

論文の内容の要旨

論文題目 Effects of fuel injection angle on combustion efficiency in a model hydrogen ram combustor

(モデル水素ラム燃焼器における燃料噴射角度が燃焼効率に及ぼす効果)

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Effects of fuel injection angle on the combustion efficiency in a model hydrogen ram combustor, which is based on a pre-cooled turbojet engine afterburner developed by Japan Aerospace Exploration Agency, were investigated both experimentally and numerically in this study.

Various combinations of fuel injection angles with two types of injection hole arrangement have been tested experimentally, the results indicated the correlations between the combustion efficiency and the injection angle at different injection hole arrangement. The combustion efficiency increased with an increase in the upstream injection angle at a serial injector arrangement. It showed an approximately 10%~15% improvement over the serial case at a zigzag arrangement case, When the upstream injection angle changed, a difference in combustion efficiency was observed.

Numerical simulation was considered necessary to understand the results revealed by the experiments. Therefore, a numerical solver for non-premixed turbulent combustion based on large eddy simulation (LES) using Flamelet Progress Variable (FPV) method was applied with OpenFOAM and validated using experimental results of Sandia Flame D. Numerical simulation of the combustion field inside the model ramjet combustor with eighteen combinations of injection angle of two arrangements with FPV model were performed. The trend of simulation results showed a good agreement with the experiments, and the zigzag arrangement injector with 30° upstream and 60° downstream injection angle achieved the best combustion efficiency. The difference between the best case of two different arrangements was close to 7%. Besides, the numerical results also revealed the working status of two kinds of injectors and explained why different arrangements and injection angles affect combustion efficiency. For both kinds of arrangement, the upstream injection angle played the most crucial role in combustion efficiency, but

the trend was converse. The downstream injection angle for both two arrangements mainly affected the recirculation zone. However, for two kinds of arrangement injectors, the way of achieving high combustion efficiency was different. The serial arrangement injector increased the combustion efficiency by increasing the penetration height. The zigzag achieving the high combustion efficiency mainly depended on the recirculation zone in the wake of the injector.