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CONCEPTUAL DESIGN OF THREE STAGE HYBRID ROCKET USING GENETIC ALGORITHM

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The hybrid rocket has advantage regarding its safety, cost and environmental impact. However, due to low fuel regression rate and difficulty of the controlling fuel flow, it is difficult to design a higher performance hybrid rocket than existent liquid/solid rocket. In our work, the conceptual design methodology of three-stage hybrid rocket including the thrust evaluation, the vehicle sizing and the trajectory analysis was developed using the multi-objective genetic algorithm.

Overview of Rocket Sizing The hybrid rocket treated in this study has a nozzle, a chamber, an oxidizer tank, a pressurized tank and exterior wall structure for each stage and the payload. Figure 1 shows the conceptual illustration of the rocket and Fig. 2 shows the evaluation procedure. As single port fuel grain is considered here. The regression rate is expressed as follow.

$$\dot{r}_{port} = \beta a \left[G_o(t) \right]^n \tag{1}$$

The β is design variable to simulate swirling effect of oxidizer which can increase a. The coefficient a and the exponent n are empirical coefficients. This study employs the paraffin as a fuel. Using the paraffin, a and n are 0.1561 and 0.3905, respectively. Using β in Eq. 1 and combustion time as design parameters, the performance of each stage such as the thrust, the engine weight and the trajectory can be calculated.

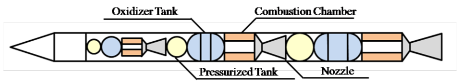

Figure 1: Conceptual illustration of the multi-stage hybrid rocket.

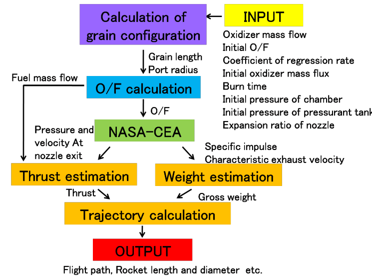

Figure 2: Flow chart of the design and evaluation.

Formulation and results In this study, the design problem of the launch vehicle for the space transportation using the hybrid rocket is considered. For high efficient system, the design problem is formulated as

$$\begin{cases} Maximizing\ M_{pay}/M_{tot} \\ Minimizing\ M_{tot} \end{cases} \tag{2}$$

M_{pay} is payload weight and M_{tot} is the resulting total vehicle weight. 3 shows the Pareto solutions obtained by the present design methodology and fig:res2 shows the visualization of the design variables and objective function regarding the Pareto solutions. From these figures, maximum M_{pay}/M_{tot} is around 1% when the M_{tot} is about 8ton. the design which has larger expansion ratio achieves lower pressure of chambers or tanks. It reveals that the lower expansion ratio can reduce weight of tank and nozzle. In addition, the design which shows lower chamber pressure can be optimum design when the expansion ratio is smaller.

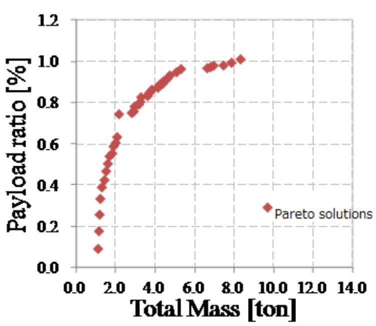

Figure 3: Pareto solutions of the present design problem obtained by MOGA.

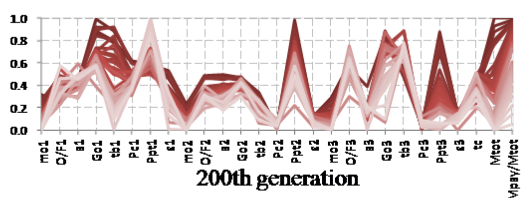

Figure 4: Visualization of the design space and the solution space.

REFERENCES

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