Progress and Challenges in Combustion Dynamics

Abstract

Much fundamental research has concerned combustion dynamics issues. This effort initially motivated by problems encountered during the early development of rocket propulsion has been focused during the last period on issues raised by gas turbines. To reduce NOx emissions, these machines now operate in a lean premixed combustion mode. In the new combustor architectures, the flames are more compact, the power density is higher, and the damping rate is reduced, a combination of factors that promotes instabilities. Under certain conditions, this leads to unacceptable levels of pressure oscillations in the system and this has become an essential issue in the design of these systems. Much progress has been accomplished in the physical understanding of the fundamental processes giving rise to combustion dynamics phenomena and self-sustained oscillations. This has been based on well-controlled experiments, new theoretical ideas and high performance simulations. This lecture will include some introductory material on fundamentals of combustion dynamics, a review of a unified framework for the nonlinear analysis of self-sustained oscillations based on the Flame Describing Function, a brief discussion of the dynamics of swirling flames, and will focus on the dynamics of ignition in annular combustors and on azimuthal modal coupling in this geometry. The last topics are of importance because the annular geometry is typical of many practical systems like jet engines and gas turbines. This situation is investigated by making use of novel experimental configurations, high-speed imaging, low order models and large eddy simulations. Aimed at a general audience, this lecture will include introductory material and many illustrative examples and will underline the link between knowledge and applications.

Biography

Dr. Sébastien Candel is a University professor emeritus at CentraleSupélec, University Paris-Saclay and a honorary professor at Institut Universitaire de France. He obtained an engineering degree from Ecole Centrale Paris, a PhD from the California Institute of Technology and a Doctorate in science from UPMC (University of Paris 6). Many of his research contributions have concerned turbulent combustion issues, combustion dynamics analysis modeling and simulation, combustion control, cryogenic combustion under transcritical conditions and high performance simulation with application to aerospace propulsion and energy. Among many distinctions, Dr. Candel has been the recipient of the Silver medal of CNRS, the Marcel Dassault Grand Prize of the French Academy of sciences, the Distinguished Alumni Award of the California Institute of Technology, the silver and Gold medals both from the Combustion Institute. Dr. Candel is a member of the French Academy of sciences and its President in 2017 and 2018, he is a founding member of the French Academy of technologies and a foreign member of the National Academy of Engineering of the United States.