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Modeling and Simulation of Primary Atomization and Its Effects on Internal Flow Dynamics in a High Torque Low Speed Diesel Engine

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Abstract : Diesel engines are most efficient and reliable in terms of efficiency, reliability and adaptability. Most of the research and development up till now have been directed towards High-Speed Diesel Engine, for Commercial use. In these engines objective is to optimize maximum acceleration by reducing exhaust emission to meet international standards. In high torque low-speed engines the requirement is altogether different. These types of Engines are mostly used in Maritime Industry, Agriculture industry, Static Engines Compressors Engines etc. Unfortunately due to lack of research and development, these engines have low efficiency and high soot emissions and one of the most effective way to overcome these issues is by efficient combustion in an engine cylinder, the fuel spray atomization process plays a vital role in defining mixture formation, fuel consumption, combustion efficiency and soot emissions. Therefore, a comprehensive understanding of the fuel spray characteristics and atomization process is of a great importance. In this research, we will examine the effects of primary breakup modeling on the spray characteristics under diesel engine conditions. KH-ACT model is applied to cater the effect of aerodynamics in an engine cylinder and also cavitations and turbulence generated inside the injector. It is a modified form of most commonly used KH model, which considers only the aerodynamically induced breakup based on the Kelvin–Helmholtz instability. Our model is extensively evaluated by performing 3-D time-dependent simulations on Open FOAM, which is an open source flow solver. Spray characteristics like Spray Penetration, Liquid length, Spray cone angle and Souter mean diameter (SMD) were validated by comparing the results of Open Foam and Matlab. Including the effects of cavitation and turbulence enhances primary breakup, leading to smaller droplet sizes, decrease in liquid penetration, and increase in the radial dispersion of spray. All these properties favor early evaporation of fuel which enhances Engine efficiency.

Keywords : Kelvin–Helmholtz instability, open foam, primary breakup, souter mean diameter, turbulence
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