# Acceleration Effects on Instability of High-Pressure Fuel Jets

D. Jarrahbashi*, W. A. Sirignano
University of California, Irvine, USA
djarrahb@uci.edu and sirignan@uci.edu

**Abstract**

The transient behavior of the jet during the start-up and shut-down portion of the injection at very high Reynolds and Weber numbers is addressed in the present work. The acceleration of the liquid during start-up is about $10^6$ m/s$^2$ at the orifice exit for high Reynolds numbers. The influence of acceleration on the dynamics of jets has never been fully considered previously. When the jet emerges from the orifice, drag forces due to the dense ambient air cause a deceleration. Also, the dynamic protrusions from the jet surface created by Kelvin-Helmholtz (KH) instability are subject to local accelerations. The Rayleigh-Taylor (RT) instabilities are driven by acceleration when the liquid accelerates away from the gas locally. With this instability, the waves corrugate at the free surface during acceleration. Ultimately, these waves will finger into the liquid, causing it to break up. The effects of the RT and KH instabilities on jet break-up during start-up and shut-down transient are considered in this research. During start-up and shut-down, the jet exit velocity varies producing an acceleration which enters into the equations of motion transferring from the laboratory frame to an accelerating frame fixed to the liquid mass center as a generalized body force. In addition, the fingers have an accelerating motion, even during steady injection. At very high Reynolds and Weber numbers, calculations show that the unstable wavelengths could be as small as a few microns. To tackle the resolution problem and capture the shortest unstable surface wavelengths, we examine stream-wise segments of the jet, treating these segments as ballistic slugs coming from the orifice. This slug or liquid section of the jet deforms and exchanges both mass and momentum with the surrounding gas during start-up and shut-down. Use has been made of the unsteady multidimensional code with a finite-volume solver of the Navier-Stokes equations for liquid streams and adjacent gas, a boundary-fitted-gridding scheme, and a level-set method for gas/liquid interface tracking. We also simulate the full transient jet during the transients. These results have been very fruitful for an estimate of the acceleration and also for implementing the proper boundary conditions in the liquid-section model. The effects of the acceleration on the surface instability and the range of unstable wavelengths in the liquid-section model have been compared with the classical instability theories.

* Corresponding author: djarrahb@uci.edu