## Investigation on the structure of rotating detonation wave

Report Number: R20ECMP12

Subject Category: Competitive Funding

URL: https://www.jss.jaxa.jp/en/ar/e2020/14259/

#### Responsible Representative

Shingo Matsuyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

### Contact Information

Shingo Matsuyama(smatsu@chofu.jaxa.jp)

## Members

Shingo Matsuyama

### Abstract

In this study, combustion analysis by large eddy simulation (Large-Eddy Simulation, LES) was carried out in order to clarify propagation characteristics and detailed structure of rotating detonation wave. Two-dimensional and three-dimensional simulations were carried out for stable operating conditions in the combustion test of the rotating detonation combustor conducted at the Kakuda Space Center from the equivalence ratio of 0.6 to 1.6 to reproduce the rotating detonation wave propagating in the combustor.

This work was supported by Innovative Science and Technology Initiative for Security Grant Number JPJ004596, ATLA, Japan.

### Reasons and benefits of using JAXA Supercomputer System

To performe a combustion LES considering more than 20 chemical species generated by the combustion of methane fuel is very expensive, so that it is impossible to carry out it on usual workstations. In addition, the use of a supercomputer is indispensable in order to execute a large number of parametric analyses for a plurality of injection conditions in a realistic computing time.

#### Achievements of the Year

Two-dimensional LES of non-premixed rotating detonation of CH<sub>4</sub> and O<sub>2</sub> was performed assuming an annular combustor with 101 mm diameter (Fig. 1). It was shown that the propagation velocity of the rotating detonation wave obtained by LES with the equivalence ratio of 0.6 to 1.6 was about 60 to 70% of the Chapman-Jouguet velocity. In the case of LES on a coarse grid, the simulated propagation velocities were slightly higher than those obtained in the combustion tests, but the measured data were successfully reproduced by increasing the resolution (Fig. 2).



Fig. 1: Instantaneous pressure contours obtained by the two-dimensional simulations at ER = 1.0 with (a) coarse mesh (resolution = 200 µm), and (b) fine mesh (resolution = 50 µm). Adapted from non peer-reviewed paper 2).



Fig. 2: Comparison of propagation speeds of detonation waves between the twodimensional simulations and the experiment. Adapted from non peer-reviewed paper 2).

### Publications

- Non peer-reviewed papers

 Shingo Matsuyama, Kazuya Iwata, Makoto Kojima, Yoshio Nunome, Hideyuki Tanno, Hideto Kawashima, and Toshiharu Mizukaki, "Large-Eddy Simulation of a Non-premixed CH<sub>4</sub>/O<sub>2</sub> Rotating Detonation Combustor", Proceedings of the 58th Symposium (Japanese) on Combustion, B225, 2020.

2) Shingo Matsuyama, Makoto Kojima, Yoshio Nunome, Hideyuki Tanno, Hideto Kawashima, and Toshiharu Mizukaki, "CFD Analysis on Combustion in a Rotating Detonation Combustor", Proceedings of the Symposium on Shock Waves in Japan, 2A3-1, 2021.

### - Oral Presentations

1) Shingo Matsuyama, Kazuya Iwata, Makoto Kojima, Yoshio Nunome, Hideyuki Tanno, Hideto Kawashima, and Toshiharu Mizukaki, "Large-Eddy Simulation of a Non-premixed CH<sub>4</sub>/O<sub>2</sub> Rotating Detonation Combustor", the 58th Symposium (Japanese) on Combustion, 2020.

## Usage of JSS

# • Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	80 - 5250
Elapsed Time per Case	100 Hour(s)

# • Resources Used(JSS2)

Fraction of Usage in Total Resources<sup>\*1</sup>(%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage <sup>*2</sup> (%)
SORA-MA	27,532.98	0.01
SORA-PP	224.09	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage <sup>*2</sup> (%)
/home	342.25	0.31
/data	1,628.02	0.03
/ltmp	279.02	0.02

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

<sup>\*1</sup>: 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<sup>\*1</sup>(%): 22.91

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage <sup>*2</sup> (%)
TOKI-SORA	126,286,540.15	27.17
TOKI-RURI	415.98	0.00
TOKI-TRURI	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage <sup>*2</sup> (%)
/home	342.25	0.23
/data	1,628.02	0.03
/ssd	13.62	0.01

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

<sup>\*1</sup>: 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.