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Author: Mr. Jonah Zimmerman
Stanford University, United States

Mr. Benjamin Waxman
Stanford University, United States
Prof. Brian Cantwell
Stanford University, United States
Mr. Greg Zilliac
National Aeronautics and Space Administration (NASA), United States

SELF-PRESSURIZING PROPELLANT TANK DYNAMICS

Abstract

A self-pressurizing propellant is a technology that has the potential to reduce propulsion system mass and complexity. In this case, the liquid propellant has a high vapor pressure that may be used to pressurize the liquid, allowing a traditional pressurization system to be eliminated entirely or significantly reduced in size. However, the expulsion dynamics of a self-pressurizing propellant tank must be accurately modeled for system performance to be predicted. For nitrous oxide, a common self-pressurizing propellant used throughout the hybrid rocket community, such a model has yet to be developed.

To aid in the development of such a model, an experimental apparatus has been constructed with a transparent polycarbonate cylinder functioning as a propellant tank. This allows for optical measurements to be made in addition to traditional pressure, temperature, and mass flowrate measurements. Carbon dioxide has been identified as an analog for nitrous oxide, facilitating a significant reduction in the cost, negative environmental consequences, and hazards to personnel associated with this type of testing.

Initial results of tests with this system show that there is significant boiling within the liquid and that the propellant is not maintained in thermodynamic equilibrium. Furthermore, both supercharge configuration and mass flowrate strongly affect the dynamics of self-pressurizing propellants. In this paper, these and other results will be discussed, along with comparisons to model predictions. In order to demonstrate carbon dioxide's accuracy as an analog for this work, comparison tests with nitrous oxide and carbon dioxide have also been performed.