Using Tapered Channels to Improve LAD Performance: Suborbital Testing Results

Kevin Supak, Amy McCleney, Steven Green
Southwest Research Institute®, Fluids Engineering Department, San Antonio, TX, USA

Abstract

Improvement of cryogenic fluid storage and transfer technology for in-space propulsion and storage systems is required for long-term space missions. Screened-channel liquid acquisition devices (LADs) have long been used with storable propellants to deliver vapor-free liquid during engine restart and liquid transfer processes. The use of LADs with cryogenic fluids is problematic due to the low temperatures associated with cryogenic fluids. External heat leaks will cause vapor bubbles to form within the LAD that are difficult to remove in the existing designs. A new design has been proposed to reliably remove vapor bubbles without costly thrusting maneuvers or active separation systems. This presentation will review the proposed design, recent microgravity flight test results, and funded research that will be conducted on future microgravity flights.

Tapered LAD Design

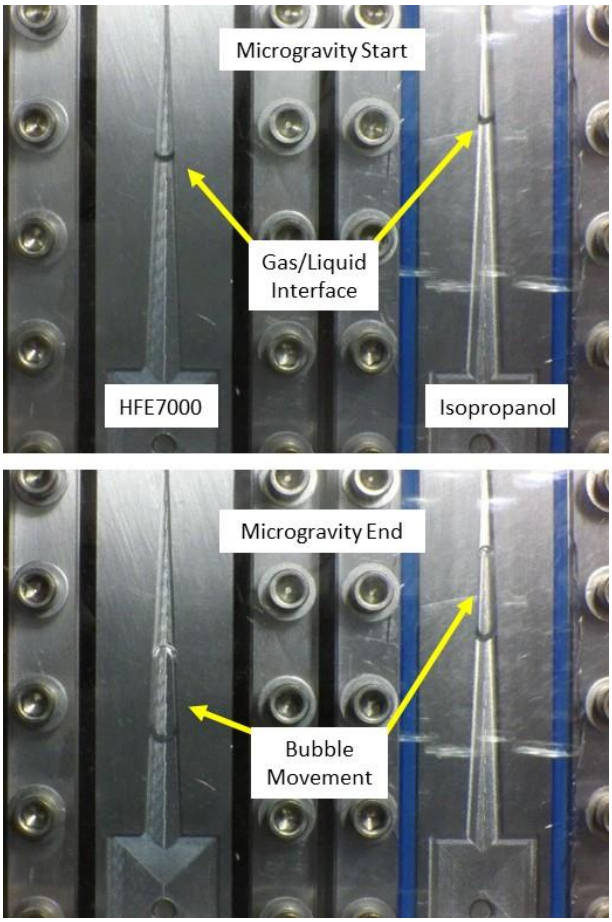
Southwest Research Institute (SwRI®) and NASA Glenn Research Center have evaluated a small modification to a commonly used LAD: a tapered channel. This design passively removes or "pumps out" cryogenic vapor bubbles that are internally generated using surface tension forces, substantially improving the transfer or delivery of cryogenic fluids. A model was developed by SwRI to predict the bubble movement as a function of fluid properties, bubble size, and LAD geometry.

Microgravity Testing

The tapered LAD design was previously ground tested at SwRI to provide model validation data. Utilizing funding from NASA's Flight Opportunities Program, several tapered channels were tested in microgravity aboard Blue Origin's New Shepard vehicle. This vehicle provided more than three minutes of high-quality microgravity. This duration of microgravity is beneficial for this test program because it takes several minutes for the bubble to migrate to the wider end of the channel.

Conclusions

Analysis of the bubble movement data captured in microgravity testing is ongoing and the results will be discussed and compared to the model and ground test data during the presentation. Future flight tests will further investigate bubble movement in tapered LAD designs based on the initial test results.



Tapered LAD Bubble Movement in Microgravity
The bubble starts at the top of the LAD due to the acceleration forces during launch. In microgravity, the bubble moved towards the wider end of the channel due to capillary action.