Fundamental numerical analysis on propagation of detonation waves

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Abstract

Detonation waves are sel- propagated waves assisted by shock waves. Utilizing the detonation waves would rialize high-efficiency propulsion system. The pourpose of this project is to establish numerical analysy method for detonation characteristics obtained by experiments.

Ref. URL: https://www.mzkklab.com/

Reasons and benefits of using JAXA Supercomputer System

This project needed supersonic combustion analysis code. The CHARIOT, supersonic combustion code developed my JAXA, is installed on JSS3. Also, JSS3 provides optimized envilomentfor using the CHARIOT.

Achievements of the Year

1) As a basic analysis of detonation wave propagation, we analyzed the cell structure of detonation waves with an ethylene / oxygen mixture gas (Fig. 1). The cell width decreases with incrresing of the initial pressure ratio. We also compared dependence of mesh on the analysis results. From the obtained results, the grid width to be used for future analysis was determined.

2) Detonation wave propagation mode inside the linear combustor used for detailed study of the detonation wave structure inside the detonation engine combustor, premixed air (Fig. 2) and non-premixed air conditioner (Fig. 3). Was analyzed and the propagation characteristics were clarified.

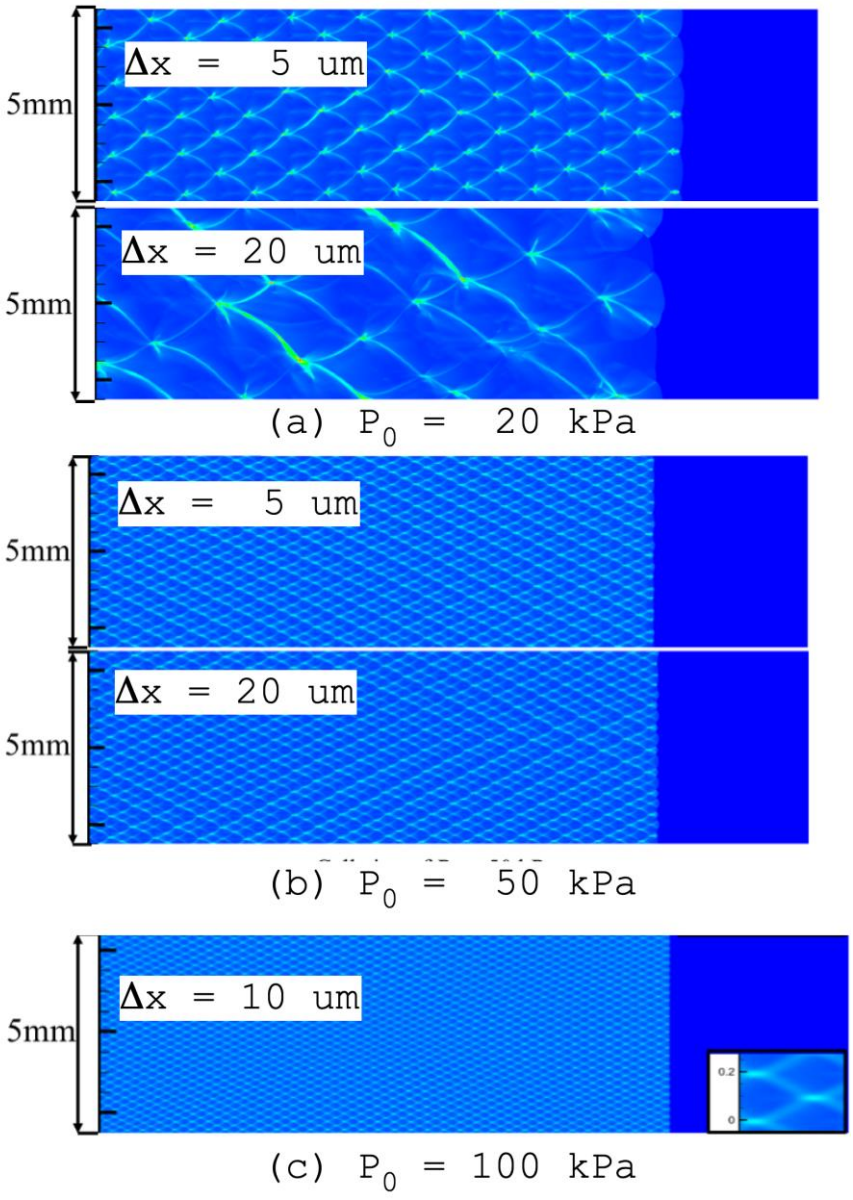

Fig. 1: Detonation cell structure with ethylene/oxygen mixture gas with varied initial pressure and mesh interval.

