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Author: Ms. Charmaine Neufeld
University of British Columbia, Canada, charmainecneufeld@gmail.com

INVESTIGATION OF NUMERICAL MODELING METHODS FOR LIQUID FUEL COMBUSTION AND APPLICATIONS FOR SMALL-SCALE BIPROPELLANT LIQUID ROCKET ENGINES

Abstract

Physical testing of rocket engines requires careful consideration of personnel safety, as well as a great deal of hardware, planning, and resources. While physical testing is necessary to verify system functionality for launch, characterizing a liquid rocket engine through modeling and numerical simulations can significantly reduce valuable resources spent and ensure safe and controlled tests are performed.

Liquid rocket combustion is unpredictable due to the various processes like liquid droplet atomization, thermochemistry, and turbulent combustion. This paper investigates and compares current modeling methods for turbulent combustion reactions such as Reynolds-averaged numerical simulation (RANS), large eddy simulation (LES), and probability density function (PDF) methods. While RANS calculations require less computational resources, LES provides a better understanding of the thermochemistry and turbulence interactions with statistical results. Additionally, PDF models deal with the nonlinear reaction terms, but do not adequately model mixing. Through consideration of these models for simulation of a bipropellant liquid engine, it was found that LES results best agreed with experimental results. Implications of this analysis can be used to characterize the combustion of liquid rocket engines throughout system design stages in industry, as well as small scale applications.