Date of joining: December, 2018

No. of PhD Graduated: None yet, 4 ongoing

No. of M. Tech. Graduated: 3

Five Best Contributions:

1. Mimani, A., "Acoustic Analysis and Design of Short Elliptical End-Chamber Mufflers" Springer Nature, Singapore (2021) https://www.springer.com/gp/book/9789811048272
2. Mimani, A., (2021) "A point-like enhanced resolution of experimental Aeolian tone using an iterative point-time-reversal-sponge-layer damping technique" Mechanical Systems and Signal Processing, 151, 107411.
3. Mimani, A., Fischer, J., Moreau, D. J. and Doolan, C. J., (2018), "A comparison of time-reversal and cross-spectral beamforming for localizing experimental rod-airfoil interaction noise sources" Mechanical Systems and Signal Processing, 111, pp. 456-491.
4. Croaker, P., Mimani, A., Doolan, C. J. and Kessissoglou, N., (2018), "A computational flow-induced noise and time-reversal technique for analysing aeroacoustic sources" The Journal of the Acoustical Society of America, 143(4), pp. 2301-2312.
5. Mimani, A., Prime, Z., Doolan, C. J. and Medwell, P. R. (2015) "A sponge-layer damping technique for aeroacoustic time-reversal" Journal of Sound and Vibration, 342(1), pp. 124-151.

Faculty profile

Name: Sarvesh Kumar Mishra

Academic Degree:

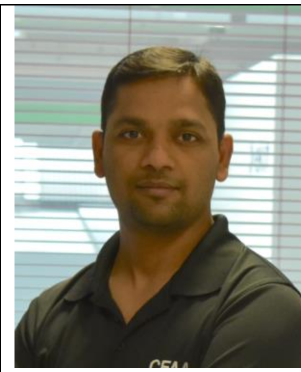
Ph. D.	IIT Delhi	2020
M. Tech.	IIT BHU	2014
B. Tech.	UPTU, Lucknow	2012

Specialization: Manufacturing Sciences

Date of joining: July, 2022

No. of PhD Graduated: NA

No. of M. Tech. Graduated: NA



Five Best Contributions:

1. S. K. Mishra, D. Talwar, K. Singh, A. Chopra, S. Ghosh, S. Aravindan, Micromechanical characterization and wear dynamics study of AlTiN and AlCrN coated WC/Co tools for dry turning of Ti6Al4V alloy, Ceram. Int. 47 (2021) 31798-31810 (Q1, SCI)
2. S. K. Mishra, S. Ghosh, S. Aravindan, Temporal and spatial crater wear prediction of WC/Co tools during dry turning of Ti6Al4V alloy, Wear. 448–449 (2020) 203229. (Q1, SCI)
3. S. K. Mishra, S. Ghosh, S. Aravindan, Investigations into friction and wear behavior of AlTiN and AlCrN coatings deposited on laser textured WC/Co using novel open tribometer tests, Surf. Coatings Technol. 387 (2020) 125513. (Q1, SCI)
4. S. K. Mishra, S. Ghosh, S. Aravindan, Physical characterization and wear behavior of laser processed and PVD coated WC/Co in dry sliding and dry turning processes, Wear. 428 (2019) 93–110 (Q1, SCI)
5. S. K. Mishra, S. Ghosh, S. Aravindan, 3D finite element investigations on textured tools with different geometrical shapes for dry machining of titanium alloys, Int. J. Mech. Sci. 141 (2018) 424–449 (Q1, SCI)

Five Best Recognitions:

- Guest to The European Society of Precision Engineering and Nanotechnology at ICE2022 (CERN, Geneva, CH)
- Heidenhain scholarship (Dr. J Heidenhain GmbH Germany/EUSPEN-UK, June 2020)
- Excellence award in oral presentation (TACT Taiwan, November 2019)
- Research excellence travel award (IIT Delhi, May 2019)
- Research scholar travel grant (IIT Delhi, April 2019)

Faculty profile

Name: Supratik Mukhopadhyay

Academic Degree:

Ph. D. (Aerospace)	University of Bristol	2016
M. Tech. (Mechanical)	IIT Kharagpur	2011
B. E. (Production)	Jadavpur University	2009

Specialization: Mechanics of composites, Computational damage mechanics, Nonlinear finite element method

Date of joining: November, 2018

No. of PhD Graduated: 0

No. of M. Tech. Graduated: 6

Five Best Contributions:

1. S. Mukhopadhyay, M.I. Jones, S.R. Hallett, Compressive failure of laminates containing an embedded wrinkle; experimental and numerical study, Composites Part A: Applied Science and Manufacturing. 73 (2015) 132–142.
2. S. Mukhopadhyay, M.I. Jones, S.R. Hallett, Tensile failure of laminates containing an embedded wrinkle; numerical and experimental study, Composites Part A: Applied Science and Manufacturing. 77 (2015) 219–228.
3. S. Mukhopadhyay, O.J. Nixon-Pearson, S.R. Hallett, An experimental and numerical study on fatigue damage development in laminates containing embedded wrinkle defects, International Journal of Fatigue. 107 (2018) 1–12.
4. S. Mukhopadhyay, S.R. Hallett, A directed continuum damage mechanics method for modelling composite matrix cracks, Composites Science and Technology. 176 (2019) 1– 8.
5. S. Mukhopadhyay, S.R. Hallett, An augmented cohesive element for coarse meshes in delamination analysis of composites, Composite Structures. 254 (2020) 112890.

Five Best Recognitions:

- Commendation letter for being selected among the 10 best PhD thesis submitted in 2015-16 in the Engineering faculty, by the Queens school of Engineering, University of Bristol, 2016.
- Kenneth Harris James Prize for best journal paper in 2015 in the aerospace division of Institute of Mechanical Engineers (IMechE), UK, 2015.
- University Silver Medal for being selected as the best student in order of merit among the outgoing M. Tech. students, Mechanical Engineering Department, 2010-2011, IIT Kharagpur.
- B.M Belgaumkar memorial prize for highest CGPA among all M. Tech. students in the Mechanical Engineering Department, in 2010-2011, by IIT Kharagpur.
- University Gold Medal for standing first in order of merit among B.E students of Production Engineering in batch 2005-2009, by Jadavpur University.

