Experiments on the Rayleigh-Taylor Instability using a Linear Induction Motor Accelerator

J. Jacobs, N. Yamashita, G. Johnson, V. Chivukula and M. Mokler

Department of Aerospace and Mechanical Engineering
University of Arizona
Tucson, Arizona, USA

Experiments are presented in which an incompressible system of two stratified miscible liquids is accelerated downward to produce the Rayleigh-Taylor instability. The acceleration required to drive the instability is produced by two high-speed linear induction motors mounted to an 8 m tall drop tower. The motors are mounted in parallel and have an effective acceleration length of 1.7 m and are each capable of producing 15 kN of thrust. Two liquid combinations are used: isopropyl alcohol and a calcium nitrate solution, and isopropyl alcohol and a sodium iodide solution, both giving Atwood numbers of approximately 0.2. The liquids are contained within a square acrylic tank with inside dimensions 76 x 76 x 184 mm. The tank is mounted to an aluminum reaction plate which is driven by the linear induction motors to create constant accelerations in the range of 1-20 g's (though the potential exists for higher accelerations). Also attached to the reaction plate are a high-speed, shock-rated camera and a surface mount LED backlight to provide continuous video imaging of the instability using backlit photography. In addition, an accelerometer is used to provide acceleration measurements during each experiment. Two permanent magnet brakes are used to slow the reaction plate, using eddy current braking, before impacting two shock absorbers positioned at the bottom of the tower. The experiments are visualized using ordinary backlit photography in which one of the fluids is colored using a light absorbing dye. In addition, experiments were performed in which molecular mixing is measured using the reaction of sodium hydroxide mixed with the salt solution and the pH indicator phenolphthalein mixed with the alcohol. In this case the fluids are colorless except where molecular mixing has occurred. Thus the molecularly mixed region can be easily visualized using backlit imaging. Experimental image sequences will be presented which show the development of a random three-dimensional instability from an unforced initial perturbation. Measurements of the growth of the mixing zone width will be compared with results from previous experiments and traditional growth models.