High Efficiency and Clean Combustion Modes for Diesel Engines

Abstract

Internal combustion engines are employed in transport, power generation, and agriculture sectors. More than 99.9% of transport vehicles are powered by reciprocating type engines (for land and water) and jet type engines (for air). Diesel engines are preferred over their gasoline counterparts due to their high thermal efficiency and fuel economy benefits. However, diesel engines produce more oxides of nitrogen (NO_x) and particulate matter (PM) emissions due to the combustion of the heterogeneous fuel-air mixture at higher temperatures. Because of the sharp contrast in the formation mechanism of these two pollutants, conventional diesel combustion (CDC) leads to a NOx-PM trade-off that makes it challenging to control these pollutants simultaneously through in-cylinder emission control methods. Low-temperature combustion (LTC) is an alternative combustion mode to CDC that offers a simultaneous reduction in NO_x and PM emissions while retaining the higher thermal efficiency of diesel engines. There are several LTC strategies introduced to date, among which the most widely investigated strategies include homogeneous charge compression ignition (HCCI), premixed/partially premixed compression ignition (PCCI) and reactivity controlled compression ignition (RCCI). These strategies have a positive ignition dwell that helps achieve premixed lean combustion with ultra-low NO_x and PM emissions. A limited engine operating load range and high unburned hydrocarbon (HC) and carbon monoxide (CO) emissions are the significant shortcomings to be addressed to realize LTC as a commercially viable option. In this talk, I will discuss the different approaches carried out by our research group at IIT Madras to address the shortcomings of LTC strategies.