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PRELIMINARY STUDY ON EXPANDER CYCLE METHANE ENGINE FOR POST-KSLV 2 PROGRAM

Abstract

Korea Aerospace Research Institute (KARI) has been developing 75-ton class thrust engines for 1st & 2nd stage and a 7-ton class thrust engine for 3rd stage of the Korea Space Launch Vehicle II(KSLV-II). All of them are kerosene-fueled gas-generator cycle engines. At the same time, a 10-ton class staged-combustion cycle kerosene engine is being developed for the KSLV-II improved version. The flight model of 75-ton class thrust engine delivered for a one-staged test vehicle assembly at the end of 2017, and the first engine flight test using the test vehicle was completed successfully in November 2018. The flight test of KSLV-II is scheduled at the end of 2021. In order to continuously develop a competitive launch vehicle after the KSLV-II program and to respond to the rapidly changing global launch market, KARI started the 'Next Generation Low Cost Launch Vehicle Technology Analysis Project' in early 2018 and the expander cycle methane engine was selected as one of the preliminary research subjects. In the scope of the project, the research objective on the expander cycle methane engine is to conduct the cycle analysis of 2-ton class thrust engine and to make a combustor-demonstrator using a 3D printer. The design requirements of the methane engine are 20 kN thrust and specific impulse is 360 seconds in vacuum. The regenerative cooling channel of the combustor has been designed to obtain adequate temperature for driving the turbine at throttling conditions through thermal analysis. The turbine pressure ratio was obtained by differentiating the relation equation between the combustion pressure and the turbine pressure ratio derived from the energy balance equation between the turbine and the pump. The available turbine power and pump power were calculated using the turbine pressure ratio, and the maximum possible RPM of turbopump and the temperature rise in the pumps were also calculated. Based on this energy balance analysis the basic design parameters and pressure levels in the expander cycle engine have been selected. The 2-ton class thrust combustor was manufactured using only 3D printers. The combustor head consists of nine coaxial injectors and has the internal diameter of 80 mm. The injectors are coaxial and include swirls by applying the advantages of 3D printer manufacturing. The parametric analysis of the expander cycle methane engine and the production of the combustor demonstrator using the 3D printer have confirmed its applicability to the next generation low cost launch vehicle.