

Numerical Study on Combustible Flow in Supersonic Flight Engines and Rocket Engines

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● Abstract

Fundamental studies on nozzles and combustors for Japanese rocket engines and supersonic engines are performed by using numerical simulations.

● Reasons for using of JSS2

Academic and applicative researches on fluid dynamics and combustion mechanism, and development of effective numerical methods are carried out in order to develop Japanese rocket engines and supersonic engines.

● Achievements of the Year

Three-dimensional numerical simulation on a hydrogen jet and a freestream hydrogen flow under supercritical pressures are performed to estimate the effects of pressure on mixing process. The results show that the jet trajectory strongly depends on the momentum flux ratio, and pressure and Reynolds number also affect the jet trajectories in Figs. 1 and 2. In addition, it was demonstrated that the cryogenic jets pass through the higher trajectories under the transcritical pressure condition. By using these results, we proposed a new scaling rule for the jet trajectories including the effect of supercritical condition.

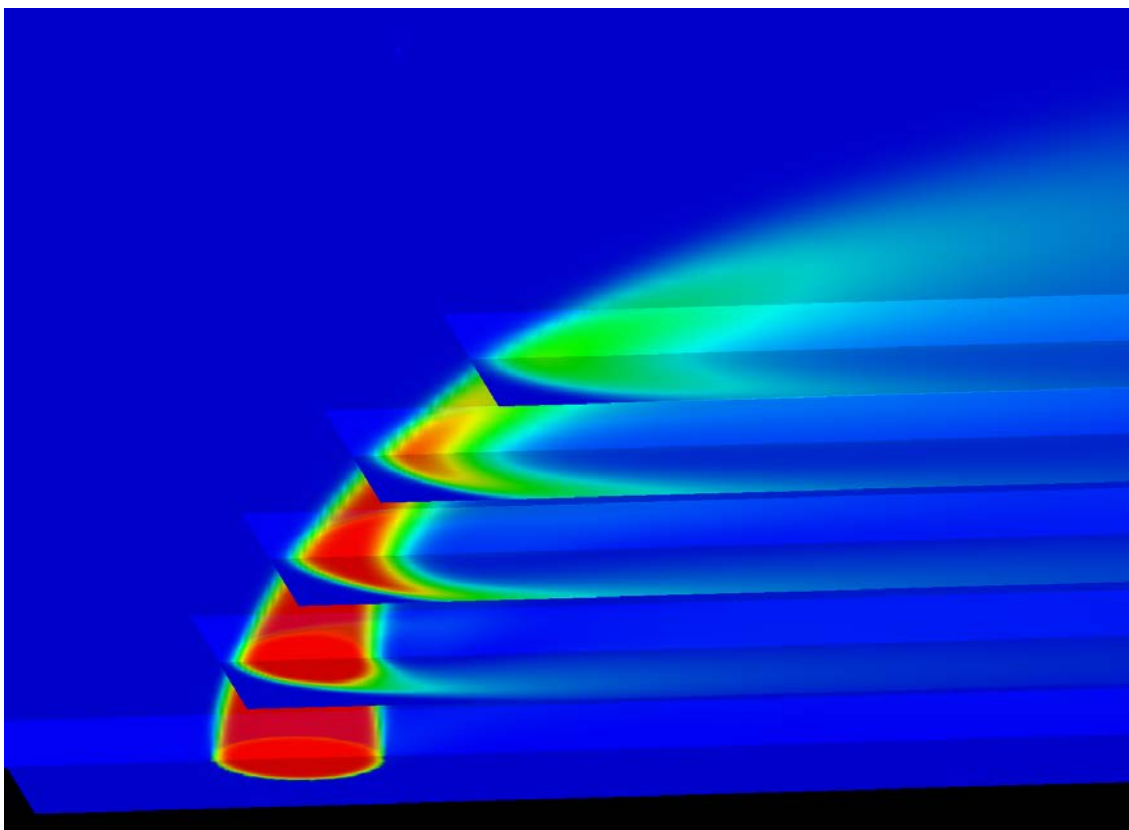


Fig.1 Time averaged density contours near injection

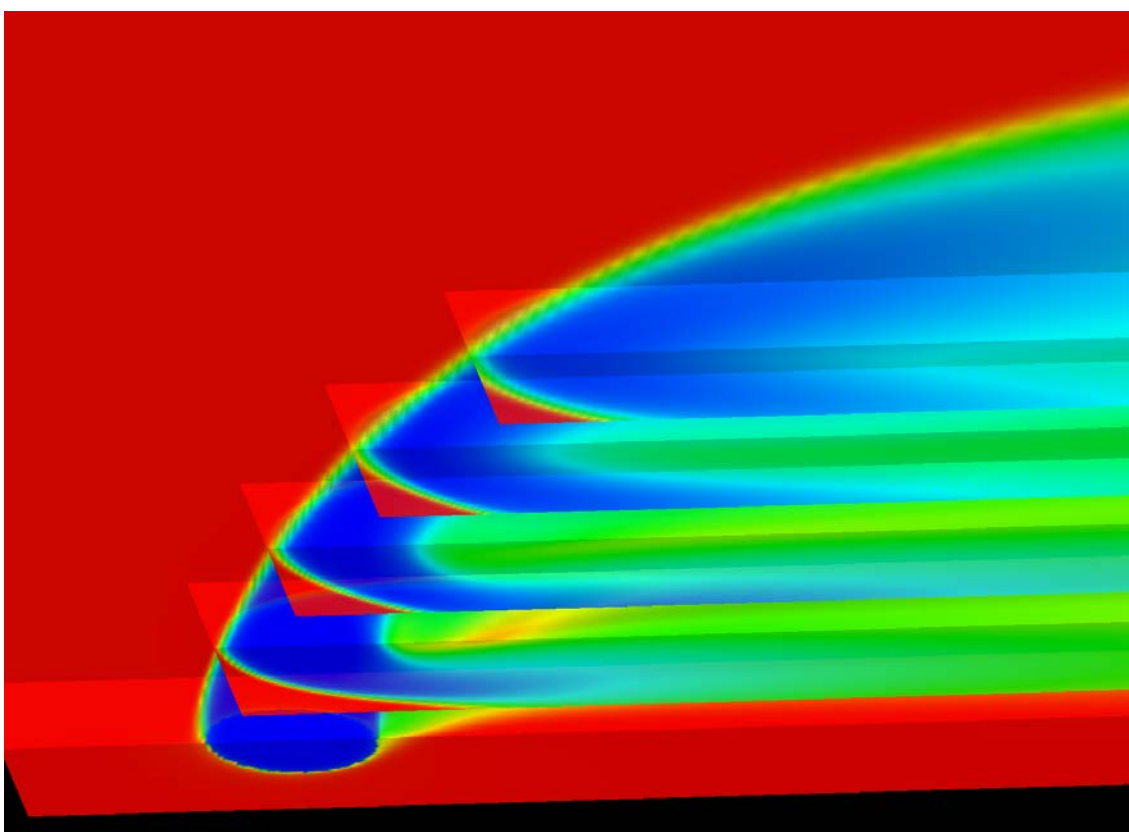


Fig.2 Time averaged temperature contours near injection

● Publications

● Presentations

- 1) Maiko Iwai, Keisuke Yoshida, Youhi Morii, Nobuyuki Tsuboi and A.Koichi Hayashi, "Two-dimensional Numerical Analysis on Shock Flame Interaction in Premixed Gas of Hydrocarbon/Oxygen with Multi-Step Reaction Model," 26th ICDERS(International Colloquium on the Dynamics of Explosions and Reactive Systems) , 1050, Aug. 2017.
- 2) Maiko Iwai, Keisuke Yoshida, Youhi Morii, Nobuyuki Tsuboi, A.Koichi Hayashi, Tetsuro Obara and Shinichi Maeda, "Numerical Analysis on Shock/Flame Interaction in Hydrocarbon/Oxygen Premixed Gas - Difference in the Propagation Types-," ISEM 2017(The 6th International Symposium on Energetic Materials and their Applications) , O02-3, Nov. 2017.
- 3) Toshihiro Iwasa, Keiichiro Fujimoto, Daiki Muto, Nobuyuki Tsuboi, "Numerical Simulations of Transverse Jet in Supersonic Crossflow toward an Understanding of Interaction Mechanism," 31st International Symposium on Shock Waves (ISSW), SBM000350, Nagoya, Japan, July 2017.