Faculty profile

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Name: K. Muralidhar

Academic Degree:

- Bachelor of Engineering (Mechanical Engineering), 1979, Visvesvaraya Regional College of Engineering, Nagpur
- Master of Technology (Mechanical Engineering), 1981, Indian Institute of Technology Madras
- Doctor of Philosophy (Applied Science), April 1985, University of Delaware, Newark DE, USA

Specialization: Interfacial flow phenomena, heat transfer and phase change; biomechanics and biomedical devices

Date of joining: July, 1987

No. of PhDs graduated: 26

No. of MTech-MS graduated: 95

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Five Best Contributions:

1. Raghvendra K. Dwivedi, Vandana Jain, and K. Muralidhar, Dynamic contact angle model for resolving low viscosity droplet oscillations during spreading over a surface with varying wettability, Physical Review-Fluids 7, 034002 (23 pages) (2022).
2. Praveen M. Somwanshi, V. V. Cheverda, K. Muralidhar, S. Khandekar, and O. A. Kabov, Understanding Vertical Coalescence Dynamics of Liquid Drops over a Superhydrophobic Surface using High Speed Orthographic Visualization, Experiments in Fluids Vol. 63:47 (21 pages) (2022).
3. Manish Bhendura, K. Muralidhar, and S. Khandekar, Determination of Evaporation Rate of Warm Water Placed inside a Partially-filled Top Cooled Enclosure, International J. of Thermal Sciences, Vol. 179, 107612 (14 pages) (2022).
4. Pritam Giri, Krishna Chandran, K. Muralidhar, and Indranil Saha Dalal, Effects of coupling of mass transport and blood viscosity models for microchannel flows, Journal of Non-Newtonian Fluid Mechanics 302:104754 (2022).
5. Abdullah Usmani and K. Muralidhar, Unsteady hemodynamics in intracranial aneurysms with varying dome orientations, ASME J. Fluids Engg., Vol. 143, 061206 (1-14) (2021).

Five Best Recognitions:

- Fellow-ASTFE (American Society of Thermal and Fluids Engineering).
- Fellow of National Academy of Sciences.
- Fellow of Indian National Academy of Engineering.
- Editor-in-Chief, Journal of Flow Visualization and Image Processing, since January 2018.
- Delivered the M.V. Krishnamurthy endowed Plenary lecture during the IHMTC-ASTFE conference at IIT Roorkee, December 2019.

Faculty profile

Name: Anikesh Pal

Academic Degree:

Ph. D. (Mechanical Engineering)	University of California San Diego USA	2016
M. Tech. (Mechanical Engineering)	IIT Kanpur	2010
B. Tech. (Mechanical Engineering)	Kalyani Government Engineering College	2007

Specialization: Fluid Mechanics, Thermal Sciences

Date of joining: July 2019

No. of PhD Graduated: -

No. of M. Tech. Graduated: 07

Five Best Contributions:

1. Pal A., "*Deep learning emulation of subgrid-scale processes in turbulent shear flows*." Geophysical Research Letters, 47(12), e2020GL087005 (2020).
2. Pal A. , Mahajan S., Norman M. R., "*Using Deep Neural Networks as Cost-Effective Surrogate Models for Super-Parameterized E3SM Radiative Transfer*." Geophysical Research Letters 46 (11), 6069-6079.
3. Pal A. , Sarkar S., Posa A., and Balaras E. *,"DNS of stratified flow past a sphere at a subcritical Reynolds number of 3700 and moderate Froude number*." J. Fluid Mech, 826, 5-31 (2017).
4. Pal A. , Sarkar S., Posa A., and Balaras E. ,"*Regeneration of turbulent fluctuations in low-Froude number flow over a sphere at a Reynolds number of 3700*." J. Fluid Mech., 804 R2 (2016).
5. Pal A. and Sarkar S., "*Effect of external turbulence on the evolution of a wake in stratified and un-stratified environments*" J. Fluid Mech. , 772, 361-385 (2015).

Faculty profile

Name: P. K. Panigrahi **Academic Degree:** • B. Tech. (1987), ME, UCE Burla, • M. Tech. (1992), ME, LSU, Baton Rouge, USA • M. Tech. (1997), CSC, LSU, Baton Rouge, USA • Ph. D. (1997), ME, LSU, Baton Rouge, USA **Specialization**: Fluid Mechanics and Thermal Sciences **Date of joining**: January, 1998 **No of PhD Graduated:** 14 **No of MTech Graduated:** 82	

Five Best Contributions:

1. Bal Krishan Mishra, Archana Gupta, and P. K. Panigrahi "Near-wall characteristics of wall-normal jet generated by an annular DBD plasma actuator ", Physical Review Fluids, 7, 033702 (2022) https://doi.org/10.1103/PhysRevFluids.7.033702
2. Ayaj Ahamad Ansari, Samarshi Chakraborty, Randeep Ravesh, Pradipta Kumar Panigrahi and Malay Kumar Das "Synthesis of Cu-Al LDH nanofluid and effectiveness as a promoter for CO2 hydrate formation", Chemical Engineering Journal, Vol. 453, Part 3, 134786 (2022) https://doi.org/10.1016/j.cej.2022.134786
3. Sunil K. Saroj, Pradipta Kumar Panigrahi, "Magnetophoretic control of diamagnetic particles inside an evaporating droplet", Langmuir, 37, 51, 14950–14967 (2021) https://doi.org/10.1021/acs.langmuir.1c02968
4. Tapan K. Pradhan, and Pradipta Kumar Panigrahi, "Vapor mediated interaction of two condensing droplets", Colloids and Surfaces A: Physicochemical and Engineering Aspects, Vol 608, 125555,(2021) DOI : https://doi.org/10.1016/j.colsurfa.2020.125555
5. Samarshi Chakraborty, Pradipta Kumar Panigrahi, "Stability of nanofluid: A review", Applied Thermal Engineering, Vol 174, 115259 (2020) DOI : https://doi.org/10.1016/j.applthermaleng.2020.115259

Five Best Recognitions:

- DAAD Fellowship, GERMANY, 2010
- Swarnajayanti Fellowship, DST, 2006
- Humboldt Fellowship, GERMANY, 2004
- BOYSCAST Fellowship, JAPAN, 2000.
- Career Award, AICTE, 1998

Faculty profile

Name: Keval Shrihari Ramani

Academic Degree:

Ph. D. (ME)	Uni-Michigan, Ann Arbor, USA	2020
M. S. (ME)	Uni-Michigan, Ann Arbor, USA	2015
B. E. (Hons.) (ME)	BITS Pilani K K Birla Goa Campus	2012

Specialization: Manufacturing Sciences, Robotics and Automation

Date of joining: July, 2022

No. of PhD Graduated: Nil

No. of M. Tech. Graduated: Nil

Five Best Contributions:

