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Corresponding author: Keisuke Bando
e-mail of corresponding author: bando8989@ihi-g.com
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Title

Verification of Turbopump in the Small Thrust LOX/Methane Engine Firing Tests

Authors

Keisuke Bando [1], Toru Kuga [1], Toru Tsukano [1], Satoshi Takada [2], Hiromitsu Kakudo [2]*

** Corresponding author*
[1] IHI Corporation, 229, Tonogaya, Mizuho-machi, Nishitama-gun, Tokyo 190-1297, Japan, bando8989@ihi-g.com
[2] Japan Aerospace Exploration Agency, 1 Koganezawa, Kimigaya-aza, Kakuda-shi, Miyagi 981-1525, Japan

Abstract

Recently, LOX/methane rocket engines are being actively developed, since there are many advantages of applying methane as rocket propellant compared to hydrogen. For example, liquified methane can be stored at the temperature close to LOX, so that a thermal insulator and evaporation rate of the fuel can be reduced. Also, liquified methane is denser than LH2 and can minimize a size of a propellant tank. Currently, JAXA/IHI are developing a full-expander cycle engine with a target thrust of 30kN and a target specific impulse of 370s [1]. This engine uses a single-shaft LOX/methane turbopump. This turbopump aims a rated rotational speed of 60,000 rpm and has a balance piston mechanism. Furthermore, this turbopump was aimed to make smaller, then it was achieved a full length of about 350 mm and weight of about 16 kg. Using this turbopump, each component test (turbopump test, multi-element injector firing test, regeneratively cooled combustion chamber firing test) was successful in FY2018 [2].

Afterwards, the full-expander cycle engine firing tests were carried out in FY2021. In order to improve sealing performance of a shaft seal, it has been changed from a floating ring seal to a mechanical seal since this test series. This makes it possible to reduce propellant leakage. In order to apply a mechanical seal for the small turbopump, it was necessary to develop the small mechanical seal and redesign the internal flow of the turbopump. To begin with, the small mechanical seal developed by JAXA with sufficient sealing performance and longevity was adopted. The width of this mechanical seal is about 22 mm, and the outer diameter is about 58mm. Next, the most important and difficult part in redesigning the internal flow of the turbopump was the control of the axial thrust of the shafting and the differential pressure of the mechanical seal. In order to solve these problems, the route of the drain paths was devised in the limited space inside the small turbopump, and several lines were newly established. The pressure inside the turbopump can be adjusted by changing the diameter of the orifice attached these drain paths.

Using this modified turbopump, the full-expander cycle engine firing tests were carried out in FY2021. Propellant leakage at the shaft seal was reduced by applying a small mechanical seal. In addition, the control of the axial thrust of the shafting and the differential pressure of the mechanical seal were realized by redesigning the internal flow of the turbopump. Moreover, it was confirmed that various other performances were also satisfied as a component of the engine. This means that this small turbopump can be applied for flight engines.

References

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