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NUMERICAL STUDY ON PERFORMANCES OF AN ELECTRIC PUMP-FED CYCLE ROCKET ENGINE

Abstract

In our previous work, the feasibility study on electric pump-fed cycle (EP-cycle) rocket engines was performed. The effects of the replacement of an ordinary turbopump system with an electric pump system in rocket engines were investigated especially in terms of mass and thrust controllability. The mass of power sources was found to be the critical factor for the merit against rocket engines with the conventional engine cycles. By using the rocket engine simulator called REDS which was developed at the Kakuda Space Center of JAXA, it was also found that an EP-cycle rocket engine would have higher controllability than those of conventional rocket engines. In those simulations, a simple DC-motor system was modelled, and a power supply system was also assumed to be a simple power source providing DC power. In the present work, the simulator of the EP-cycle rocket engine has been largely revised to present more practical EP-cycle engine models. The electric motor system is assumed to be a PMSM (Permanent Magnet Synchronous Motor) system, which is widely and practically applied in industrial motor systems and has been developed to be higher performance and smaller system. The power sources in the present models are assumed to be more practical Lithium-ion battery and fuel cell systems. The present EP-cycle engine simulator has been created using the simulation tool, Simcenter Amesim, developed by Siemens Industry Software. Same as in our previous work, the EP-cycle rocket engine was modelled based on the RSR engine which is the expander-bleed cycle engine with the thrust of 40 kN using LOX/LH2 and developed in JAXA. Based on this engine, the simulation model of the EP-cycle engine was created for the LOX/LH2 engine with the thrust of 20 kN. The PMSM model was originally designed to drive the fuel and oxygen pumps of this engine and installed in the simulator. These PMSM are controlled by the vector control system using an inverter system, which is also modelled in the simulator. The simulation results showed that the EP-cycle engine with the PMSM system could be throttled same as shown in the DCM system in our previous work. In the present work, the effects of the characteristics of the power sources on the dynamic behavior of the engine system will be also examined. Especially in the system using FC system, the supplying system of the hydrogen and oxygen gases to FC will be also examined and discussed.