Challenges and Opportunities in Combustion Research

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Abstract:

With more than 85% of the current world energy is converted by combustion, the use of alternative fuels and low-temperature combustion is among the most important solutions for energy sustainability and has posted a grand challenge in combustion research to develop predictive tools for innovative engine design. The seminar will discuss several technical challenges and opportunities in combustion research arising from the use of alternative fuels and their complex chemical kinetics, modeling, diagnostics, and ignition control at extreme conditions. The first challenge of a drop-in alternative fuel is its impact on engine performance and emissions. As the future engines are designed for higher pressure, lower temperature, and dual and multiple fuels, how do we control and predict the ignition and heat release rate to achieve better efficiency and lower emissions? In this lecture we will present a generic surrogate fuel modeling approach and concepts of radical index and transport weighted enthalpy to rank the fuel reactivity and model real fuel combustion with a few component fuel mixtures. The second challenge is that combustion of a realistic alternative fuel and its blends often involves thousands of species and ten thousands of reactions. Many of the combustion properties and elementary reactions are strongly pressure dependent. How do we develop a kinetic model to be applicable to practical engine conditions? How do combustion diagnostics and ab initio quantum chemical computation play a role in kinetic model development? The lecture will use hydrogen, dimethyl ether, and biodiesel as a few examples of the gap of knowledge in high pressure combustion and introduce the opportunities of new combustion diagnostics such as the mid-infrared Faraday rotational spectroscopy and ab initio quantum chemical computation. The third challenge is how to understand turbulence-chemistry interaction at low temperature and how to model turbulent combustion with hundreds and thousands of species? The lecture will discuss a new turbulent diagram and experimental method to address high pressure and low temperature turbulent combustion, and present a multi-time scale method (MTS) with a correlated-dynamic adaptive chemistry (CO-DAC) approach to improve drastically the computation efficiency of combustion with large kinetic mechanisms. Finally, opportunities using plasma assisted combustion to activate low temperature chemistry and enable ultra lean combustion will be presented.

Bio:

Yiguang Ju is a Robert Porter Patterson Professor at Princeton University. His bachelor degree in Engineering Thermophysics from Tsinghua University in 1986, and his PhD degree in Mechanical and Aerospace Engineering from Tohoku University in 1994. He was appointed as an Assistant and Associate Professor at Tohoku University in 1995 and 1998, and as a Changjiang Professor and the Director of Thermophysics Institute at Tsinghua University in 2000. He joined Princeton University in 2001 and became a full professor in 2011. Prof. Ju’s research interests include combustion and propulsion in the area of near limit combustion, microscale combustion, plasma assisted propulsion, alternative fuels, chemical kinetics, multiscale modeling, and functional nano-materials. He has published more than 140 refereed journal articles. He is an ASME Fellow and an associate editor for AIAA Journal and Proceedings of Combustion Institute. He received a number of awards including the Distinguished Paper Award from the International Symposium on Combustion (2011, 2015), the NASA Director’s Certificate of Appreciation award (2011), the Friedrich Wilhelm Bessel Research Award by the Alexander von Humboldt Foundation (2011).

This seminar is co-sponsored by the Academy of Mechanical and Aerospace Engineers

Refreshments will be served at 3:15 p.m.