- 4) Satoshi Kozuka, Daiki Muto, Hiroshi Terashima, Nobuyuki Tsuboi, "Numerical Study of Cryogenic Hydrogen Jet in Crossflow under Supercritical Pressures," Asia-Pacific International Symposium on Aerospace Technology, E6-2, Seoul, Korea, October 2017.
- 5) Ryuji Takahashi, Nobuyuki Tsuboi, Takashi Tokumasu, Shin-ichi Tsuda, "Validation of applicability of classical mixing rule in a van der Waals type equation of state for oxygen-hydrogen mixture system", The 13th International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows, ISAI13-S-0074, Okinawa, Japan, May, 2017.
- 6) Ryuji Takahashi, Nobuyuki Tsuboi, Takashi Tokumasu, Shin-ichi Tsuda, "Validation of classical mixing rule coupled with a cubic equation of state for the thermodynamic properties in oxygen-hydrogen mixture system", The Ninth JSME-KSME Thermal and Fluids Engineering Conference, TFEC9-1422, Okinawa, Japan, October, 2017.
- 7) Ryuji Takahashi, Nobuyuki Tsuboi, Takashi Tokumasu, Shin-ichi Tsuda, "Validation of classical mixing rule in van der Waals type equation of state applied to a non-ideal binary mixture fluid", Fourteenth International Conference on Flow Dynamics, CRF-49, Miyagi, Japan, November, 2017.
- 8) Tomoki Uzaki, Tomoyuki Muta, Nobuyuki Tsuboi, Yusuke Maru, Kazuhisa Fujita, "A Numerical and Experimental Approaches on Aerodynamic Characteristics of Waverider with Orbiter", 31th International Symposium on Space Technology and Science, g-21, June, 2017.
- 9) Yoshiki Nishikawa, Nobuyuki Tsuboi, Takashi Ito, Satoshi Nonaka "Aerodynamic Characteristics Steady on Reusable Sounding Rocket using Numerical Calculation", 31th International Symposium on Space Technology and Science, 2017-g-22, Ehime, Japan, May 2017.

● Usage of JSS2

● Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	72
Elapsed Time per Case	83.00 hours

● Resources Used

Fraction of Usage in Total Resources*1 (%): 0.26

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	2,047,352.81	0.27
SORA-PP	200.55	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	133.51	0.09
/data	1,335.14	0.02
/ltmp	27,343.76	2.06

Archiver Resources		
Archiver System 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