Numerical Simulation of the Ram Combustor

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Responsible Representative

AOYAMA Takeshi, Director, Aeronautical Technology Directrate, Aircraft Lifecycle Innovation Hub

Contact Information

Kazuya Uchiyama(kazuchiyama@toki.waseda.jp)

Members

Kazuya Uchiyama

Abstract

High-Mach Integrated Control Experiment (HIMICO), being conducted by JAXA and universities, is the first phase of research and development for the realization of a hypersonic passenger aircraft. The ramjet engine used in this project is fueled by gaseous hydrogen. There are issues such as a lack of experimental data due to limitations in the number of experiments and combustion test facilities, and discrepancies between flight conditions and experimental conditions. Therefore, numerical analysis is performed to interpolate experimental data and to understand combustion phenomena such as ignition and flame holding.

Reasons and benefits of using JAXA Supercomputer System

The computational cost of LES with detailed chemical reactions on an actual scale of more than 10 million grid points is high. The use of the JAXA supercomputer, which is capable of parallel processing, made it possible to perform the analysis in a realistic amount of time.

Achievements of the Year

In order to elucidate the self-ignition phenomena in the ram combustor for HIMICO and to predict the self-ignition limit, we improved the reactive fluid analysis solver developed in our laboratory by implementing the transport equations of chemical species, etc. based on JAXA's fast fluid analysis solver FaSTAR.

Using this solver, we investigated the effect of distortion caused by intake upstream of the combustor on self-ignition. Numerical analysis using LES was performed for a full-scale combustor, considering 23 reactions of 9 hydrogen-air chemical species. The results showed that the case with

distortion at the combustor inlet had a slightly faster ignition (0.96 times) than the case without distortion, but the effect was not significant.