1. Ramani, K.S., He, C., Tsai, Y., & Okwudire, C.E. (2022). SmartScan: An Intelligent Scanning Approach for Uniform Thermal Distribution, Reduced Residual Stresses and Deformations in PBF Additive Manufacturing, *Additive Manufacturing.* Vol. 52, 102643.
2. Duan, M., Okwudire, C.E., & Ramani, K. S., *Use of Filtered Basis Splines to Compensate Servo-Induced Motion Errors, US* Patent # 10585414, Pub. Date Mar. 10, 2020.
3. Ramani, K. S., Edoimioya, N., & Okwudire, C. E. (2020). A Robust Filtered Basis Functions Approach for Feedforward Tracking Control—With Application to a Vibration-Prone 3-D Printer. IEEE/ASME Transactions on Mechatronics, 25(5), 2556-2564.
4. Ramani, K. S., Duan, M., Okwudire, C. E., & Ulsoy, A. G. (2019). Optimal Selection of Basis Functions for Minimum-Effort Tracking Control of Nonminimum Phase Systems Using Filtered Basis Functions. J. of Dynamic Systems, Measurement and Control, 141(11), 111009.
5. Ramani, K. S., & Okwudire, C. E. (2021). Optimal Selection of Basis Functions for Robust Tracking Control of Uncertain Linear Systems-with Application to 3D Printing. Journal of Dynamic Systems, Measurement, and Control*,* 143(10), 101006.

Five Best Recognitions:

- Best Paper Award at the IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM) 2022.
- Author of finalist (6 among 284 papers) for the 2021 Best Transaction Paper Award for IEEE/ASME Transactions on Mechatronics published in the year 2020
- Co-author of Best Student Paper Award winning paper at the 2015 ASME Dynamic Systems and Control Conference (DSCC 2015)
- Recipient of Goa Scholar 2013-14 by Government of Goa, India, towards MS degree at University of Michigan, Ann Arbor, MI, USA
- Ranked 5th (among 588 students) in the campus and 1st (among 112 students) in the ME department for the BE graduating class of 2012

Faculty profile

Name: J. Ramkumar
Academic Degree:

B. Tech.	NIT Trichy	1996
M. Tech.	IIT Madras	2000
Ph. D.	IIT Madras	2003

Specialization: Micro/Nano Manufacturing and New product/ process development, Tribology, Composite, Process modelling

Date of joining: December, 2003

No of Ph. D Graduated: 18

No of M. Tech Graduated: 86

Five Best Contributions:

1. Patent ID: 202011012055: "Apparatus for Performing an Electrochemical Micro-machining Process", Inventors: Dr. VK Jain, Dr. J Ramkumar, Mr. Divyansh Patel
2. Patent ID: 202011056116: "A Thermally Stable and Reinforced Polypropylene-SiC Nanocomposite, A Method and Application Thereof", Inventors Name: Dr. Kantesh Balani, Dr. J Ramkumar, Mr. Surya Prakash Singh, Ms. Shruti Dubey
3. Patent ID: 201911029291: "Surface Finishing Composition For AFM Process and AFM Process Using the Same ", Inventors: Dr. Kamal Krishna Kar, Dr. J. Ramkumar, Mr. Gopal Ashok Gupta
4. Patent ID: 201911002684: "Mn-Al-Fe Impregnated RGO Hybrid Composite for Arsenic Adsorption and its Sludge as Super-capacitor", Inventors: Dr. J Ramkumar, Dr. Kamal Krishna Kar, Mr. Yaswanth Kumar Penke, Mr. Amit Kumar Yadav, Ms. Iram Malik, Ms. Alekha Tyagi
5. Patent ID: 201911050380: "Protective Layer for Microwave Metamaterial Absorbers and Method Thereof" Inventors: Dr. J. Ramkumar, Dr. S. A. Ramakrishna, Dr. K. V. Srivastava, Dr. Praveen C. Ramamurthy, Ms. Kajal Chaudhary

Best Recognitions:

- Eminent Production Engineer Award 2022; IE (I); Eminent Engineer Award 2019, IIPE; Eminent Mechanical Engineer 2015; IE(I), IEI Young Engineers Award, 2011, IE (I), Kolkatta
- IETE- Shri Devi Singh Memorial Award 2021, IETE, New Delhi
- IEI BLC-FCRIT Excellence Award 2021; SITARE GYTI Award, 2020
- Satish Chandra Agarwal Chair Professor, 2022; Ram Tiwari Chair Professor 2017; Gopal Das Bhandari Memorial Distinguished Teacher Award 2015 IIT Kanpur
- Outstanding Scientist 2017, DST, India
- National Design Award in Mechanical Engineering 2015
- Class of 1984 fellowship award from 2012-2015, 2012
- Rajkumar Varshney Awards - System Society of India, 2010
- Young Scientist Award - Engineering Science - Indian Science Congress Association, 2007
- Young Scientist Award - Dept. of Atomic Energy, India, 2007
- Innovation Potential of Student Projects Awards - INAE, 2004
- Gold medallist in M. Tech, IIT Madras, 1999; Best outing B..E. (Prod) student 1996

Faculty profile

Name: Ushasi Roy

Academic Degree:

Ph. D. (Mechanical Engg.)	Georgia Institute of Technology, Atlanta, USA	2020
M. Tech. (Metallurgical and Materials Engg.)	IIT Kharagpur, India	2013
B. E. (Metallurgical and Materials Engg.)	Jadavpur University, India	2011

Specialization: Solid Mechanics and Design

Date of joining: September, 2021

No. of Ph. D. Graduated: NA

No. of M. Tech. Graduated: NA

Five Best Contributions:

1. U Roy, N A Fleck, V S Deshpande, "An assessment of a mechanism for void growth in Li anodes", Extreme Mechanics Letters, Vol. 46, (2021), 101307.
2. U Roy, D L McDowell, and M Zhou, "Effect of texture on ductile fracture of polycrystalline metals", Journal of the Mechanics and Physics of Solids, Vol. 151, (2021), 104384.
3. U Roy and M Zhou, "A multiscale computational framework for predicting the fracture toughness of metals as function of microstructure", Journal of Mechanics and Physics of Solids, Vol. 142, (2020), 103955.
4. Y Wei, R Ranjan, U Roy, J H Shin, S Menon, M Zhou, "Integrated Lagrangian and Eulerian 3D microstructure-explicit simulations for predicting macroscopic probabilistic SDT thresholds of energetic materials", Computational Mechanics, Vol. 64, Issue 2 (2019), pp. 547-561.
5. U Roy, S Kim, C Miller, Y Horie, M Zhou, "Computational study of ignition behavior and hotspot dynamics of a potential class of aluminized explosives", Modelling and Simulation in Materials Science and Engineering, Vol. 26, Issue 8 (2018), pp. 085004-32.

