NUMERICAL STUDY OF SOOT CONCENTRATION IN CO-FLOW LAMINAR ETHYLENE-AIR DIFFUSION FLAMES AT ELEVATED PRESSURES

Amin Mansouri, Seth B. Dworkin
amin.mansouri@ryerson.ca
Department of Mechanical and Industrial Engineering, Ryerson University
350 Victoria Street, Toronto, Ontario, M5B 2K3 Canada

Work-In-Progress Abstract

Mitigating soot emission is a global concern and it is one of the essential ways to control climate change and global warming. Moreover, decomposed soot particles can lead to a great number of health concerns such as cancer and chronic respiratory problems, which put this type of research at the center of attention of academics and industry professionals. In this work, soot concentration of pure and nitrogen-diluted co-flow ethylene laminar diffusion flames is studied numerically to investigate the effects of increasing pressure on soot formation. In previous studies, it has been shown that maximum soot volume fraction and maximum soot yield for pure ethylene-air flames increase due to an increase in pressure. Experimentally, it has been shown that soot concentration for nitrogen-diluted ethylene flames also exhibit the same trend due to an increase of pressure [Karatas and Gülder, Combust, Flame 162 (2015) 1566-1574]. Karatas and Gülder also have shown that maximum soot volume concentration shifts from the center to the wings with increasing pressure in both pure and nitrogen-diluted ethylene flames. They considered ethylene flames from 1 to 7 atm and diluted flames from 5 to 20 atm.

The goal of the present work is to apply a numerical analysis to the aforementioned experimental data sets. As most industrial combustion applications occur at elevated pressure, developing a detailed fundamental understanding of soot formation at high pressures is of great concern. Soot behavior of pure and nitrogen-diluted ethylene-air laminar diffusion flames are investigated in this study to further our understanding of high pressure soot formation with varying stoichiometry. While experimental studies are of great value for system characterization, with more complex subjects such as soot behavior, numerical studies can reveal a finer level of detail and help improve and broaden the knowledge of the field. To study soot yield of a laminar co-flow nitrogen-diluted ethylene-air diffusion flame at increasing pressure, the CoFlame code [Eaves *et al.* Comput. Phys. Commun., 207 (2016) 464-477] has been used. The CoFlame code implements the finite volume conservation equations in parallel, considering detailed chemistry and transport, and sectional soot particle dynamics. Based on preliminary results, the dependency of soot yield of pure and nitrogen-diluted ethylene-air laminar diffusion flames on pressure is elucidated.