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 to evaluate combustion control methods.

Reasons and benefits of using JAXA Supercomputer System

In combustors, supersonic / subsonic flows are mixed and chemical reaction takes place, and LES or LES/RANS Hybrid methods are found to be promissing. Huge calculation resource is required for such calculations, and JSS matchs the requirement for prompt output .

Achievements of the Year

Effects of fuel injection angle combustion phenomena were investigated. Either upstream oriented injector or perpendicular injector was installed at upstream of a flame-holding cavity. LES/RANS hybrid calculation was applied for unsteady calculation, and so-called cavity flame, i.e, flame propegated from the anchor flame within the flame-holding cavity, was observed for the perpendicular injection, while so-called jet-wake flame, i.e., flame attached to teh fuel jet, was observed for the upstream injection (Fig. 1). THis difference in flame structure as well as the mixing enhancement due to aerodynamic effect resulted in higher mixing efficiency and higher combustion efficiency (Fig. 2).

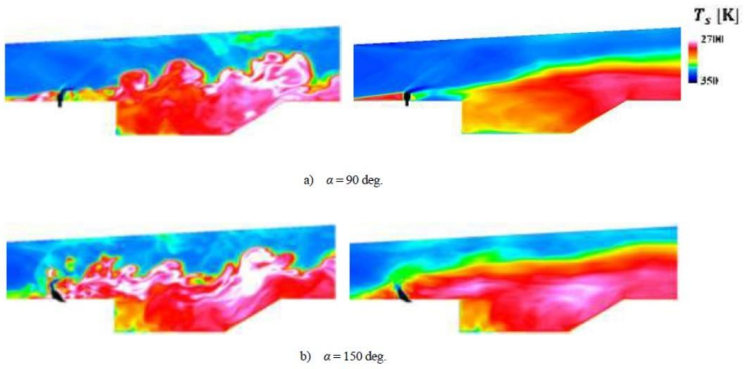

Fig. 1: Instantaneous (left) and averaged (right) static temperature contour with perpendicular injection (upper) and upstream injection (lower).

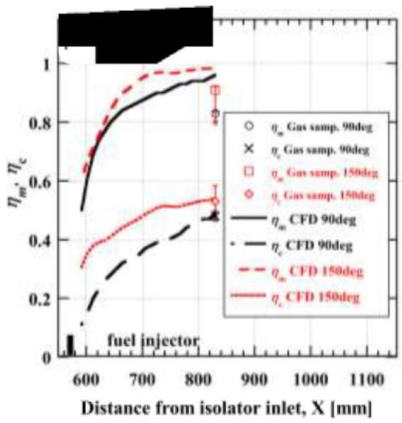

Fig. 2: Mixing and combustion efficiencies distributions

Publications

- Peer-reviewed papers

H. Nishiguchi, et al., 'Unsteady Numerical Analysis of a Dual-Mode Scramjet Combustor with a Cavity,' Trans. JSASS, 66 (2023), pp. 103-117.

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](%): 0.65

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	17,121,085.13	0.77
TOKI-ST	76,257.42	0.08
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	1,801.89	0.14
TOKI-TST	525.51	0.01
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	1,350.00	1.12
/data and /data2	58,851.00	0.36
/ssd	6,748.00	0.64

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)	1,383.02	0.62

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