Five Best Recognitions:

- Postdoctoral fellowship awarded from Massachusetts Institute of Technology, USA in 2021.
- Postdoctoral fellowship awarded from University of Cambridge, UK in 2020.
- Secured the best paper award in NMD ATM 2013 for the Advanced Materials section.
- Secured second position in the MME department of IIT Kharagpur in MTech.
- Secured third position and awarded with Bronze medal in MME department of Jadavpur University in BE.

Faculty profile

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Name: Arun K Saha

Academic Degree:

- B. E. (Gauhati University, 1991)
- M. Tech. (IIT Kanpur, 1994)
- Ph. D. (IIT Kanpur, 1999)

Specialization: Fluid and Thermal Sciences

Date of joining: October 2004

No. of Ph.D Graduated: 10 (graduated) + 2 (submitted)

No. of M. Tech. Graduated: 51

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</table>

Five Best Contributions:

1. Gohil, T.B., Saha, A. K., Muralidhar, K., "Simulation of the Blooming Phenomenon in Forced Circular Jets", Journal of Fluid Mechanics, Vol. 783, pp. 567-604, 2015.
2. Ramgadia, A. G., Saha, A. K., "Numerical Study of Fully Developed Flow and Heat Transfer in a Wavy Passage", Int J. Thermal Sciences, Vol. 67, pp. 152-166, 2013.
3. Saha, A. K., "Far-Wake Characteristics of Two-Dimensional Flow Past a Normal Flat Plate", Phys Fluids, Vol. 19, Article No. 128110, 2007.
4. Saha, A. K., "Three-Dimensional Numerical Simulations of the Transition of Flow Past a Cube", Phys Fluids, Vol. 16, pp. 1630-1646, 2004.
5. Saha, A. K., Biswas, G. and Muralidhar, K., "Three-Dimensional Study of Flow Past a Square Cylinder at Low Reynolds Numbers", Int. J. Heat Fluid Flow, Vol. 24 (1), pp. 54-66, 2003.

Best Recognitions:

- Best paper (Heat Transfer Division) award by Internal Gas Turbine Institute of ASME, 2006
- Champa Devi Gangwar Chair Professorship (July 20, 2022 - July 19, 2025)
- Lead-Editor of a Special Issue “Visualization of Complex Flow Structures in Jets and Wakes”, Journal of Flow Visualization and Image Processing (JFVIP).
- Co-Editor of a Special Issue “Momentum and energy transport at fluid-fluid interfaces: fundamentals and applications”, Journal Name: Mathematical Problems in Engineering.
- Senate Chairman's Commendation for teaching a course “ME647: Introduction to Turbulent Fluid Flow”.
- Best Paper Award: Singh, S. and Saha, A. K., "Numerical Study of Heat Transfer During Oblique Impact of a Cold Drop on a Hot Liquid Film" ICTFSD 2022, 22-23 March, 2022.
- Best Presentation Award: To J. Gupta; Gupta, J. and Saha, A. K., "A Flow-Visualization Study of an Elevated Jet in Crossflow", Paper Number: FF-130, 9-11 June 2022.

Faculty profile

Name: Abhishek Sarkar

Academic Degree:

Ph. D.	Iowa State University	2018
M. S.	Iowa State University	2017
B. Tech.	Delhi Technological University	2015

Specialization: Fluid Mechanics and Thermal Sciences

Date of joining: 08, February, 2022

No. of PhD Graduated: 0

No. of M. Tech. Graduated: 0

Five Best Contributions:

1. Involvement in development of 3D printed bonded magnet technology in collaboration with Oak Ridge National Laboratory.
2. Development of technology for fast charging of commercial lithium-ion batteries by external magnetic field control.
3. Development of technology on green battery recycling and lithium extraction from end-of-life lithium battery using only water.
4. 14 publications in international journals.
5. Contributed towards three US utility patents (under review).

Five Best Recognitions:

- Received ISU PDA Postdoctoral Research Excellence Award, 2021.
- Received Gold Medal for First Position in B. Tech. – Mechanical Engineering at Delhi Technological University.

Faculty profile

Name: Subrata Sarkar **Academic Degree:** • BE. (Mech), B.E. College (Cal Univ.), 1984 • M.E (Mech), I.I.Sc, Bangalore, 1986; • Ph.D, I.I.T., Madras, 1995. **Specialization**: Turbomachinery, Transition and Turbulence, CFD and LES/DNS **Date of joining**: November, 1997 **No. of PhD Graduated**: 10 **No. of MTech Graduated:** 58	

Five Best Contributions:

1. Katiyar, S., and S. Sarkar, 2022 "Flow Transition on the Suction Surface of a Controlled-Diffusion Compressor Blade using a Large-Eddy Simulation." Physics of Fluids, Vol. 34, 094108 (19 pages).
2. Pradeep Singh and S. Sarkar, 2021, Excitation of Shear Layer Due to Surface Roughness Near the Leading Edge: An Experiment, ASME J. Fluids Engineering, Vol. 143 (5), 051301 (12 pages).
3. Nair, K. M. and Sarkar, S, 2017, "LES of Self-Sustained Cavity Oscillation for Subsonic and Supersonic Flows", ASME Journal of Fluids Engineering, 139 (1), 011102.
4. Samson, A. and Sarkar, S., 2016, "Effects of Free-stream Turbulence on Transition of a Separated Shear Layer Over the Leading-edge of a Constant Thickness Aerofoil": ASME Journal of Fluids Engineering, 138(2), 021202-021202-19,
5. S. Sarkar, 2009, Influence of wake structure on unsteady flow in an LP turbine blade passage, ASME Journal of Turbomachinery, Vol.131, 041016 (14 pages).

Five Best Recognitions:

- HAL Chair, 2017-20.
- Review Chair, ASME Gas Turbine India Conference, 2014
- Member of the Propulsion Panel, AR & DB, Govt. of India, 2010-12.
- Awarded Visiting Fellowship for two years, 2001-2003, University of Surrey, UK.
- Members of Academic Review Committee, NIT Allahabad, 2014
- External Member of Academic Senate for three years, 2015-17, NIT Kurukshetra.

