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DESIGN OPTIMIZATION OF LIQUID ROCKET ENGINE USING A GENETIC ALGORITHM

Abstract

In the preliminary design of the liquid rocket engine, design parameters are determined by system analysis considering requirements and constraints. In this study, the design optimization program has been developed to obtain design parameters for the best performance using a genetic algorithm.

The gas-generator cycle and the staged-combustion cycle are available and 3 types of pump-turbine arrangements can be selected by users. For the propellant, it provides RP-1, liquid hydrogen, methane as fuel with liquid oxygen as an oxidizer.

The program consists of a system analysis section and an optimization section. The system analysis section is composed of sub-module programs such as the thrust chamber module, the gas-generator module, the turbo pump module and the turbine module. CEA2 was applied for the combustion analysis, and the weight was obtained by function of chamber pressure, nozzle expansion ratio and required thrust. The efficiencies of turbo-pumps were measured by specific speed and RPM with discharge pressure determined as the sum of chamber pressure and the pressure losses at supply components. The analysis model was assumed to be in steady state. The steady state conditions were built to satisfy energy, pressure, and mass flow balances.

The optimization section includes a real code genetic algorithm with the elite strategy. Main combustion chamber pressure, nozzle expansion ratio, oxidizer fuel ratio have been selected as design variables. The weighting method has been used for multi-objective optimization to maximize the specific impulse(Isp) and the thrust to weight ratio(T/W).

Consequently, the Pareto frontier lines of each cycles and fuels were obtained for various thrust requirements(1,000kN 4,000kN) by the developed program. Comparing the performances of real engines, the results shows that the program is appropriate. And it is ascertained that the high-thrust engines tend to have high specific impulse and thrust to weight ratio as well-known. This program is expected to improve efficiency and performance of liquid rocket engines in the preliminary design process or the launch vehicle design.