

Article

Numerical and Experimental Study of Nose for LOx Floating Ring Seal in Turbopump

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Abstract: Floating ring seals are widely used as a leakage control solution for turbomachines because they effectively operate with small clearances between the shaft and seal. The oxidizer pump of the 7 tonf liquid engine in the Korea Space Launch Vehicle II (KSLV-II) operates at high rotational speeds and under cryogenic conditions and has floating ring seals in the bearing cooling path to reduce leakages. In this study, we evaluated the frictional force acting on the nose of the floating ring in the oxidizer pump of the 7 tonf turbopump using numerical analysis, and we investigated the radial force on the floating ring induced by the vibration of the rotor and the flow characteristics around the floating ring seal. Through a comparison of the frictional and floating forces according to the change in the diameter of the floating ring noses, we also estimated the dynamic positioning of the floating ring. In addition, we examined the leakage of the floating ring seals with the rotational speed and gap size of the floating ring, and we used the results as data for designing a floating ring seal. Finally, we performed turbopump real-propellant tests with the floating ring seal of the high and the middle noses, finding that the test result was in good agreement with the results of numerical analysis.

Keywords: liquid rocket engine; turbopump; liquid oxygen; floating ring seal; nose; numerical analysis; turbopump real-propellant test; leakage; vibration; friction; floating force; wear

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1. Introduction

The Korea Space Launch Vehicle II (KSLV-II), which was developed by the Korea Aerospace Research Institute (KARI), is a three-stage rocket powered by liquid engines with open-cycle turbopump feed systems (Figure 1). It has four and one 75 tonf liquid engines used for the first and second stages, respectively, and a 7 tonf liquid engine used for the third stage [1]. The turbopump used in liquid engines is a fluid machinery that rotates at a high speed using centrifugal force to pressurize a low-pressure propellant and supply it to a combustor. The propellant that burns at a temperature above 3000 °C in the combustor is discharged as gas to obtain the necessary thrust during flight. Turbopump-type engines are lighter and more efficient than pressure-fed engines, thus it increases the payload limit [2]. The turbopump in the KSLV-II consists of an oxidizer pump (hereinafter referred to as a LOx pump) and a fuel pump that supply the oxidizer and fuel, a turbine that drives the pumps, and the shaft and seal systems with a rotor [3]. Turbopumps operate at a high rotating speed and high pressure under various environmental conditions with cryogenic media (liquid oxygen and liquid hydrogen), at room temperature (kerosene), and at high temperature (turbine gas) in liquid and gas states. Therefore, its design requirements are strict for the hydraulics, which must include thermal and structure analysis; seal design to control propellant leakage; consideration of axial thrust distribution; dynamic analysis of rotors to prevent bearing damage; and

Nose An Experimental Study Of Reactions

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Nose An Experimental Study Of Reactions Book Review: Unveiling the Magic of Language

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