Faculty profile

Name: Aditya Saurabh

Academic Degree:

BT-MT Dual (Aerospace)	IIT Madras	2010
Ph. D.	Technische Universitaet Berlin	2017

Specialization: Fluid Mechanics, Thermal Sciences

Date of joining: January, 2019

No. of PhD Graduated: 0

No. of M. Tech. Graduated: 1

Five Best Contributions:

1. Premixed Flame Dynamics in Response to Two-Dimensional Acoustic Forcing, Saurabh, A. and Paschereit, C. O., Combustion Science and Technology, 191(7), 2019
2. Fractal Characteristics of Combustion Noise, Saurabh, A., Imran, H., Nawroth, H, Paschereit, C. O., Journal of Engineering for Gas Turbines and Power, 140(12), 2018
3. Swirl flame response to simultaneous axial and transverse velocity fluctuations, Saurabh, A., Moeck, J. P., Paschereit, C. O., Journal of Engineering for Gas Turbines and Power, 139(6), 2017
4. Noise-induced dynamics in the subthreshold region in thermoacoustic systems, Saurabh, A, Kabiraj, L., Steinert, R. and Paschereit, C. O., Journal of Engineering for Gas Turbines and Power, 139(3), 2017
5. Dynamics of premixed swirl flames under the influence of transverse acoustic fluctuations, Saurabh, A. and Paschereit, C. O., Combustion and Flame, 182, 2017

Five Best Recognitions:

- Graduated with Summe-cum-lauda for PhD research (2017).
- Selected as a DST-INSPIRE faculty fellow (2018).
- Recipient of the TU Berlin Seed Funding for early stage researchers (2015).
- Recipient of the International Gas Turbine Institute Student Scholar award (2012).
- Recipient of the Boeing travel grant for presenting at an international conference as an undergraduate student (2010).

Faculty profile

Name: Anupam Saxena **Academic Degree*:*** B. Tech., Mechanical Engg., IIT, Bombay, 1995 M. S., University of Toledo, USA ,1997 1995-1997 Ph. D., University of Pennsylvania, USA, 2000 **Specialization**: Mechanical Engineering **Date of joining**: March 2001 **No of PhD Graduated:** 04 **No of MTech Graduated:** 24	

Best Contributions:

1. Khatik V. M. Nishad S. S. Anupam Saxena. 2021. Comprehending finger flexor tendon pulley system using systematic computational analysis. ASME Journal of Biomedical Engineering. 143. 111009-1-10.
2. BVS Nagendra Reddy. Anupam Saxena. 2021. Topology synthesis of a 3-kink Contact-aided compliant switch. ASME Journal of Mechanical Design. 143. 081704-1-15.
3. Singh N. Kumar P. and Saxena A. 2020. On Topology Optimization with Elliptical Masks and Honeycomb Tessellation with Explicit Length Scale Constraints. Structural and Multidisciplinary Optimization, 62(3), 1227-1251.
4. Saxena A. Valero-Cuevas F J. Lipson H. 2012. Functional inference of complex anatomical tendinous networks at a macroscopic scale via sparse experimentation. PLOS Computational Biology. 8(11): p.1-17 (e1002751).
5. Saxena. A. Ananthasuresh. G. K. 2001. Topology Synthesis of Compliant Mechanisms for Nonlinear Force-Deflection and Curved Output Path. ASME J. Mechanical Design. 2001. Vol. 123. pp 33-42.
6. Saxena, A. and Ananthasuresh, G. K., 2000, On an Optimality Property of Compliant Topologies, Structural and Multidisciplinary Optimization, 19 (1), pp. 36-49.

Best Recognitions:

- Alexander von Humboldt Fellowship 2010-
- In top 2% (Design Practice & Management)-Ioannidis J. P. A, Boyack Kevin W, Baas Jeroen, 2020, Updated science-wide databases of standardized citations, PLOS Biology, 2020.
- Associate Editor, ASME Journal of Mechanisms and Robotics 2021-
- Associate Editor, ASME Journal of Mechanisms and Robotics 2011-2015
- AICTE Career Award 2006; Procter and Gamble Best Professional Paper Award 1997
- Vivek Vir Award, Government of Madhya Pradesh, INDIA 1992
- Silver Medal, Mathematics Talent Search Examination, Government. of INDIA 1991

Faculty profile

Name: Basant Lal Sharma

Academic Degree:

B. Tech. (ME, IIT Bombay, 1999)

PhD (Mechanics, Cornell University, 2004)

Specialization: Mathematical Analysis of Crystalline Defects, Dynamics of Lattices, and Elasticity.

Date of joining: 11 January, 2007

No of PhD Graduated: 01

No of MTech Graduated: 11

Five Best Contributions:

1. Sharma BL, "Diffraction of waves on square lattice by semi-infinite crack", SIAM Journal on Applied Mathematics, 75(3), 1171-1192 Jun 2015
2. Sharma BL, "On energy balance and the structure of radiated waves in kinetics of crystalline defects", J. of Mechanics and Physics of Solids, Vol. 96, Nov 2016, 88-120
3. Sharma BL, "Electronic transport across a junction between armchair graphene nanotube and zigzag nanoribbon", The European physical journal B, May 2018, 91:84
4. Sharma BL, "Discrete scattering by two staggered semi-infinite defects: reduction of matrix Wiener-Hopf problem", J. Engineering Mathematics, Vol. 123, 41-87, Aug 2020
5. Sharma BL and Basak N, "Null Lagrangians in Cosserat elasticity", Journal of Elasticity, Vol. 143, pages 337–358 2021

Five Best Recognitions:

- Invited to give a talk in Aug 2019 as part of "Factorisation of matrix functions: New techniques and applications [WHTW01]", Isaac Newton Institute for Mathematical Sciences, Cambridge University, UK.
- Invited to give a talk in October 2018 as part of ``Dynamic phenomena in media with microstructure" (Israel Science Foundation), Fac. of Engineering, Tel Aviv University, Israel.
- Director's letter for excellence in teaching and Nomination for C.N.R. Rao award at Indian Institute of Technology Kanpur.
- EGIDE Fellowship '05-'06, Ecole Polytechnique, Palaiseau, France; SIAM Student Travel Award for the SIAM Conference on Nonlinear Waves and Coherent Struc- tures, 2004; SIAM Student Travel Award for the SIAM Conference on Mathematical Aspects of Materials Science, 2004; State Merit Award for P.E.T. 1995 by the state Governor, MP, India, 1996; All India Talent Search Award'93 and Scholarship, Prime Minister of India, 1993 – 94; NTSE Scholarship, 1992 Merit Scholarship for Highest Marks, 1990–92.

