Study on future space transportation system - combined cycle engine (JAXA-Tohoku Univ. collaborative course)

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Abstract

Fully reusable launch vehicle will reduce the transportation cost and increase the space launch demands. Introduction of airbreathing engine will afford system weigth penalty necessary to realise reuablity by reducing on-board oxygen consumption. Enabling prediction of scramjet engine and scramjet-rocket combined cycle engine performance is prime target of the present study, especially on reacting flow within combustor with presence of separation and within cooling channel.

Reasons and benefits of using JAXA Supercomputer System

In combustors, supersonic / subsonic flows are mixed and chemical reaction takes place. In cooling channel flow, supercritical / subcritical flows are mixed and endothermic reaction takes place. In both cases, huge calculation resource is required, and JSS matchs the requirement for prompt output .

Achievements of the Year

A unsteady analysis was conducted using RANS/LES hybrid method in CRUNCH CFD to evaluate the effect of fuel type on combustion characteristics in a dual-mode combustor with two-staged injection.

As a result, changes of the static temperature contour under combustion state were observed; in addtion, differences of the combustion characteristic owing to the fuel type were confirmed (Fig. 1).

To investigate the effect of the inhomogeneous airflow caused by the scramjet intake on the combustion state of the scramjet combustor, a steady-state RANS analysis using CFD++ was performed.

The CFD results showed that the difference of the boundary layer thickness changed the combustion area and the pressure distribution. In addition, the CFD analysis results reproduced that the flame shape in the vicinity of the cavity changed the flame went back upstream along the sidewall from the cavity front edge in the case of thin boundary layer thickness.

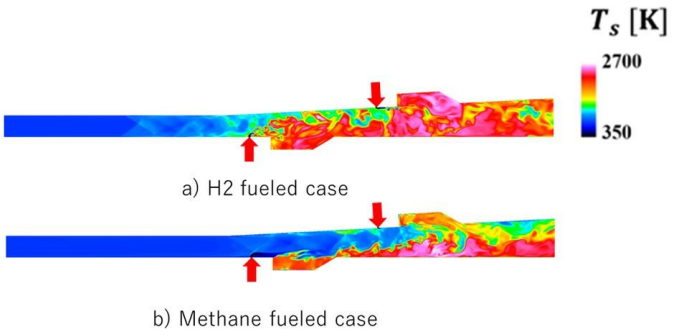

Fig. 1: Instantaneous static temperature contours of the dual-mode combustor with the two-stage-fueled injector (1st stage fuel: equivalence ratio = 0.4, 2nd stage fuel: equivalence ratio = 0.1)

Publications

- Peer-reviewed papers

Nishiguchi, H., et.al., 'Unsteady Numerical Analysis of a Dual-Mode Scramjet Combustor with Cavity,' Trans. JSASS (accepted).

- Oral Presentations

Hironobu Nishiguchi, Masatoshi Kodera, Kan Kobayashi, and Sadatake Tomioka, "Study on Fuel Types and Combustion Characteristics of Two-Staged Fueled Dual-mode Scramjet Combustor,"JSASS Northern Branch 2023 Annual Meeting and the 4th Symposium on Reusable Space Transportation Vehicles Northern Branch of the Japan Society for Aeronautical and Space Sciences, 2023.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32 - 9600
Elapsed Time per Case	60 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.94

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	18,740,745.48	0.82
TOKI-ST	1,571,678.98	1.57
TOKI-GP	0.00	0.00
TOKI-XM	520.79	0.33
TOKI-LM	13,997.86	0.94
TOKI-TST	6,211.28	0.16
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	1,022.50	0.93
/data and /data2	58,856.00	0.45
/ssd	7,473.00	1.04

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.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	4,860.62	3.38

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