Abstract:
Two-phase flow inside and near nozzle regions of the automotive fuel injectors is an important area of research. Extreme low pressure regions develop in the high pressure direct injection fuel flow inside the fuel injector holes, compelling the liquid fuel to transform to vapor phase in the form of cavities or bubbles, a phenomenon known as cavitation. The cavitation phenomenon determines the quality of primary atomization and hence affects the performance of direct injection diesel or gasoline engines. A cavitation model, coupled with the mixture multiphase approach and RNG k-e turbulence, has been developed and implemented in the ANSYS Fluent platform for analysing cavitation in diesel injectors. The model predictions were in decent agreement with the experimental findings. Comparison of the model predictions with those of other existing models such as, Schnerr & Sauer, and Zwart-Gerber-Belamri indicated that the developed model provides reasonable numerical predictions and does not have some of the fundamental drawbacks imbibed in the equations of the other existing cavitation models. The developed model has also been extended to execute a comparative analysis of diesel and biodiesel cavitation. At lower pressure differentials biodiesel cavitation prediction was lower than that of diesel, but at high pressure differentials both diesel and biodiesel cavitation patterns were comparable. For cavitation inception scenarios i.e. at low pressure differentials molecular viscosity appeared to be a dominant factor for the diesel versus biodiesel cavitation study. The developed model has also been extended to a three-dimensional fuel injector with a moving needle and the predictions were in accordance with the published results.

Gasoline direct injection (GDI) is a growing trend in the automotive sector for the past decade. High injection pressure, better fuel economy have provided the impetus to the developments of GDI systems. At low or part load conditions the in-cylinder pressures are often sub-atmospheric and thus, the heated (around 360 K) injected gasoline fuel is subjected to superheated conditions. In such scenarios bulk liquid fuel undergoes rapid transformation to bulk vapor and the phenomenon is known as flash boiling. Experimental studies have indicated that extent of flashing strongly depends on the degree of superheat. Previous studies indicated that flash boiling strongly affects the spray characteristics and combustion phenomena in GDI engines. A mixture multiphase model coupled with Homogeneous Relaxation Model (HRM) has been developed and implemented in the CONVERGE code for analysing flash boiling problems. Reasonable agreements have been obtained with experimental findings and published numerical results. Best practices for running a flash boiling simulation using a cartesian cut-cell method has been outlined. It has been found the model setup is capable of capturing the two-phase flow characteristics under different thermodynamic conditions, substantiated by prior thermodynamic calculations. The model has also been used to understand the needle lift effects on flashing patterns in GDI systems.

--------------------------------------------------------------------------------------------------------

Biography:

Kaushik Saha is currently pursuing his postdoctoral research at Argonne National Laboratory, under supervision of Dr. Sibendu Som. At Argonne National Laboratory he is working on flash boiling phenomenon of Gasoline Direct Injection systems. Dr. Saha finished his undergraduate studies in Mechanical Engineering at Jadavpur University. He pursued his Masters in Mechanical Engineering at University of Connecticut, USA. During Masters he carried out numerical studies in the field of material processing in thermal plasmas. After his Masters, he completed his doctoral studies at University of Waterloo, Canada. At University of Waterloo Dr. Saha worked on topics such as, Urea-SCR for NOx reduction, blended diesel-biodiesel droplet evaporation and cavitation in diesel injectors. His PhD thesis focused on two-phase flow inside diesel injectors. He has authored 6 journal publications and 12 conference papers and presentations. Dr. Saha was also a recipient of Outstanding Teaching Assistant award at University of Waterloo.

--------------------------------------------------------------------------------------------------------