Indian Institute of Technology Kanpur

C N R Rao Lecture Series

6 PM, Wednesday, 11th March 2015, Venue: Outreach Auditorium*

Professor Anindya Chatterjee
Department of Mechanical Engineering

Title: Simple models for frictional hysteresis

Abstract

Hysteresis, for this lecture, is a largely rate independent, history dependent, and irreversible behavior seen in electromagnets, material dissipation, plasticity, liquid-solid contact angles, and other areas. I will begin by describing the Bouc-Wen model, often used for hysteresis in structural systems; and the classical Preisach model, used for magnets. I will then discuss hysteresis in high-dimensional frictional systems, and novel low-order models for the same that I have developed with my students.

We have studied two systems with signum nonlinearities and high dimensionality. The governing equations, involving signs of velocities, are not differential equations in the usual sense. They are solved incrementally using a linear complementarity problem formulation. From this numerical solution, to develop a reduced-order model, basis vectors are chosen using the singular value decomposition. The slip direction in generalized coordinates minimizes a complicated dissipation-related function. That function includes frictional dissipation through signum nonlinearities at many friction sites. Luckily for this research effort, it allows a convenient analytical approximation. The approximated minimization problem yields the slip direction. An evolution rule for a few states is finally obtained that matches the full solution well.

The above line of attack was first implemented on a 500-state frictional system, whereby we developed a six-state hysteresis model. The shortcomings of that model helped us identify a second system for similar analysis. The new system leads to more pleasing outcomes. The basis functions for model reduction now have simple analytical description. The number of states required decreases from six to a theoretical minimum of two. Fitted parameters are dramatically fewer in number. Parameter fitting to match different specified hysteresis loops is demonstrated.

In summary, a two-state, physically based, first-principles model of single-input single-output hysteresis is developed that is ready for practical implementation. This model has no parallel in the literature that I know of.

About the Donor

Prof. Chintamani Nagesa Ramachandra Rao was born on June 30, 1934 in Bangalore. In 1958, he completed his Ph.D. from Purdue University and became a research chemist at the University of California at Berkeley. Returning to India in 1959, he worked as a lecturer at the Indian Institute of Science in Bangalore. From 1963-76, he was a Professor of Chemistry at IIT Kanpur. During 1984 -89, he was the Director of IISC Bangalore.

Prof. Rao is a recipient of Bharat Ratna.

The annual Lecture is supported by a donation from Prof. C N R Rao.

Tea at 5.45 PM

About the Speaker

Prof. Anindya Chatterjee received his B Tech in Mechanical Engineering from IIT Kharagpur in 1989. He worked for Telco (now Tata Motors) as a graduate engineer trainee for a year, and then joined the University of Florida at Gainesville in 1990. There, he received concurrent masters degrees in Engineering Mechanics and in Applied Mathematics in 1993. He then received his PhD in theoretical and applied mechanics from Cornell University at the end of 1996. He was a postdoctoral research associate at Penn State University until early 2000, when he joined the Mechanical Engineering department at IISc Bangalore as an Assistant Professor. He moved to IIT Kharagpur as Professor of Mechanical Engineering in 2009, and to IIT Kanpur as Professor of Mechanical Engineering in 2012. He has been at IIT Kanpur since then. He is also the Coordinator of the IGCAR Cell.

His teaching interests are in engineering mechanics, statics, dynamics, strength of materials, vibration, and applied mathematics. His research interests have included rigid body impact models, walking machines, rotors, vehicle dynamics, fatigue damage modeling, delay differential equations, parametrically forced systems including ion dynamics in Paul traps, fractional order derivatives, various linear and nonlinear vibration problems, material damping, and hysteresis models.

He is a Fellow of the Indian National Academy of Engineering.

Past five speakers

Year	*Name*	*Title*
2014	Raj Chabbra	To yield or not to yield: Convection in Visco-plastic Fluids
2013	Debasis Kundu	Analyzing Periodic Data: Statistical Perspectives
2012	Sanjay Mittal	Using High Performance Computing (HPC) for Understanding Fluid Flows
2011	Amalendu Chandra	Molecular simulations of liquids and interfaces: An HPC activity at IITK
2010	Gautam Biswas	Understanding Vapor and Air Bubbles

Contact: Dean of Research & Development