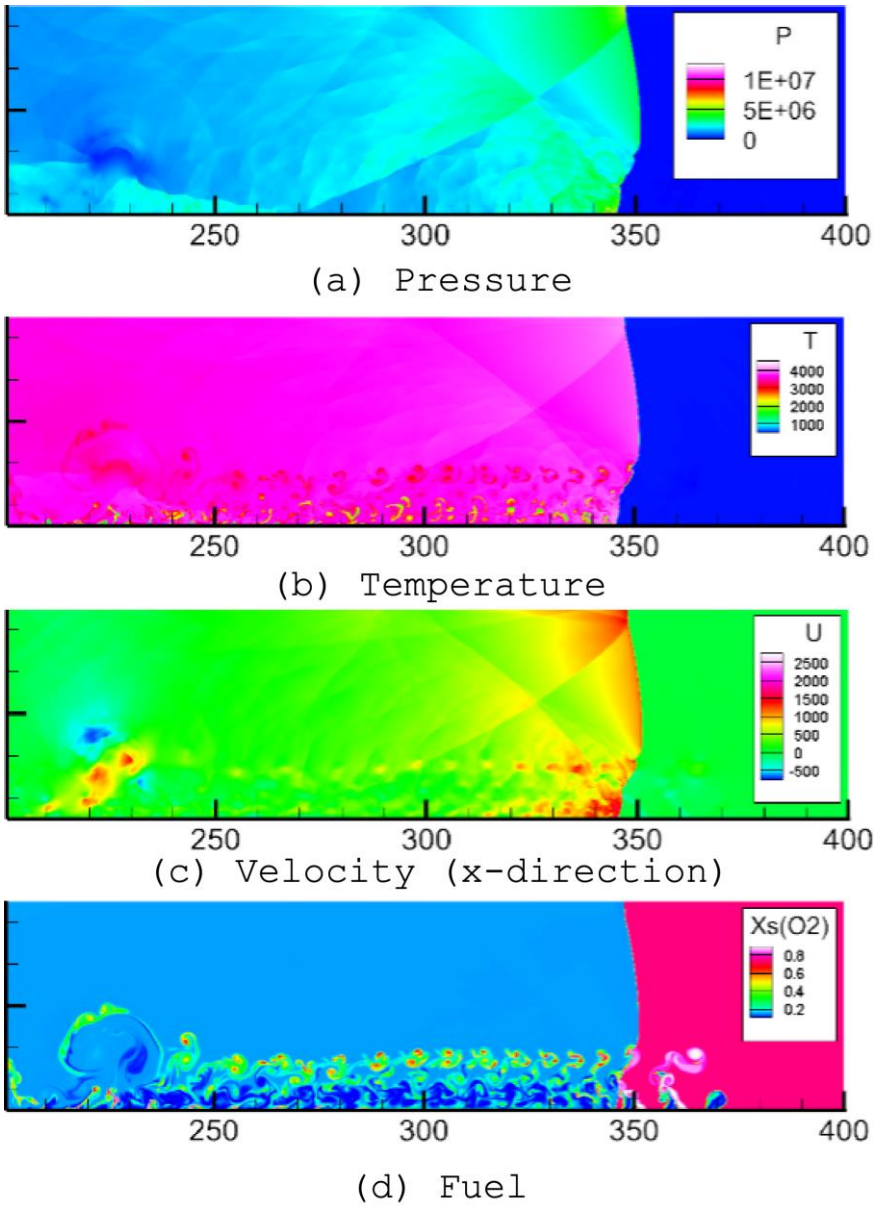

Fig. 2: Propagation of detonation waves inside a linear combuster for fundametal study on rotating detonation combuster (ethylene/oxygen premixture gas).

