The Design, Instrumentation, and Validation of a Multiphase Shock Tube Facility

Constantine Avgoustopoulos

Advisor: Jacob A. McFarland

ABSTRACT

This paper investigates the experimental work in Shock Driven Multiphase Instabilities (SDMI). SDMIs occur when an interface consisting of a particle seeded gas is instantaneously accelerated and begins mixing. SDMIs have similar flow morphologies to the Richtmyer-Meshkov Instability (RMI), however, the driving force inducing this flow is very different. SDMIs occur when there is a relative velocity difference between surrounding gas and the moving particles. This results to a shear at the edges and ultimately leads to rollups that are similar to a RMI. To investigate this phenomena, a shock tube facility was designed, calibrated, and tested to perform experiments. The experimental data was qualitatively compared to simulations performed, as well as to literature of similar experiments. Quantitative data was analyzed using Particle Imaging Velocimetry (PIV) to understand the flow of the instability. The flow morphologies observed in experiments have similar behavior to those performed in simulations. Additionally, the qualitative observations of experiments performed in this lab are also in agreement with experimental literature. Two different effective Atwood numbers are investigated in this study. The first case looks at a gas cylinder interface with an effective Atwood number of -0.01 and a gas Atwood number of -0.02, shocked with a Mach 1.66 shock wave. The observations show a dominating instability resulting in the gas Atwood number. What ends up happening is the smaller particles are pulled into the vortex and the large particles separate and trail behind. The second case looks at the same gas cylinder perturbation but with an effective Atwood number of 0.03 and a gas Atwood number of 0, shocked at Mach 1.66. The higher Atwood number was achieved by modifying the experimental apparatus slightly to deliver a greater number of particles to the shock tube. The experiments observed show that there is agreement with literature and simulations. Certain unusual filaments begin forming at late times, ~4.0ms after shock. This was thought to only appear in a pure RMI. In the case of a SDMI, these filaments are a result of colliding particles.