Mechanical Engineering Thesis Defense

Computational Framework for Modelling Spray Cooling using the Quadratic Formula - Applied to Flat-Fan Sprays

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Abstract

Spray flows are important in a myriad of practical applications including fuel injection, ink-jet printing, agricultural sprays, and industrial processes. Two-phase sprays find particular use for spot cooling applications with high heat fluxes as in casting processes and power electronics. Computability of sprays in a cost-effective manner provides a path to optimize the design of nozzles in order to tune the spray characteristics for the needs of a particular application. Significant research has so far been devoted to understand and characterize spray flows better, be it from a theoretical, experimental or computational standpoint. The current thesis discusses a methodology for modeling primary atomization using the Quadratic Formula which is derived from an integral formulation of the governing equations. The framework is then applied to different examples of flat-fan hydraulic sprays. For each case, the spray is first resolved as a continuous fluid using the volume of fluid method. Atomization criterion is then applied to the velocity flow-field to determine the sites for primary atomization. At each site, local diameters for particle injection is determined using the quadratic formula. The trajectory of injected particles are then monitored through a particle tracking algorithm. Different approaches are discussed for modelling the interaction of particles with the wall in order to determine the heat transfer and impact pressure distributions. The results from the numerical analysis are compared with experimental data to validate the computational framework.

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