ME Seminar

Flame Spread in Normal and Zero Gravity Environment

Prof.Subrata Bhattacharjee, San Diego State University

ABSTRACT

Understanding the behavior of flame spreading in a microgravity environment has direct implications to fire safety in spacecraft. Compared to normal Earth gravity conditions where radiative effects are insignificant (for small flames) due to high buoyancy, the absence of an opposing flow in the space environment can make the residence time (time spent by oxidizer and fuel at the flame leading edge) relatively large, resulting in strong radiative effects. A simplified analysis will be presented that predicts that flame spread over solid fuels is self-extinguishing even in a high oxygen environment, provided that a non-dimensional radiation number exceeds a certain critical value. Numerical analysis suggests that the asymmetry between the species and temperature fields caused by enhanced radiative losses creates a vitiated atmosphere around the spreading flame, leading to its extinction. With the non-dimensional radiation number being proportional to fuel thickness and inversely proportional to the ambient pressure, the Residence Time Driven Flame Spread (SoFIE-RTDFS) investigation will vary these two parameters in upcoming (June 2024) long duration experiments aboard the International Space Station (ISS). The intended experiments should provide direct evidence to prove, or disprove, the predicted flame extinguishment and provide unprecedented insight into the mechanism of flame spread in a microgravity environment. The analysis will be expanded to establish closed-form formulas for downward flame spread over cylindrical fuels in a normal-gravity environment. The second half of the talk will be devoted to a demonstration of the web-ware TEST (The Expert System for Thermodynamics – www.thermofluids.net) freely available to all educators.

ABOUT THE SPEAKER

Professor Bhattacharjee earned a B.Tech. degree in Mechanical Engineering from Indian Institute of Technology, Kharagpur in 1983 and his Ph.D. from Washington State University, Pullman, USA in 1988. After two years of post-doctoral work on a NASA project, he joined San Diego State University in 1991 and currently holds Professorship in Mechanical Engineering Department and Affiliated Professorship in Computer Science Department. His current research interests include flame spread in microgravity, radiation signatures of flames, scale analysis, computational fluid dynamics, and web-service based software development. His research at SDSU has been supported by NASA and NSF and led to more than 70 archival journal publications, two books, one book chapter, several Ph.D. dissertations and many Masters thesis in ME and CS areas. His thermodynamic textbook (Thermodynamics: An Interactive Approach, Pearson 2015) and the accompanying courseware TEST (www.tehrmofludis.net) are used in many universities around the world. He is a member of the Combustion Institute, ASEE, and a fellow of ASME. Professor Bhattacharjee can be contacted at prof.bhattacharjee@gmail.com.

September 29, 2023 (Friday)
4:00 PM, A.R. Auditorium