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

Report Number: R20ECWU07
Subject Category: Cooperative Graduate School System
URL: https://www.jss.jaxa.jp/en/ar/e2020/14273/

Responsible Representative

Sadatake Tomioka, Associate Principal Researcher, Research and Development Directorate, 4th Unit.

Contact Information

Sadatake Tomioka (R&D directorate)(tomioka.sadatake@jaxa.jp)

Members

Sadatake Tomioka, Hironobu Nishiguchi, Kota Kubosaki, Yosuke Kono, Motoki Hattori, Ryota Ito, Naotaka Ikeda, Shota Hatta

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 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

Reacting flow field in supersonic combustor with large scale separation was simulated by using easy-to-handle RANS method, with various turbulent model employed, and the results were compared with experimental results. Compared to the case with the Re-Normalisation Group (RNG) model employed so far, addition of the Explicit Algebraic Stress Model (EASM) resulted in better prediction of the size of the separation region observed in the experiments (Fig. 1), the change in the size was larger than those by varing turbulent St number. Fuel/air mixing was also found to be affected by the addition of the EASM (Fig. 2), .

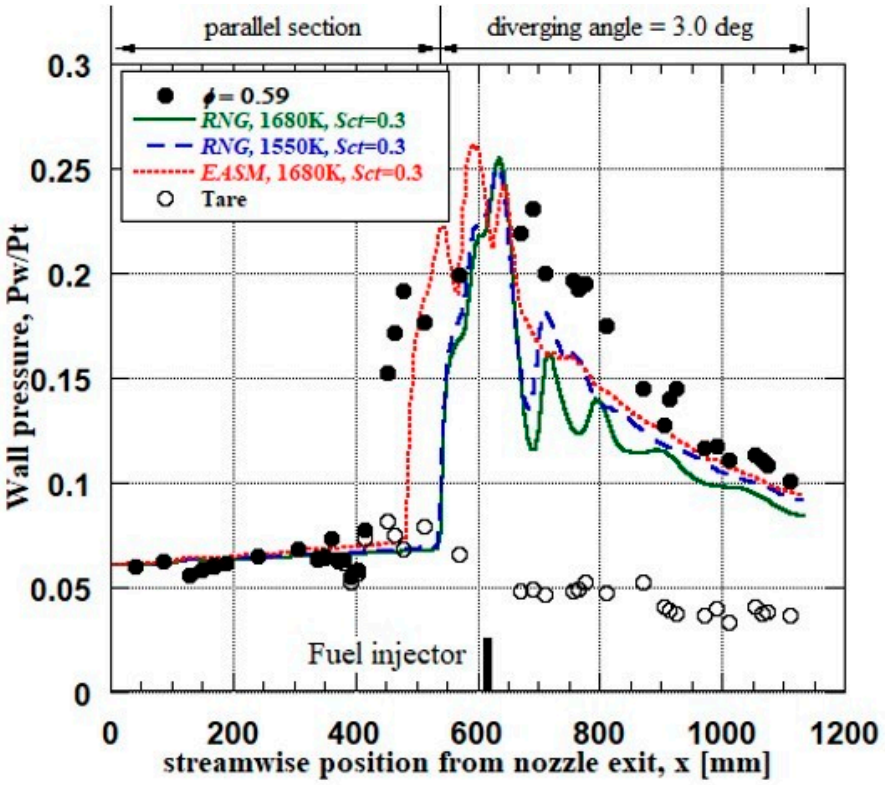

Fig. 1: Wall pressure distributions within supersonic combustor with large scale separation; circles showt experimental data, lines show CFD results with varioud turbulent models.

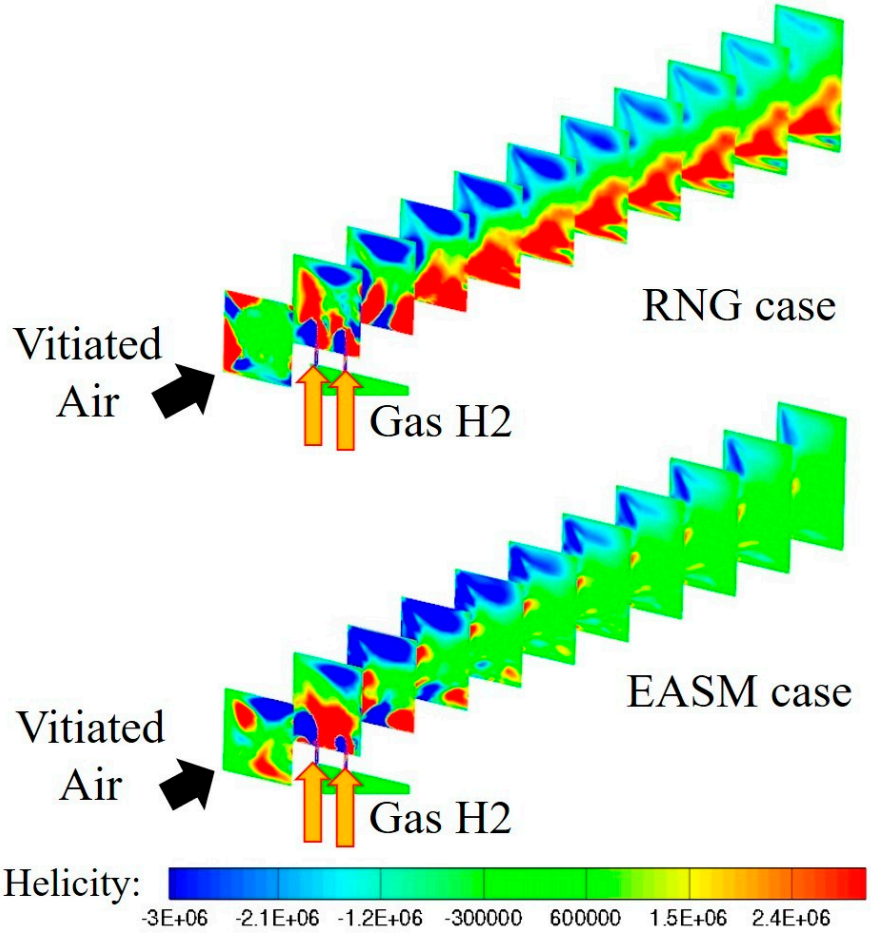

Fig. 2: Helicith distribution within supersonic combustor; upper figure with RNG model and lower figure with EASM addition.

Publications

- Oral Presentations

Nishiguchi, H., Kodera, M., Tomioka, S., "Turbulence Model Effects on RANS Simulations of the Direct-Connected Scramjet Combustor Test", AIAA Propulsion and Energy 2020 Forum, August,2020.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32 - 1024
Elapsed Time per Case	50 Hour(s)

- **Resources Used(JSS2)**

Fraction of Usage in Total Resources[*1](%): 0.19

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	360,350.01	0.07
SORA-PP	83,188.34	0.65
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	168.80	0.15
/data	6,387.71	0.12
/ltmp	8,203.13	0.70

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.

- **Resources Used(JSS3)**

Fraction of Usage in Total Resources[*1](%): 0.60

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.85	0.00
TOKI-RURI	917,453.57	5.25
TOKI-TRURI	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	336.17	0.23
/data	12,355.81	0.21
/ssd	2,453.81	1.28

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.