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Title

Development of Liquid Oxygen/Liquid Methane Pressurization Systems for Launch Vehicles

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Abstract

Small Launcher Research Division(SLRD) of Korea Aerospace Research Institute(KARI) has been developing advanced propulsion technologies based on liquid oxygen and liquid methane, with a focus on two vehicle systems; 1) a Vertical Takeoff and Vertical Landing (VTVL) demonstrator, 2) an upper stage of a two-staged Small Launch Vehicle (SLV).

A. Pressurization system for VTVL

A reusable operation platform that can perform a short-duration flight composed of ascent and landing phases has been designed and built, to mainly demonstrate and a verify the capability of a landing engine through an actual flight. For the landing engine, a pressure-fed cycle has been chosen due to its compactness, and Nitrogen is used as the pressurant gas. The VTVL demonstrator has two separate propellant tanks for fuel and oxidizer and two side-strapped pressurant tanks. The pressure of gaseous Nitrogen in the ullage volume is controlled via adjusting a set of four solenoid valves that have different flow coefficients. When combined, these valves can provide sixteen steps for controlled mass flowrates. The combustion chamber pressure of the engine is set to 35 bars at full thrust of one-ton force. And the ullage volume of the propellant tanks has to be pressurized and maintained at 62 bars to feed propellants into the engine. For this, two pressurant tanks are filled with Nitrogen gas and pressurized up to 270 bars prior to the engine ignition. The combustion chamber is designed to operate at lower thrust levels as it uses both liquid oxygen and liquid methane as coolants. The pressure control tests of the pressurization system were performed with liquid nitrogen loaded in the propellant tank, and it was confirmed that the pressurization system satisfies the pressurization capability within the required accuracy.

B. Pressurization system for SLV

The upper stage of the small launch vehicle is powered by a 3-tonf class liquid oxygen-liquid methane expander cycle rocket engine with an autogenous pressurization system. In the autogenous pressurization system, liquid oxygen tank is pressurized by gaseous oxygen heated through a 3D printed heat exchanger located at the outlet of turbine, methane tank is pressurized by heated gaseous methane, which has flown through regenerative cooling channels of the thrust chamber. Since the control scheme of the pressurization system of the upper stage is similar to that of VTVL, a small-scale test device is designed and built out of a cryogenic propellant tank(300 liter) to investigate the heat transfer and mass flow of gaseous propellant that is evaporated for pressurization. The test device is used to determine the required flow rate of evaporated pressurant that can maintain constant pressure(5.5 bar) in the ullage volume and feed the liquid propellant to the engine at a constant flow rate(10 liter/s). Since November 2022, tests have been being conducted to confirm the heat-mass transfer characteristics and pressurization ability of the various pressurants.