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NUMERICAL ANALYSIS OF LE-9 ENGINE TURBOPUMPS

Abstract

LE-9 is currently developed as a first stage booster engine of H3 launch vehicle, that is a next Japanese mainstay launch system. LE-9 aims to be a low cost, high-reliable rocket engine to make H3 launch vehicle competitive within a worldwide launch service market. In order to enhance a reliability of the engine, an expander bleed cycle is chosen as an engine cycle due to its simplicity and robustness. Propellant of LE-9 engine is liquid oxygen (LOX) and liquid hydrogen (LH2), and two turbopumps, a fuel turbopump (FTP) and an oxygen turbopump (OTP), are mounted to feed propellant to an injector. Configurations of FTP and OTP are similar, as they both consist of an inducer, an open-shroud impeller and two-stage supersonic turbines. The turbopumps of the expander bleed cycle work as follows. A pump side of FTP pressurizes LH2, and a certain portion of LH2 is delivered to an injector whereas the rest of LH2 is sent and heated as within cooling channels of a regenerative combustion chamber. The heated gas hydrogen (GH2) flows into a turbine section of FTP to provide power to pressurize LH2. Then, GH2 exited from the FTP turbine drives the OTP turbine to pressurize and send LOX to the injector. Finally, GH2 exhausted from the OTP turbine is sent to the engine nozzle manifold and burnt inside a nozzle skirt. Due to the nature of the expander bleed cycle, a capability of the engine is heavily depending on the performance of turbopumps such as pump head, pump efficiency, and turbine efficiency. In order to design and develop high-reliable turbopumps, the CFD analysis is applied, in order to derive an optimal turbopump configuration by running parametric studies and to minimize uncertainties before manufacturing processes and engine firing tests. Thus, it is important to be capable of simulating complex flow within turbopumps by high-fidelity CFD analysis by capturing aerodynamic characteristics of the supersonic turbines and the hydrodynamics features of the impellers and inducers This study introduces CFD analysis applied to the turbopumps within the development phase. The prediction of the numerical analysis is compared to engine test results, and applicability of CFD analysis is discussed.