IOWA STATE UNIVERSITY

Center for Multiphase Flow Research and Education

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"Advancing Zero-carbon Fuels for Heavy Duty Applications through Computational Modeling and Simulation"

Abstract

Climate change continues to push every industry away from traditional fossil fuel-based energy sources towards renewable alternatives, especially those that do not utilize any carbon. Electrification is a possibility for many fields, but heavy-duty applications such as large-scale agriculture, aviation, or marine transport still need the high energy storage density and conversion rates offered by liquid fuels and combustion devices. Ammonia, NH_3, is a promising carbon-free fuel candidate that can be generated from renewable energy and already has global infrastructure for distribution. Despite several advantages, ammonia also has several problems as a fuel, including poor combustion properties. Mixing ammonia with hydrogen can mitigate some of these combustion properties, but designing internal combustion systems to run on ammonia/hydrogen blends will require computer simulations that are able to capture the spray, mixing, and combustion behaviors of ammonia and ammonia/hydrogen blends. Due to the high saturation pressure of ammonia, liquid ammonia sprays will undergo strong flash boiling behavior. Flash boiling is a difficult process to capture accurately, especially for Lagrangian-Eulerian (LE) methods that are the primary modeling approach for fuel sprays in internal combustion engines. Detailed in-nozzle simulations have been used to help inform modeling approaches for engine-scale LE spray simulations, including understanding the effects of spray boundary conditions on spray predictions and the evaluation of models' ability to capture flashing and non-flashing spray behaviors. Ammonia-air flames have very slow flame speeds, and therefore experience greater buoyancy effects. Full 3D computational fluid dynamics simulations have been carried out of ammonia flames to better understand the buoyancy effects and the resulting flame deformations, and evaluate the ability of current combustion models to match experimental ammonia flames. The spray and combustion modeling will help future simulations of ammonia-fueled internal combustion engines.

Biography

Prof. Noah Van Dam is an assistant professor at University of Massachusetts Lowell where he leads the Multiphase and Reacting Flow Laboratory, which uses high performance computing to understand complex flows in energy and other applications. Current research projects in his lab include the development of ammonia- and hydrogen-based internal combustion engines for power generation, the effects of salt-air on low-pressure burners for marine applications, the use of physics informed machine learning to accelerate detailed chemical kinetics calculations, and understanding numerical errors in Lagrangian-Eulerian methods for disperse multiphase flows. Before joining UMass Lowell, Prof. Van Dam was a postdoctoral researcher at Argonne National Laboratory where he worked on simulations of biofuels for transportation engines. Prof. Van Dam received his Ph.D. from the University of Wisconsin-Madison working on Large-eddy Simulations of fuel sprays and internal combustion engine flows.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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