Faculty profile

Name: Ishan Sharma

Academic Degree:

Doctor of Philosophy (ME)	Cornell University, Ithaca, NY, USA	2004
Bachelor of Engineering (ME)	Indian Institute of Technology, Kanpur, India	1999

Specialization: Solid Mechanics and Design

Date of joining: September, 2006

No. of PhD Graduated: 07

No. of M. Tech. Graduated: 28

Five Best Contributions:

1. D Banik, K Gaurav, I Sharma, Regolith flow on top-shaped asteroids, Proceedings of the Royal Society A Publication date 2022
2. K Gaurav, D Banik, I Sharma, P Dutt, Granular flow on a rotating and gravitating elliptical body, Journal of Fluid Mechanics, Volume 916, Pages A40:1-40
3. Prasad Sonar, Sachin Modi, Ishan Sharma, Estimating forces during ploughing of a granular bed Publication date 2019/9 Journal of Fluid Mechanics Volume 875 Pages 376-410 Publisher Cambridge University Press
4. Ishan Sharma, Structural integrity of rubble asteroidal satellites, Publication date 2019/2/1 Journal Icarus Volume 319 Pages 770-784 Publisher Academic Press
5. Ishan Sharma, High-speed impacts of slender bodies into non-smooth, complex fluids, Publication date 2019/2 Journal of Fluid Mechanics Volume 861 Publisher Cambridge University Press

Faculty profile

Name: Sachin Y. Shinde

Academic Degree:

Ph. D. (Mechanical)	IISc, Bangalore, India	2012
M. Sc. (Engg.) - ME	IISc, Bangalore, India	2007
B. E. (Mechanical)	Walchand College of Engg. Sangli,	2000

Specialization: Experimental Fluid Mechanics, Fluid-structure interaction, Bio-fluid dynamics, Flapping Foil Propulsion

Date of joining: 15 October 2015

No. of PhD Graduated: 02 ongoing; 01 submitted

No. of M. Tech. Graduated: 09

Five Contributions:

1. Chayanit Nigaltia and Sachin Y. Shinde, "Numerical investigation of switching of a jet generated by a foil pitching in still fluid", Book Chapter in "Recent Advances in Computational Mechanics and Simulations, Volume-II: Nano to Macro", Springer, Pages 283 – 294, (2020).
2. Sachin Y. Shinde and J. H. Arakeri, "Physics of unsteady thrust and flow generation by a flexible surface flapping in the absence of a free stream", Proceedings of the Royal Society A, 474, 20180519, (2018). doi: http://dx.doi.org/10.1098/rspa.2018.0519
3. Sachin Y. Shinde and J. H. Arakeri, "Flexibility in flapping foil suppresses meandering of induced jet in absence of free stream", Journal of Fluid Mechanics, 757, 231–250, (2014).
4. Sachin Y. Shinde and J. H. Arakeri, "Jet meandering by a foil pitching in quiescent fluid", Physics of Fluids, 25, 041701, (2013).
5. Aman Soni, Sachin Y. Shinde, and Abhishek, "Performance enhancement of helicopter in forward flight by attaching flexible flap to rotary blades", the patent filing is in progress.

Five Recognitions

- Recognized thrice as an Excellent Instructor (by student feedback survey), IIT Kanpur Fall Semester 2021, Fall Semester 2020, Winter Semester 2017.
- Our B.Tech. Project (BTP) team received the "Best Project Award" of the Mechanical Engineering Department, IIT Kanpur in 2017 for the design and development of "Seed Dibbler".
- Our Letter stood 1st among the "Top 20 Most Read Articles" in Physics of Fluids in April 2013: Shinde, S. Y. & Arakeri, J. H. 2013, Phys. Fluids, 25.
- "Gold Medal" and "Best Thesis Award" for M.Sc. (Engineering) (2009), Department of Mechanical Engineering, Indian Institute of Science, Bangalore, India
- National Merit Scholarship (twice) for securing 12th rank in the Higher Secondary Certificate (HSC) Merit List (1996 – 2000), and for securing 26th rank in the Secondary School Certificate (SSC) Merit List (1994 – 1996).

Faculty profile

Name: Manjesh Kumar Singh

Academic Degree:

Ph. D. (Materials)	ETH Zurich	2016
M. E. (Materials Engineering)	IISc Bangalore	2011
B. E. (Mechanical Engineering)	IIEST Shibpur	2009

Specialization: Soft Matter, tribology and rheology

Date of joining: September 16, 2019

No. of PhD Graduated: 06 ongoing

No. of M. Tech. Graduated: 4 M.Tech. and 3 MS(R)

Five Best Contributions:

1. Thermal Conductivity of Semicrystalline Polymer Networks: Crystallinity or Crosslinking?; Manoj K. Maurya, James Wu, Manjesh K. Singh, Debashish Mukherji; ACS Macro Letters, 11, 925-929, (2022).
2. Computational indentation in highly cross-linked polymer networks; Manoj K. Maurya, Céline Ruscher, Debashish Mukherji, Manjesh K. Singh; Physical Review E, 106(1), 014501 (2022).
3. Polymer cyclization for the emergence of hierarchical nanostructures; Chen, C., Singh, M.K., Wunderlich, K. *et al.; Nature Commun* 12, 3959 (2021).
4. Tuning thermal transport in highly cross-linked polymers by bond-induced void engineering; Debashish Mukherji and Manjesh Kumar Singh Phys. Rev. Materials 5, 025602 (2021).
5. *Glass Transition Temperature of Disentangled Polymer Melts: Single-chain-nanoparticles approach;* Manjesh K. Singh, Minghan Hu, Yu Cang, Hsiao-Ping Hsu, Heloise Therien-Aubin, Kaloian Koynov, George Fytas, Katharina Landfester and Kurt Kremer; Macromolecules 2020, 53 (17), 7312-7321.

Five Best Recognitions:

- Scholarship covering registration, accommodation and travel assistance to attend International Nanotribology Forum: Thailand 2020, Jan. 12-17, 2020 at Chiang Rai, Thailand.
- Best Oral Presentation (academia) at IndiaTrib-2019, Dec. 1-4, 2019, at Bangalore, India.
- Scholarship covering registration, accommodation and travel assistance to attend International Nanotribology Forum: Kerala 2014, Jan. 6-10, 2014 at Cochin, Kerla, India.
- Travel grant to attend Gordon Research Conference: Tribology, July 8-13, 2012 at Waterville, ME, USA.
- GATE Scholarship, MHRD, Govt. of India, 2009-2011.

