Flow Dynamics in High Shear Injectors

Saptarshi Basu
Associate Professor
Department of Mechanical Engineering,
Indian Institute of Science
Tel: 7760808825
E-mail: sbasu@mecheng.iisc.ernet.in

BIO:

Saptarshi Basu is currently an Associate Professor in the Department of Mechanical Engineering at Indian Institute of Science.

Saptarshi basu received his M.S. and Ph. D. degrees in Mechanical Engineering from University of Connecticut in 2004 and 2007 respectively. Before that he finished his B.E in Mechanical Engineering from Jadavpur University in2000. Prof. Basu was a tenure track faculty member in the Department of Mechanical, Materials and Aerospace Engineering in University of Central Florida, USA from 2007-2010. He joined Indian Institute of Science as a faculty member in 2010. Prof. Basu is the recipient of DST Swarnajayanti Fellowship from Government of India in Engineering Sciences. He is a Fellow of the Indian National Academy of Engineering. He also received the K.N Seetharamu medal from Indian Society of Heat and Mass Transfer for his contributions in multiphase transport. Prof. Basu is a member of ASME, ISHMT and Combustion Institute.

His current research interests include combustion instability, flame-vortex interaction, droplet level transport, multiphase combustion, spray atomization and breakup, water transport characteristics in fuel cells and general areas of heat and mass transfer. He has vast experience in optical diagnostics particularly laser induced fluorescence, particle image velocimetry, tunable diode laser absorption spectroscopy, rayleigh scattering and laser induced incandescence. He has over 170 technical publications in reputed journals and conferences. Prof. Basu also holds an US patent for developing novel laser based dianostics to detect and measure water vapor concentrations in the channels of a PEM fuel cell. A significant portion of his work is dedicated towards droplet level heat and mass transfer cutting across multiple disciplines ranging from gas turbines, surface patterning, thermal barrier coatings, spray dryers, pharmaceutics etc. Prof. Basu leads large scale initiatives at IISc with respect to both combustion and solar thermal applications. He is a project leader in Indo-Us funded clean energy center where he developed the first optically accessible realistic scale thermal storage loop based on thermocline concept. Prof. Basu also established realistic scale combustors and atomizer setups at IISc to probe into the mechanisms of flow-flame-droplet coupling as in gas turbines. Prof. Basu has also studied and deciphered key combustion characteristics and stability mechanisms of nanofuels which is a new concept that uses nanoadditives in fuels to enhance stability and burning along with pollution reduction. In addition, Prof. Basu also conducts small or mini-micro scale studies to probe into the transport mechanisms in nanoparticle laden sessile and levitated droplets with a focus on surface patterning and 3D printing.

Abstract :

This work discusses the influence of geometrical parameters over the performance of high shear injector. In particular, we have meticulously analyzed the global evolution of the flow field, spray patternation and droplet size distribution using high fidelity laser diagnostic tools. High shear injector usually consists of a series of air swirlers (primary and secondary) with diverging flare at the exit and centrally mounted fuel nozzle. In this study, we have considered only parameters pertains to air swirler i.e. geometrical swirl number (SN_{geo}), flow split ratio (γ), area ratio (Δ), flare angle (θ), flow orientation of primary and secondary swirers (i.e. co / counter rotation). It should be noted that, the above parameters can be globally categorized into two paradigms, first, the parameters SN_{geo}, γ , Δ are called as swirler internal geometrical parameters, which essentially induces variations in the bulk Reynolds number at the exit. Whereas, the parameters flare angle **(** θ **)**, flow orientation doesn't yield any variations in bulk Reynolds number. The main idea is to identify the sensitivity of the swirl cup results with respect to the above said two paradigms. Time resolved PIV (~ 3500 frames/s) is employed to perceive the topological structures of the flow field. The length scale $\frac{W}{D_f}$, which embodies the radial extend of the recirculation zone is used a criterion to distinguish the various test cases. It is found that, the magnitude $\frac{W}{D_f}$ of is governed by near field swirl number (SN_{10}) and Reynolds number for the cases where SN_{geo}, γ , Δ have been varied**.** Here, SN_{10} represents the experimentally measured swirl number at ~ 10mm from exit of swirl cup. On the other hand, for the cases with variations being θ and flow orientation $\frac{W}{D_f}$, founds to be only a function of near field swirl number f (SN_{10}). Next, the spatial distribution of the spray perceived from patternation studies shows linear relationship with the magnitude of $\frac{W}{D_f}$. Though, the spatial spread of the spray varies however, we have noticed uniform distribution of the spray across all the test cases. Finally, the droplet size spectrum obtained from 3D PDI also shows insensitivity with respect to the different test cases. This clearly indicates, in the high shear atomizer configuration considered in the present study, it is possible to alter the spatial spread of the spray without deterioration of spatial uniformity and size distribution.