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**Plenary Lecture**
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# From Optical Spray Diagnostics to Peripheral Fuel Injection (PeFI): Advancing Diesel Combustion for High-Efficiency and Low-Emissions

**Abstract:** Diesel engines are an important part of modern infrastructure including heavy- and light-duty transport vehicles, large tanker ships, off-road vehicles, agricultural machines, construction equipment, and distributed power generation. Next generation diesel engines must achieve higher fuel efficiency and lower air-borne emissions to keep pace with the increasingly stringent emissions regulations and rise of electrification in propulsion and power generation sectors. These conflicting, two-fold requirements require fundamental insight into diesel combustion processes and develop modern concepts that can be incorporated into existing engine hardware without significant development efforts. This presentation will explore fundamental and applied aspects of diesel combustion to address the above challenges. Multiple research groups have used optical spray diagnostics to investigate diesel combustion. In the first part, an overview of key results and advancements, especially within authors' research group will be provided. These include a constant pressure test rig for repeated fuel injection experiments, schlieren deflectometry (RSD) to simultaneously quantify liquid length as well as first and second stage ignition events, and two-color pyrometry to acquire spatially resolved soot measurements. Spray combustion physics within the framework of these diagnostics will be discussed. In the second part, Peripheral Fuel Injection (PeFI) developed recently in authors' group will be introduced. In PeFI, fuel is injected from multiple single-hole injectors located at the periphery of the cylinder head, as opposed to Conventional Diesel Combustion (CDC) supplying fuel radially outwards from a centrally located multi-hole injector. PeFI was implemented in a single cylinder research engine to demonstrate its ability retrofit in existing hardware. Test results show inherent benefits of PeFI: lower coolant heat loss, higher fuel efficiency, and large reductions in soot and CO emissions. Findings of the operational engine are consistent with the cold flow experiments and detailed non-reacting and reacting simulations. Design improvements underway will allow PeFI to also reduce NOx and unburned hydrocarbon emissions in future designs, which is profound in curtailing role of after-treatment systems in diesel engines.

***Bio:** Professor Ajay K. Agrawal is Robert F. Barfield Endowed Chair Professor in the Department of Mechanical Engineering at The University of Alabama (UA) since 2005. His current research focuses on rotating detonation combustion, high-pressure fuel sprays, diesel combustion, liquid fuel atomization, thermo-acoustic instabilities, and in general, low-emission combustion systems for propulsion, power generation, and industrial processes. His research has been supported by DOE, NASA, Army, Navy, Air Force, NSF, US Department of Education, among others. He holds 3 U.S. patents and has authored over 100 journal papers, and over 200 conference publications. He has supervised 22 PhD graduates, and 12 PhD students are currently working under him. He served as Chair of US Sections of the Combustion Institute and as chair of ASME Turbo Expo Coal, Biomass, and Alternative Fuels (CBAF) Committee. Professor Agrawal is Fellow of ASME, The Combustion Institute, and Associate Fellow of AIAA. He has received the top awards given to a faculty member across all disciplines at UA, including the Blackmon-Moody award for innovation in 2013, Burnum Distinguished Faculty Award in 2020, SEC Faculty leadership award in 2022, and T. Morris Hackney Endowed Faculty Leadership award in 2023.*