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Title

Verification of the Electrical Thrust Control Valve in the Small LOX/Methane Engine Firing Tests

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Abstract

This study reports the development result of cryogenic propellant valves operated by an electric motor and the experimental results in engine firing tests. In recent years, the development of rocket engines using LOX/Methane as propellant has been progressing worldwide, including Prometheus, M-10, Raptor, and BE-4 [1-3]. In Japan, the research and development for the performance enhancement of regenerative-cooled LOX/Methane rocket engines has been progressing step by step since 2013 with the aim of applying it to future space transportation systems [4]. A full-expander cycle engine with 30 kN class thrust was selected as a reference engine in this study. After 2020, a closed-cycle engine system; a full-expander cycle demonstration engine firing test using LOX/Methane was conducted combining the individually developed test specimens so-far developed.

Total of four electrical thrust control valves (two TCA main propellant valves and two chill down valves) were installed in the engine for the demonstration engine firing test. For the TCA main propellant valves, the electrically actuated valve operated by an electric motor was newly developed to meet engine throttling requirements. This motorized valve not only functions as a shutoff valve, but also as a flow control valve. Therefore, this valve can be used to change the thrust during engine operation. For the chill down valve, we have developed electrically actuated valves that were similar in form and downsized based on the main propellant valve to allow adjustment of the pre-cooling volume during pre-cooling in the future. In addition, for the TP bearing chill down valve, a cryogenic pneumatic valve developed by IHI in the past was applied to this demonstration engine firing test [5].

In the engine firing test, the response characteristics of valve performance to the combustion behavior of the engine were properly confirmed with using actual propellant. The electrically actuated valves were able to adjust the opening smoothly due to the effect of the modification and to maintain and control the specified opening precisely even in cryogenic conditions. The pneumatic valves also opened and closed smoothly in cryogenic conditions, and their stability during the engine firing tests was also confirmed. No remarkable problem occurred from all the electrically actuated and pneumatic valves throughout the test series, and the integrity of the valves was confirmed.

The stable operation of the electrically actuated valve under high pressure and differential pressure conditions at cryogenic temperatures was demonstrated as required and expected. This means the completion of the development of valves (electrically actuated type and pneumatic type) for cryogenic applications for future engines.

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