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LEVERAGING MICROGRAVITY TO INVESTIGATE EARTH- AND SPACE-BASED CENTRIFUGAL CASTING OF WAX

Abstract

Continued interest in paraffin wax as a high-performing hybrid rocket fuel motivates the investigation of the use of paraffin for small satellites. Shorter-chained paraffin waxes have been used as phase change materials for thermal insulation onboard satellites dating back to Apollo, but paraffin has yet to be leveraged as in-space propellant [1]. Prior work confirmed the comparable performance of hypergolic paraffin-based fuels when contrasted with state-of-the-art propellants such as hydrazine and nitrogen tetroxide [2]. The current work by the authors details an experimental and computational approach to understanding the fundamental fluid mechanical and heat transfer mechanisms which drive centrifugal casting of wax, in order to optimize variables of that process such as rotation rate and initial temperature, on Earth and in microgravity.

The research effort described herein comprises numerous parallel studies performed by the authors: (1) the ground-based investigation of length and diameter affect on minimum rotation rate required for annulus production in paraffin, beeswax, and other media; (2) the parabolic-aircraft-based microgravity platform which has been leveraged twice to date, with another flight scheduled for May 2020; (3) a 3-minute-microgravity-duration suborbital spaceflight onboard Blue Origin New Shepard scheduled for summer 2020; (4) a small satellite mission scheduled for launch in late 2020 intended to test the ability to melt wax using only solar irradiance.

This research also extends the domain of hybrid rocket studies to investigate beeswax as a potential fuel. One prior study of note quantified the differences between performance of paraffin and beeswax [3]. This work is a continuation of studies published previously by the authors on the topic [4]. The solidification rate of beeswax and paraffin was quantified using an optical technique. The radial solidification is proven to initiate at the outer surface and accelerate with time.

Bibliography

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