Fundamental study of propagation of one-dementional detonation waves

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Abstract

Detonation waves is a self-sustaining combustion wave. By using the detonation waves, a propulsion system which has a high-thermal efficiency and a thrust efficiency, compared with the ordinaly engines, would be made. The porpose of this research is to establish a process of numerical analysis on propagation of the detonation waves with CHARIOT, which was developed by JAXA.

Reasons and benefits of using JAXA Supercomputer System

A numerical simulation on propagation of detonation waves needs a simoultaious calcutation of cpmpressible fluids and reactive fluids. Forethemore, the compressible fluid analysis needs a three-dimensional analysis and the reactive fluids analysis contains more than a houndred reactive schemes. Therefore, a high-performance super computer such as JSS2 is needed to carry out our calculation. On the other hand, JSS2 has an ecelent enviloment, for numerical analysis, including mesh generators and visualization softwares. The enviloment helps us to carry out effective numerical analysis with large-scale calculation.

Achievements of the Year

With CHARIOT developed by JAXA, we carried out one-dimensional calculation on propagation of detonation waves to determine the dependency of the initial condition, pressure, temperature, and partical velocity, on pressure history at mesurement points as same as at experiments, Fig.1. Several initial conditions were examined. Results are shown bellow;

- Calculated peak overpressure and pressure decay fairly agreed well under the condition; the fuel, oxidizer, stoichiometric ratio, and the initial pressure were Etheren, Oxgen, 1.0, and both 100 kPa and 48 kPa, Fig.2.
- For the calculation, the initiation temperature, the initiation pressure, and the initial particle velocity are needed. The values of them affect caluculated pressure histories, Fig. 3.
- With decreasing of the initiation temperature, disagreement of the calculated pressure profile with physical

phenomena obviously appeared, Fig. 3a, b, and c.

- The calculation done under stoichiometric condition, result of pressure history was far away from real phenomena, Fig.3d.
- We will continue parametric servay to determine proper condition for this research.

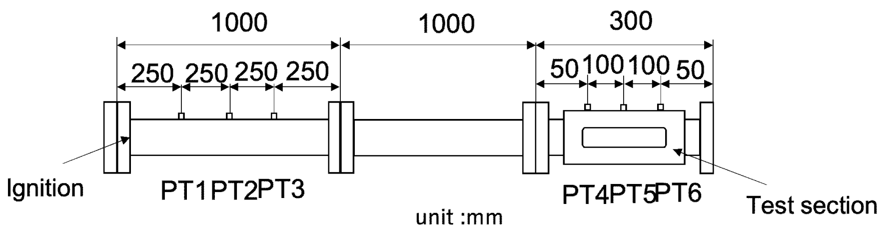


Fig. 1: Schematic diagram of the detonation tube and pressure measurement point.

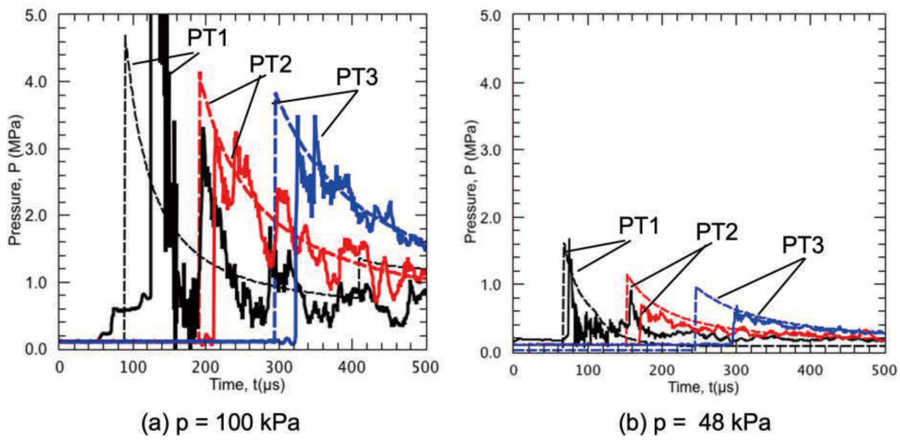
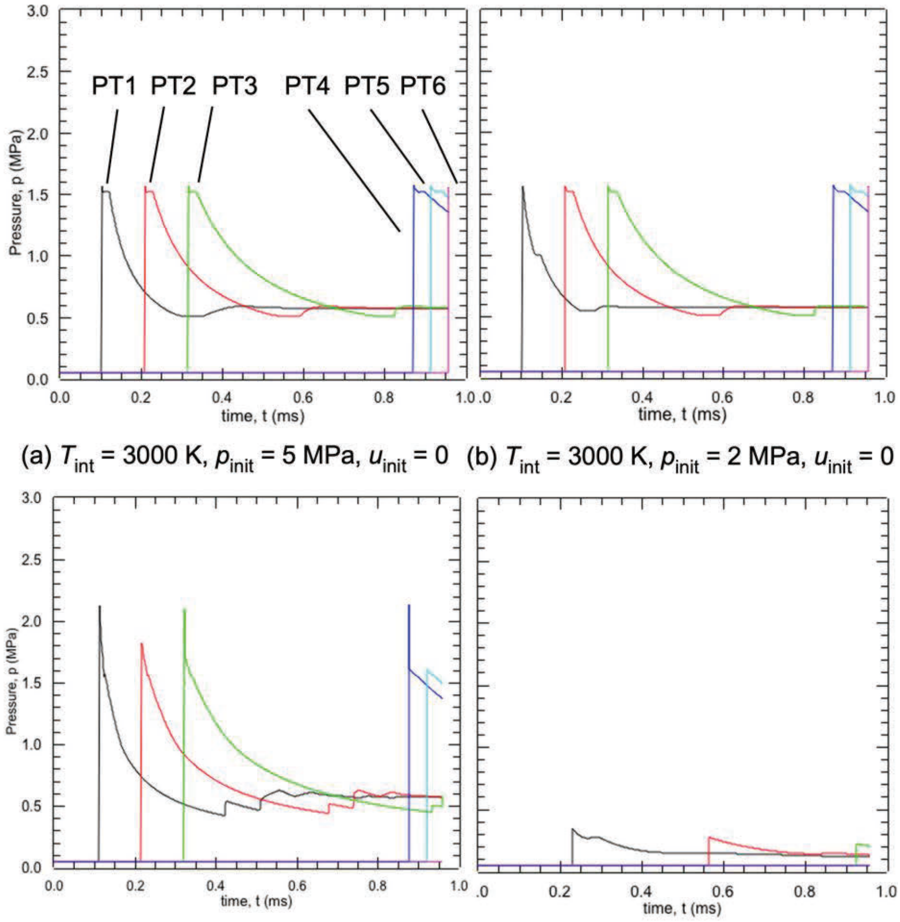


Fig. 2: Comparision between calculated and experimental pressure profiles; the initial pressure 100 kPa, and 48 kPa.



(a) T_{int} = 3000 K, p_{init} = 5 MPa, u_{init} = 0 (b) T_{int} = 3000 K, p_{init} = 2 MPa, u_{init} = 0

(c) T_{int} = 1800 K, p_{init} = 5 MPa, u_{init} = 0 (d) Chemical Equilibrium condition; T_{int} = 3784 K, p_{init} = 1.58 MPa, u_{init} = 0

Fig. 3: Comparision of pressure history with the initiation condition.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	10 - 40
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	23,838.49	0.00
SORA-PP	1.83	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*2(%)
/home	247.96	0.21
/data	4,978.18	0.09
/ltmp	2,929.69	0.25

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.