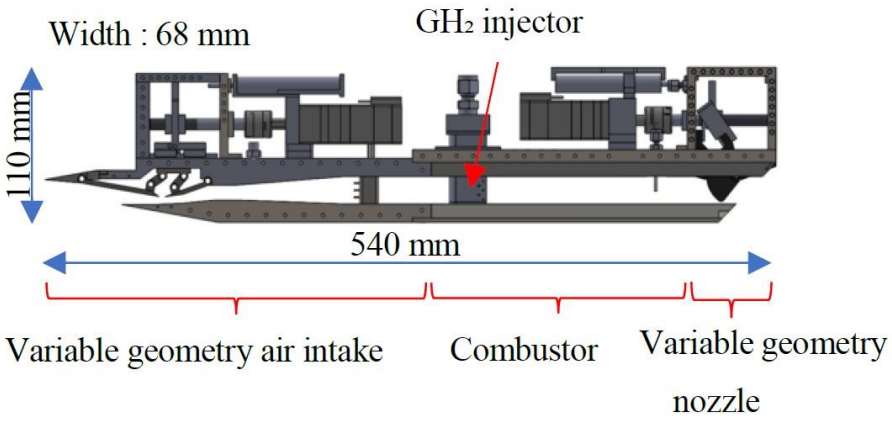

Fig. 1: Outline figure of ramjet engine for HIMICO

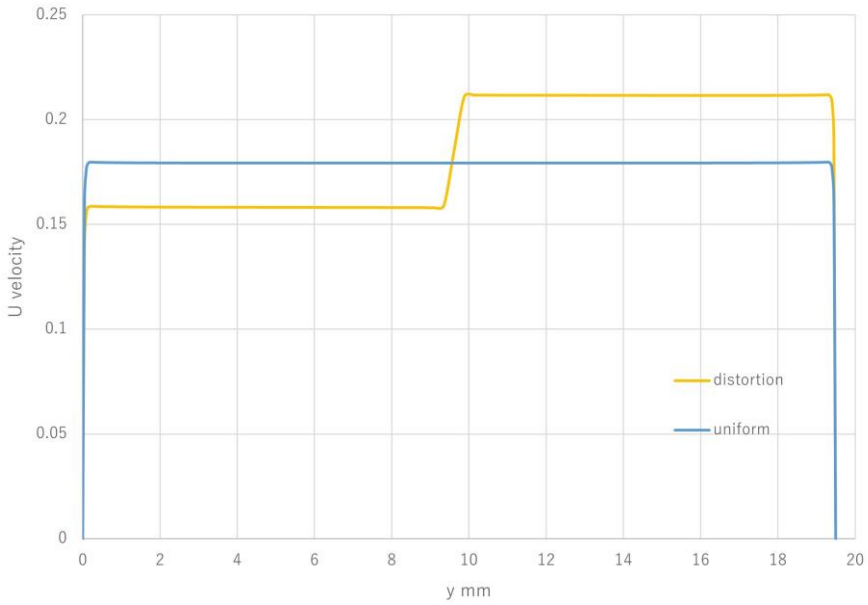

Fig. 2: Distortion given to combustor inflow boundary

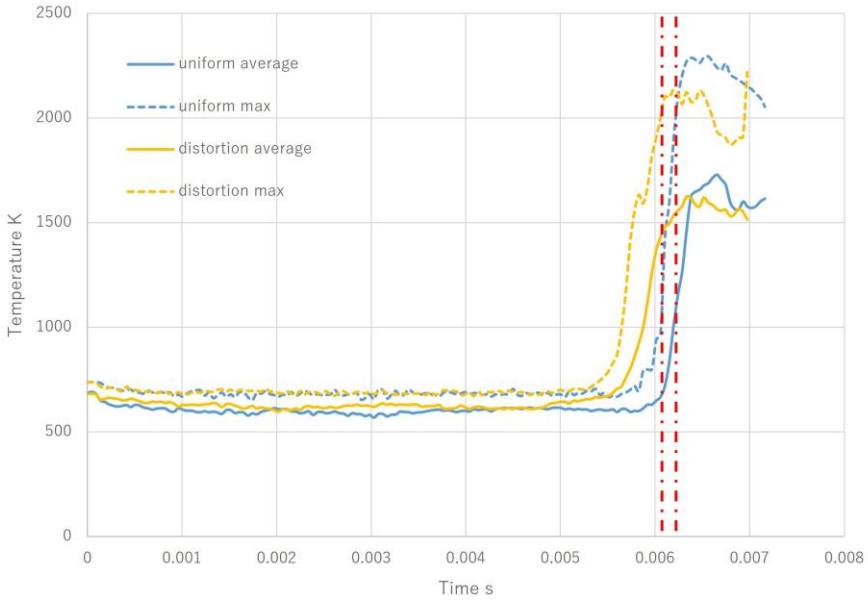

Fig. 3: Time variation of maximum static temperature and average static temperature in the recirculation area behind the injector

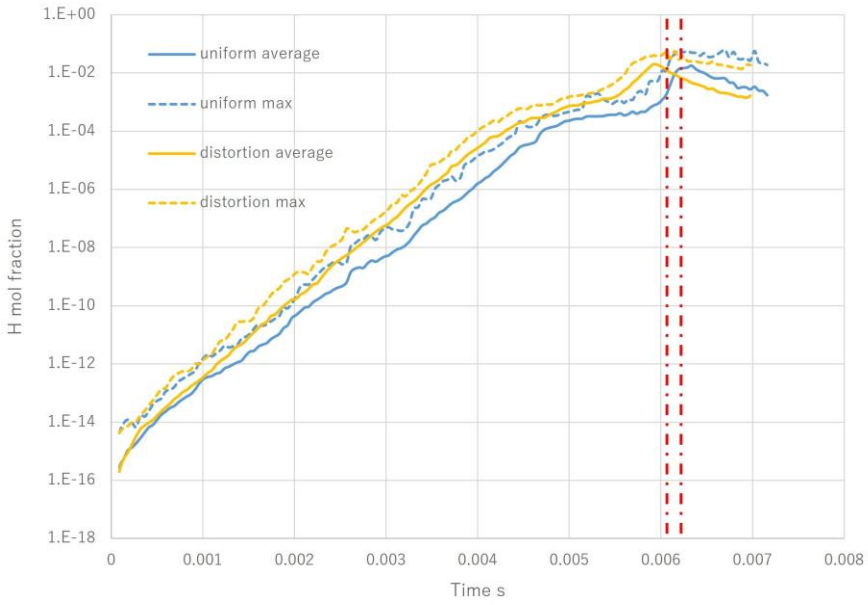

Fig. 4: Time variation of maximum H mole fraction and average H mole fraction in the recirculation area behind the injector

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1024
Elapsed Time per Case	250 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.18

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	3,974,280.21	0.19
TOKI-ST	82,960.33	0.10
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	250.00	0.25
/data and /data2	15,360.00	0.16
/ssd	1,500.00	0.39

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.01	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.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2(%)
ISV Software Licenses (Total)	716.02	0.50

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