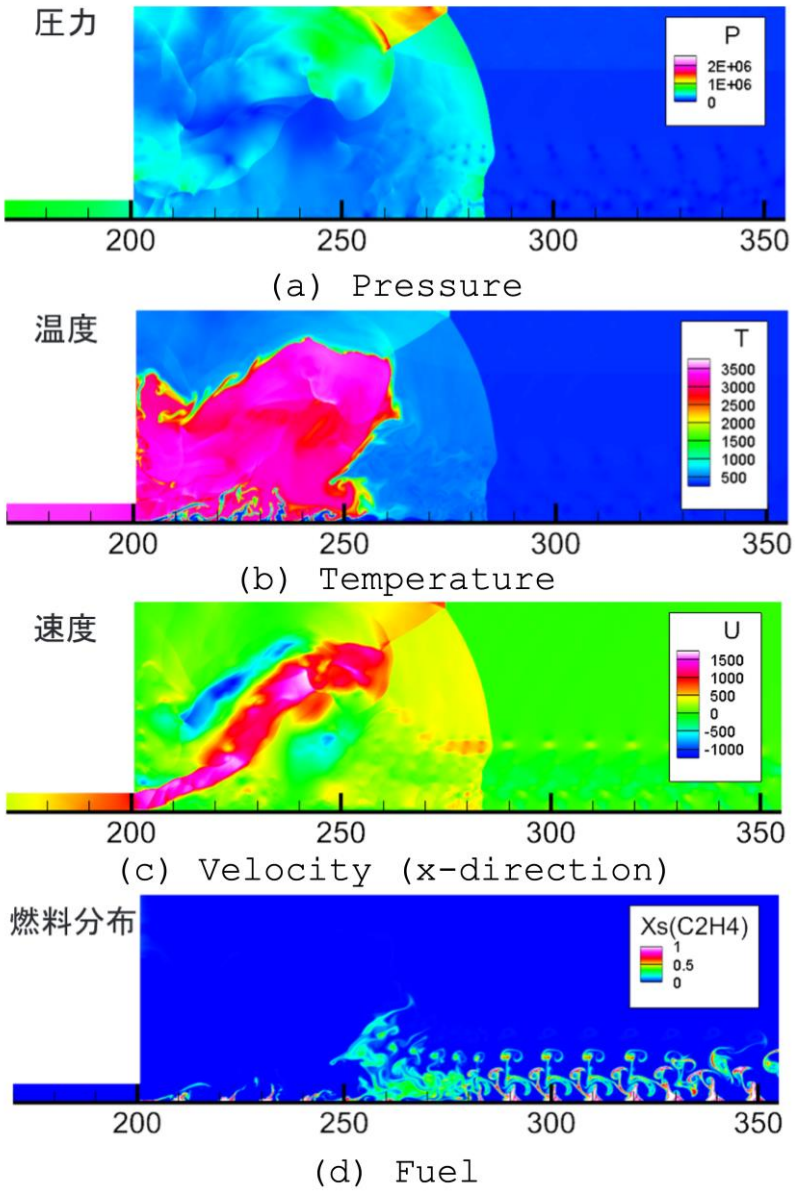

Fig. 3: Propagation of detonation waves inside a linear combuster for fundametal study on rotating detonation combuster (ethylene/oxygen non-premixture gas).

Publications

- Peer-reviewed papers

Faming Wang, Toshiharu Mizukaki and Shingo Matsuyama, Visualization and CFD of the influence of mixing on detonation wave propagation inside a rotating-detonation engine by using linear detonation channel, AIAA 2022-1456,(2022)

- Oral Presentations

Faming Wang, Toshiharu Mizukaki, Numerical analysis of detonation wave propagation inside RDE: Propagation of Detonation Wave plunging entry the fuel Jet train, Paper No. 3B1-3, FY2021 Symposium on Shock Waves in Japan (2022)

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	8 - 12
Elapsed Time per Case	72 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.15

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	3,553,716.27	0.17
TOKI-ST	49.04	0.00
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	260.00	0.26
/data and /data2	5,220.00	0.06
/ssd	150.00	0.04

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)	0.00	0.00

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