MECHANICAL ENGINEERING

PH.D. DEFENSE

The Department of Mechanical Engineering presents:

The Dissertation Defense of:

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Thermo-Fluid Dynamics of Flash Atomizing Sprays and Single Droplet Impacts

Spray atomization and droplet dynamics are research topics that have existed for many decades. Their prevalence in manufacturing, energy generation and other practical applications is undeniable, though researchers have often overlooked the importance of understanding the physics of atomization or droplet impact characteristics in the ongoing effort to improve efficiency. In this talk, I will address the atomization of thermodynamically unstable “flashing” sprays and the splashing mechanisms of single droplets impinging on flat, smooth surfaces. The related heat transfer phenomena for cooling applications are also addressed. These topics are motivated by efforts to improve the thermal protection provided by cryogenic spray cooling in laser dermatological procedures, increasing the throughput of the spray production of nano and micro-scale particulates used as dyes and catalysts, and in modeling of the release and dispersion of flammable or hazardous chemicals through large-scale collisions with storage containers.

Through the use of high-speed video imaging, phase Doppler interferometric measurements and numerical modeling of the two-phase flow taking place within spray nozzles, a detailed picture of the processes involved in flash atomization are attained. Results reveal that flashing fluid jets under low superheats undergo many dynamic processes leading to eventual droplet formation, including the nucleation of vapor bubbles within the nozzle interior and their subsequent expansion and explosion. At high superheats, a stable “flare flashing” regime is attained resulting in very fine atomization. These insights may lead to improved nozzle designs to better control the atomization process.

High-speed imaging of droplet impacts also reveals new insights into the mechanisms of splashing. The surrounding ambient air pressure, fluid viscosity, and fluid-surface affinity are found to profoundly influence the initiation and characteristics of splashing. A new analytical model explaining the mechanisms of crown splashing is developed along with correlations predicting the threshold of splashing.