JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

FALL 2019 SEMINAR SERIES

"On Large Eddy Simulations of Atomization"

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Significant progress has been made in the past decade to predict atomization using detailed numerical simulations. Advances in numerical methods have enabled the study of the breakup of liquids not only in simple geometries, but also complex realistic injectors. However, these simulations come at significant computational cost, since the range of length and time scales that needs to be resolved in a detailed simulation typically exceeds the resolution requirements of a single phase direct numerical simulation significantly. As in the single phase case, a switch to a Large Eddy Simulation (LES) approach would thus be desirable. However, the underlying assumption of LES methods that the dynamics of the unresolved sub-filter scale can be inferred from the dynamics of the resolved scales is questionable concerning the dynamics of phase interfaces. Similar to viscosity in single-phase flows, surface tension forces scale with the inverse of a length-scale, but unlike viscosity, surface tension can act to either dissipate surface corrugations preventing breakup, resulting in the Hinze scale, or enhance surface corrugations due to the Rayleigh-Plateau instability, resulting in breakup. Which process is dominant on the sub-filter scale depends entirely on the sub-filter interfacial geometry, i.e., if the interface is in the shape of ligaments, the surface tension can lead to breakup, whereas in other cases, surface-tension forces would inhibit breakup. Unfortunately, the sub-filter geometry cannot be inferred from the filtered interfacial geometry alone. Thus, LES approaches going beyond the traditional single-phase cascade hypothesis may be required for two-phase flows with atomization.

In this seminar, in addition to presenting some detailed simulation results for atomizing flows, a dual scale LES modeling approach will be discussed that can handle the dual nature of surface tension on the sub-filter scale. The model maintains a fully resolved realization of the phase interface, shifting the modeling task to reconstructing the fully resolved interfacial advection velocity from the filter-scale velocity, taking the effects of sub-filter surface tension, turbulent eddies, and shear into account. Preliminary results showing the viability of the dual-scale LES approach will be discussed.

Marcus Herrmann is an Associate Professor in the School for Engineering of Matter, Transport and Energy at Arizona State University. He received his PhD in Mechanical Engineering from the Technical University in Aachen, Germany in 2001 and was a post-doc and research associate at the Center for Turbulence Research at Stanford University from 2002 to 2007. His research is in the area of computational fluid dynamics for turbulent liquid/gas interfacial flows in both incompressible and supersonic flow environments. His specific area of interest is in understanding and predicting the primary atomization processes of injected liquids with applications ranging from fuel injection systems to medical sprays. He is the Editor-in-Chief for the Americas of the journal Atomization and Sprays. He has published over 35 articles in refereed journals, including the Annual Review of Fluid Mechanics, and has published over 80 conference publications.

Friday, November 8, 2019

3:00 PM, Gilman Hall 132