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Investigations on Pyrolysis Model for Radiatively Dominant Diesel Pool Fire Using Fire Dynamic Simulator

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Abstract : Pool fires are formed when the flammable liquid accidentally spills on the ground or water and ignites. Pool fire is a kind of buoyancy-driven and diffusion flame. There have been many pool fire accidents caused during processing, handling and storing of liquid fuels in chemical and oil industries. Such kind of accidents causes enormous damage to property as well as the loss of lives. Pool fires are complex in nature due to the strong interaction among the combustion, heat and mass transfers and pyrolysis at the fuel surface. Moreover, the experimental study of such large complex fires involves fire safety issues and difficulties in performing experiments. In the present work, large eddy simulations are performed to study such complex fire scenarios using fire dynamic simulator. A 1 m diesel pool fire is considered for the studied cases, and diesel is chosen as it is most commonly involved fuel in fire accidents. Fire simulations are performed by specifying two different boundary conditions: one the fuel is in liquid state and pyrolysis model is invoked, and the other by assuming the fuel is initially in a vapor state and thereby prescribing the mass loss rate. A domain of size 11.2 m × 11.2 m × 7.28 m with uniform structured grid is chosen for the numerical simulations. Grid sensitivity analysis is performed, and a non-dimensional grid size of 12 corresponding to 8 cm grid size is considered. Flame properties like mass burning rate, irradiance, and time-averaged axial flame temperature profile are predicted. The predicted steady-state mass burning rate is 40 g/s and is within the uncertainty limits of the previously reported experimental data (39.4 g/s). Though the profile of the irradiance at a distance from the fire along the height is somewhat in line with the experimental data and the location of the maximum value of irradiance is shifted to a higher location. This may be due to the lack of sophisticated models for the species transportation along with combustion and radiation in the continuous zone. Furthermore, the axial temperatures are not predicted well (for any of the boundary conditions) in any of the zones. The present study shows that the existing models are not sufficient enough for modeling blended fuels like diesel. The predictions are strongly dependent on the experimental values of the soot yield. Future experiments are necessary for generalizing the soot yield for different fires.

Keywords : burning rate, fire accidents, fire dynamic simulator, pyrolysis
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