Paper 29.0

Advanced laser diagnostics in combustion for prototype and modelling development

by
Robert W. Bilger
Department of Mechanical and Mechatronic Engineering
The University of Sydney
NSW 2006, Australia

ABSTRACT

This paper addresses the questions of how advanced laser diagnostics for the measurement and imaging of scalar quantities are helping in the development of new high-performance combustors and engines. Such diagnostics have greatly improved our understanding of combustion processes but their early promise for aiding more directly the development process are perhaps unfulfilled as yet. Some examples of the direct use of these diagnostics in the development of prototype engines and combustors are reviewed. It is concluded that most applications are still in the realm of the research laboratory, but that there may be an opportunity for commercially-hardened systems for use in routine development in the automotive industry. The alternative approach of using the diagnostics to improve the modelling of combustion used in computational fluid dynamics (CFD) codes is also discussed. Such codes are already widely used in prototype development for prediction of flow and mixing processes in engines and combustors. At present they are not capable of quantitatively predicting for practical combustors the effects of coupling between the flow and combustion such as those involved in pollutant formation and in flame-stabilisation, extinction and ignition processes. Joint Rayleigh/Raman/LIF measurements in turbulent jet diffusion flames and bluff-body flames of gaseous fuels are, however, providing accurate and challenging data bases for validation of advanced combustion models. Interaction between the diagnostic measurements and the modelling is the subject of an important series of international workshops. Models such as Monte-Carlo simulation of the PDF transport equation and Conditional Moment Closure are proving to have considerable success in predicting these data and the application to practical systems is likely in the near future. Advanced laser diagnostics are now capable of addressing questions of flame structure in turbulent premixed flames. It is necessary for combustion models to be based on valid concepts of flame structure. Recent measurements with joint planar Rayleigh scattering and PLIF for OH and of joint PIV and PLIF for OH indicate that considerable revision of the concepts and bounds for regimes of flame structure may be necessary.