Faculty profile

Name: Niraj Sinha **Academic Degree:** B. Tech. (Manufacturing Engineering): NIFFT, Ranchi M. Sc. (Mechanical Engineering): Uni- Saskatchewan, Canada Ph. D. (Systems Design Engineering): Uni- Waterloo, Canada **Specialization:** Nanotechnology, Bioengineering, Manufacturing Systems **Date of joining**: July, 2013 **No of PhD Graduated:** 5 **No of MTech Graduated:** 31	

Five Best Contributions:

1. Dixit, K., Gupta, P., Kamle, S. and Sinha, N., Structural analysis of porous bioactive glass scaffold using micro computed tomographic images, Journal of Materials Science, vol. 55, 12705-12724, 2020.
2. Bhandari, A., Bansal, A. and Sinha, N., Effect of aging on heat transfer, fluid flow and drug transport in anterior human eye: a computational study, Journal of Controlled Release, vol. 328, 286–303, 2020.
3. Bangari, R.S., Singh, A.K., Sadanandam, N., Singh, J.K. and Sinha, N., Magnetite-coated boron nitride nanosheets for the removal of arsenic(v) from water, ACS Applied Materials and Interfaces, vol. 11, pp. 19017-19028, 2019.
4. Bhandari, A., Bansal, A., Singh, A. and Sinha, N., Numerical study of transport of anti-cancer drugs in heterogeneous vasculature of human brain tumors using DCE-MRI, ASME Journal of Biomechanical Engineering, vol. 140, no. 5, pp. 051010 (1-10), 2018.
5. Sinha, N., Roy Mahapatra, D., Sun, Y., Yeow, J.T.W., Melnik, R.V.N. and Jaffray, D.A., Electromechanical interactions in carbon nanotube based thin film field emitting diode, Nanotechnology, vol. 19, no. 2, pp. 25701 (1-12), 2008.

Five Best Recognitions:

- NSERC Postdoctoral Fellowship 2008 – 2010 (NSERC stands for Natural Sciences and Engineering Research Council of Canada)
- Nominated for NSERC Doctoral Prize by Faculty of Engineering, University of Waterloo, 2008 (Only one thesis is nominated each year by the faculty for the award)
- NSERC Alexander Graham Bell Canada Graduate Scholarship- Doctoral 2006-2008 (Awarded to top PhD candidates nationally)
- University of Waterloo President's Graduate Scholarship 2006 – 2008 University of Waterloo Grad- uate Scholarship (Awarded 9 times during Ph. D.

Faculty profile

Name: Nachiketa Tiwari

Academic Degree:

BE, NIT, Jaipur. 3rd in the graduating class
M. Tech., IIT Kanpur.
PhD, Virginia Tech., VA, USA. GPA 4.0/4.0
MBA, Babson College, MA, USA. Summa cum laude

Current areas of interest

Nonlinear structures, acoustics, speech, phonetics, composites, defence systems, new product development, innovation, and design.

Date of joining: 2009

No of PhD Graduated: 6

No of MTech Graduated: 42

Five Best Contributions

1. **Developed the first Soft Recovery System for India, and 4th in the world**: The system developed arrests the motion of supersonic projectile (M > 3) emanating from a large calibre gun and brings it to rest over a period of 50 meters, currently installed in OFK, Medak.
2. **Modeling of an Ultra-Low Frequency Hydroacoustic Projector**: Developed a full functional prototype. System was analysed via its analog equivalent– an electrical network having several non-linear elements, switches, and innovative model for valves with rapidly changing orifice dimensions.
3. **Determination Dynamic Range and Long-Term Average Speech Spectrum for 16 Indian Languages**: A Hindi speaking person employing a hearing aid tuned to English language-based parameters would experience discomfort and poor hearing. Towards this goal, we have analysed 16 Indian languages spoken by over a billion people. We are now working with All India Institute of Speech and Hearing so that these data can now be used.
4. **Analysis of Devanagari Stop Consonants**: In this work, we have analyzed 25 stop consonants used in most Indian languages and explored their mathematical relationships. Our work shows that 25 consonants can be generated using 07 different sounds.
5. **Non-Destructive Characterization of an Electrodynamic Shaker**: There has been always a need to non-destructively determine the system parameters of an electrodynamic shaker. Such systems are non-linear, and also damping attributes of the system are strongly dependent on excitation frequencies; a reliable method to determine such parameters non-destructively is developed.

Five Best Recognitions

- Member, Establishment Committee, NCERT, New Delhi.
- Visitor's Nominee to Executive Council, Banaras Hindu University, Varanasi.
- Member, Acoustics Panel for Central Pollution Control Board
- Rais Memorial Award at National Symposium of Acoustics
- Life Fellow, Acoustical Society of India

Faculty profile

Name: P Venkitanarayanan

Academic Degree:

B. Tech.: Mechanical Engg. University of Kerala (1986)
M. Tech.: Mechanical Engineering, IIT Madras (1988)
Ph. D.: University of Rhode Island, USA (1999)

Specialization: Solid Mechanics (Fracture, dynamic behavior)

Date of joining: July, 2003

No of PhD Graduated: 12

No of MTech Graduated: 60

Five Best Contributions:

1. Ravi Sankar H and Parameswaran V, Effect of circular perforations on the progressive collapse of circular cylinders under axial impact, INTERNATIONAL JOURNAL OF IMPACT ENGINEERING, Volume 122, Pages 346-362, September 2018
2. Sharma AP, Khan SH, Kitey R, Parameswaran V, Effect of metal layer placement on the damage and energy absorption mechanisms in aluminium/glass fibre laminates, INTERNATIONAL JOURNAL OF IMPACT ENGINEERING, Volume 119, 14-25, September 2018
3. Sharma AP, Khan SH, Parameswaran V, Experimental and numerical investigation on the uni-axial tensile response and failure of fiber metal laminates, COMPOSITES PART B: ENGINEERING, Volume 125, 259-74, September 2017
4. Faye A, Parameswaran V, Basu S, Mechanics of dynamic fracture in notched polycarbonate, JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS, 77, 43-60, JAN 2015
5. Gupta N, Basu B, Parameswaran V, Microstructure Development, Nanomechanical, and Dynamic Compression Properties of Spark Plasma Sintered TiB2-Ti-Based Homogeneous and Bi-layered Composites, METALLURGICAL AND MATERIALS TRANSACTIONS A, 45A: 4646-4664, SEP 2014

Five Best Recognitions:

