Numerical Simulation of the Ram Combustor

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Abstract

As the first stage of research and development aimed at realizing hypersonic aircrafts, High-Mach Integrated Control Experiment (HIMICO) is underway by JAXA and universities. The ramjet engine mounted on the experimental aircraft aims to start combustion by self-ignition of gaseous hydrogen fuel. However, self-ignition has not been successful in the combustion tests since 2017, and there are problems such as lack of experimental data and differences between flight conditions and experimental conditions due to the limitation of the number of experiments and the limitations of the combustion experimental facilities. Therefore, numerical analysis is performed to interpolate the experimental data and to grasp the combustion phenomena such as ignition and flame holding.

Reasons and benefits of using JAXA Supercomputer System

In LES considering detailed chemical reactions on a experimental scale with more than 10 million grid points, the computational cost is high. By using a JAXA supercomputer capable of parallel processing, analysis became possible within a realistic time.

Achievements of the Year

Focusing on the injector which injects gaseous hydrogen fuel into the combustor, the effect of differences in injector wall temperature on ignition was investigated. LES was performed for HIMICO ram combustor under three different boundary conditions of the injector wall temeprature: adiabatic wall and isothermal wall (300K, 500K). As a solver, we used a reactive flow solver developed by our laboratory based on JAXA's fast fluid analysis solver, FaSTAR, implementing species transport equations and Arrehenius equation. As a result, from the unsteady temperature distribution in the combustor, it was found that the lower the temperature of the injector outer wall was, the longer it took to ignite and that the ignition of the isothermal wall 300 K was delayed by 31% compared to the case of the adiabatic wall.

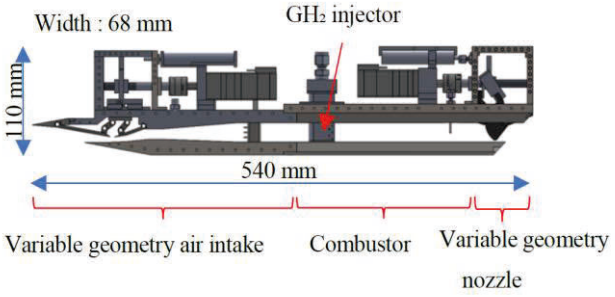

Fig. 1: Outline figure of ramjet engine for HIMICO

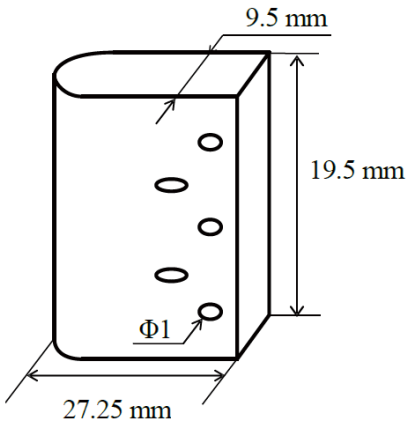

Fig. 2: Outline figure of injector

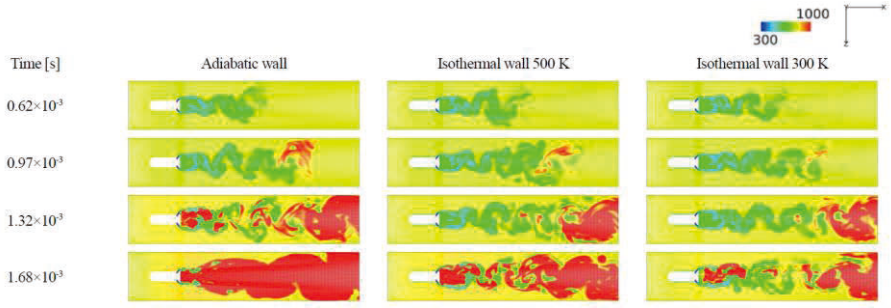

Fig. 3: Unsteady temperature distribution

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1024
Elapsed Time per Case	100 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.07

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	473,185.17	0.06
SORA-PP	18,329.24	0.12
SORA-LM	79.92	0.03
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	238.42	0.20
/data	4,882.81	0.08
/ltmp	976.56	0.08

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.