Paper ID: 51233
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (1) (1)

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BLUE WHALE 1: A NEW DESIGN APPROACH FOR TURBOPUMPS AND FEED SYSTEM ELEMENTS ON SOUTH KOREAN MICRO LAUNCHERS

Abstract

One of the most critical issues of not only the propulsion engineering, but of all modern engineering projects, is the scalability issues. The problem comes from the fact that most of the complicated functional components cannot be scaled linearly; but instead, they have a certain asymptote of convergence in which to maintain required functionalities. This is the reason why it is difficult to maintain the P/L mass proportionality as the large, conventional launchers by just reducing the structural mass. This suggests that the first and second stage engine performance has more influence on the small launchers than the larger ones. Perigee Aerospace Inc., a technical initiative originated from KAIST Department of Aerospace Engineering is making a radically different approach on propulsion system components to enable high performance even on the engines at a smaller size.

Perigee is aiming to launch its Blue Whale 1 LV, by the end of 2020; which is designed to carry 65 kg of payload into 500 km LEO with a takeoff mass of less than 1,800 kg and a dry mass less than 100 kg, making it one of the lightest, mass-effective, and thus easiest-to-operate vehicles in the world. A systematic approach suggests that an engine with a sea-level thrust of 25 kN with a vacuum specific impulse greater than 345 seconds is required, with an engine mass less than 30 kg. To achieve such a goal, an oxidizer-rich staged combustion cycle was implemented to drive the chamber at a high pressure. Also, to overcome a severe efficiency loss on pump head due to a low specific speed, some unique design methodologies were introduced to develop a Hybrid Turbopump Assembly (HTA). As a result, the developed engine can generate 25.5 kN of thrust at sea-level with a measured specific impulse of 288 seconds at Pc = 12.2 MPa for main combustor and Pc = 25 MPa for preburner with 46,000 RPM turbine speed and 512 kW of total estimated power generation for the TPA and additional 8 kW for the PB boost pump. The engine has passed total firing time of more than 2,000 seconds.

In this paper, the design and development results of the Blue 25S LOX-LNG engine was introduced, with some notable test result data of the powerpack elements. Perigee will conduct more test firings and make further improvements to secure both reliability and performance.