- F. Zandman award for the year 2019 from Society for Experimental Mechanics, USA
- Excellence in Teaching Award for the year 2019 from Indian Institute of Technology Kanpur
- Associate Technical Editor for the International Journal, Experimental Mechanics, an official journal of the Society for Experimental Mechanics, USA, published by Springer, for the period September 2010 to December 2016
- Associate Technical Editor for the International Journal of Dynamic Behavior of Materials, official journal of Society for Experimental Mechanics, USA, published by Springer, January 2017 onwards.
- Editorial Board Member for International Journal of Adhesion and Adhesives, published by Elsevier, March 2019 onwards

Faculty profile

Name: Nalinaksh S. Vyas

Academic Degree:

B. Tech. Indian Institute of Technology Bombay, 1980.
M. Tech. Indian Institute of Technology Delhi, 1983
Ph. D. Indian Institute of Technology Delhi, 1986

Specialization: Machine Dynamics, System Identification and Parameter Estimation, MEMS, Instrumentation and Sensor Technologies, Condition Monitoring & Neural Networks

Date of joining: 21 December, 1987

No of PhD Graduated: 11

No of MTech Graduated: 89

Five Best Contributions:

1. Fatigue Life Estimation Procedure for a Turbine Blade Under Transient Loads, N.S. Vyas and J.S. Rao, Journal of Engineering for Gas Turbines and Power, Trans ASME, 1996, Vol 16, pp 198-206.
2. Artificial Neural Network Design for Fault Identification in a Rotor-Bearing System, Mechanism and Machine Theory, 2000, Vol 36(2), pp. 177-188, N.S.Vyas, D.Satishkumar.
3. Convergence Analysis of Volterra Series response of Nonlinear Systems subjected to Harmonic Excitation, J. Sound Vibration, Vol. 236(2), pp. 339-358, 2000, Animesh Chatterjee and N.S.Vyas.
4. Stick-slips and jerks in an SDOF system with dry friction and clearance , Yadav, O.P. and Vyas, N.S., Int. Journal of Non-Linear Mechanics, Volume 137, 2021, 103790, ISSN 0020-7462.
5. Single and Multi-label Fault Classification in rotors from unprocessed multi-sensor data through deep and parallel CNN architectures, Nikhil A. Sonkul, Gaurav S. Dhage, Nalinaksh S. Vyas, Expert Systems with Applications, Volume 185, 2021, 115565, ISSN 0957-4174.
6. Development of State-of-Art Instrumentation and Diagnostic Tools for Thermal Power Plant Monitoring for the first time in Super Thermal Power Station, Punjab, 1999.
7. Successful completion & transfer of technology in the TECHNOLOGY MISSION FOR RAILWAY SAFETY, involving projects like SIMRAN, Derailment Detection Devices, WILD etc, 2003-2009.
8. Design & development of India's first Nanosatellite, JUGNU, launched- 2012 (with ISRO).
9. Development of the first commercially viable MEMS based Pressure Sensors in the country for Automotive Applications, under NPMASS (with SCL Chandigarh and Pricol Coimbatore), 2013.
10. Indigenous Industry 4.0 Platform Development, Technology Mission, Indian Railways, 2022.

Five Best Recognitions:

- Featured by India Today (2010), as one of the 20 Innovators Changing Our Lives
- Awadh Samman, 2009, Govt. of Uttar Pradesh
- 4th position, HSSC, Madhya Pradesh Board, 1975.

Faculty profile

Name: Pankaj Wahi

Academic Degree:

B. E. (Mechanical)	Government Engineering College, Bilaspur, C.G., India	2001
Ph. D. (Mechanical)	Indian Institute of Science, Bangalore, India	2006

Specialization: Stability of hydrodynamic systems and solid structures, Dynamics, Vibrations and Controls, Reduced order modeling, Time-delayed Systems, Robotics.

Date of joining: September, 2007

No of PhD Graduated: 10

No of MTech Graduated: 55

Five Best Contributions:

1. De, S., Sahoo, S. R., and Wahi, P., 2020, "Tracking protocol for network of double-integrator systems with heterogeneous time delays", IEEE Transactions on Industrial Informatics, 17(7), pp. 4798-4808.
2. Das, S., and Wahi, P., 2018, "Energy extraction from vortex induced vibrations using period-1 rotation of an auto-parametric pendulum", Proceedings of the Royal Society of London A, 474, 20180086, doi: 10.1098/rspa.2018.0086.
3. Gupta, S. K., and Wahi, P., 2016, "Global axial-torsional dynamics during rotary drilling", Journal of Sound and Vibration, 375, pp. 332-352, doi:10.1016/j.jsv.2016.04.021.
4. Mandal, A. K., and Wahi, P., 2015, "Natural frequencies, mode-shapes and modal interactions for strings vibrating against an obstacle: Relevance to Sitar and Veena", Journal of Sound and Vibration, 338, pp. 42-59, DOI: 10.1016/j.jsv.2014.06.010.
5. Subramanian, P., Sujith, R. I., and Wahi, P., 2013, "Subcritical bifurcation and bistability in thermoacoustic systems", Journal of Fluid Mechanics. 715, pp. 210-238, http://dx.doi.org/10.1017/jfm.2012.514.

Five Best Recognitions:

- Received citation from IIT Kanpur Senate for excellence in teaching five times in three different courses.
- Awarded the INAE Young Engineer Award for the year 2013.
- Received the INSA medal for Young Scientist, 2013.
- Awarded P K Kelkar Fellowship by IIT Kanpur from 2013-2016.
- Received the Marie-Curie fellowship to undertake research in Germany for a year.

Department of Mechanical Engineering

Indian Institute of Technology Kanpur

List of Publications

January 2015 – March 2022

Year 2022 (Till March)

1. Kumar, Santosh; Edachery, Vimal; Velpula, Swamybabu; Govindaraju, Avinash; Choudhury, Sounak K.; Kailas, Satish V., Influence of surface roughness, friction coefficient, and wrap angle on clinching joint strength and its correlation with belt friction phenomenon, PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS PART J-JOURNAL OF ENGINEERING TRIBOLOGY, Vol.236, 2022.
2. Singh, Manmeet; Bhattacharya, Jishnu; Sharma, Manoj Kumar, Computational prediction of significant efficiency gain through multi-tank modular heat storage for solar thermal systems with variable-temperature input profile (vol 18, 100551, 2020), THERMAL SCIENCE AND ENGINEERING PROGRESS, Vol.29, 2022.
3. Sharma, Manoj Kumar; Bhattacharya, Jishnu, Finding optimal operating point for advection-cooled concentrated photovoltaic system, SUSTAINABLE ENERGY TECHNOLOGIES AND ASSESSMENTS, Vol.49, 2022.
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