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PRELIMINARY DEVELOPMENT OF A FLUID TRANSFER MODEL AND TEST BENCH FOR IN-SPACE FUELING DEMONSTRATION

Abstract

In-space refueling is an emerging technology that extends satellite missions and represents a significant step toward space sustainability. Traditional hydrazine-based propellants pose a serious threat to the environment and are carcinogenic. There is an urgent need for a better alternative, and nitrous oxide offers a promising solution due to its self-pressurizing behavior, which results in a simpler propulsion system design, low toxicity, and ease of storage.

The purpose of this paper is to create a fluid transfer model for N_2O and build a test bench that simulates the fluid transfer of a self-pressurizing fluid. Modeling the behavior of N_2O is challenging due to its complex thermodynamic properties and the occurrence of two-phase flow during pressure changes. To simulate the fluid transfer, the equilibrium model was used because it is simpler and provides a comparable method to other existing models, which yield similar results but are more complex.

To validate this model, a test bench was designed in which experiments were conducted using carbon dioxide as a simulant fluid due to its similar thermodynamic properties to N_2O. This setup helped to better understand the fluid transfer dynamics of a high-vapor-pressure fluid.

Overall, this work lays the groundwork for developing safer and more efficient in-space refueling systems, contributing to sustainable space missions and the broader pursuit of cleaner propulsion technologies. These results signify a breakthrough in space technology.