This experimental study focuses on developing new combustion concepts for compression ignition (CI) engines by achieving partially homogeneous fuel-air charge resulting in lean and low temperature combustion. Premixed charge compression ignition (PCCI) is a single-stage combustion process, which shifts combustion towards increasingly premixed combustion phase, resulting in relatively leaner and lower in-cylinder combustion temperatures. All experiments were performed on a single cylinder research engine (SCRE) using mineral diesel. Unlike other multi-cylinder engines, SCRE was chosen to investigate this realm of combustion in segregated single cylinder in order to avoid adverse effects in performance of other cylinders on combustion analysis in the targeted cylinder. For controlling the load and speed of the engine, a transient dynamometer was coupled to the test engine.

Investigations were done with advanced fuel injection timings and high exhaust gas recirculation (EGR) to reduce nitrogen oxides (NOx) and particulate matter (PM) emissions simultaneously. In the experiments, flexible injection system was employed, which was capable of deploying up to four injections (2 pre-injections, 1 main and 1 post injection) in one engine cycle at variable injection timings. Various fuel injection parameters such as fuel injection pressure (FIP), fuel injection timings and number of injections were optimized in order to tackle the problems of start of combustion (SoC) and combustion phasing. The experiments were carried out using single and double pilot injection strategy. Further, the soot samples obtained at various engine operating conditions were analyzed using Transmission Electron Microscopy (TEM). This was done in order to analyze the particulate emission characteristics and correlate the results with particulate size-number and size-mass distributions obtained experimentally using Engine exhaust particle sizer (EEPS)