Fundamental Study on Fluid and Combustion for Hypersonic Flight (Evaluation of Influence of Turbulence Intensity)

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Responsible Representative

Kouichi Okita, Director, Research Unit IV, Research and Development Directorate

Contact Information

Yasunori Nagata (Okayama University) (ynagata@okayama-u.ac.jp)

Members

Masahiro Takahashi, Yasunori Nagata

Abstract

In the engine combustion test using the hypersonic wind tunnel facility, high temperature, high pressure, and high velocity flow is generated by combustion heating upstream of the nozzle. However, in this process, the turbulence of the flow and the contamination by the combustion gas are occurred unavoidably. Therefore, it is concern that the different situation is observed between ground test and actual flight because of these unavoidable factors. In this study, we focus on the mixing process of the injected fuel and the free-stream, and aim to evaluate the influence of the free-stream turbulence on the jet mixing. Thus, we develop a CFD analysis method for this evaluation by introduction of the free-stream turbulence model and validation through comparison with wind tunnel experiment result.

Reasons for using JSS2

Because of the unsteady phenomenon of jet mixing, we need to compare about statistical values between the numerical and experimental results. To do this, wide enough time range of numerical data should be obtained, which takes a lot of computational time. In addition, although it is possible to handle the shear layer which is important in the jet mixing phenomenon appropriately in LES calculation, a fine calculation grid is required, and the calculation time per time step becomes longer. Furthermore, since it is necessary to carry out the several cases of the different flow condition, the whole computational cost becomes large. Therefore, we need to use JSS2 with high computing performance.

Achievements of the Year

As a preliminary step of the free-stream turbulence case, LES calculation of the no turbulence case is carried out and compared with the jet mixing experiment performed in the supersonic wind tunnel of Okayama University. It compared with the distribution of the mean jet mole fraction obtained by the experiment using plane laser induced fluorescence (PLIF) technique, and confirmed that it is able to simulate well by LES calculation about the mixing

condition of the jet (Fig. 1, 2). We also tried to introduce the free-stream turbulence using Random Flow Generation (RFG) method. In addition, because our LES calculation code was only compatible with thread parallel by OpenMP, it is modified to be also compatible with process parallel by MPI, which is suitable to obtain high computational efficiency on JSS2.

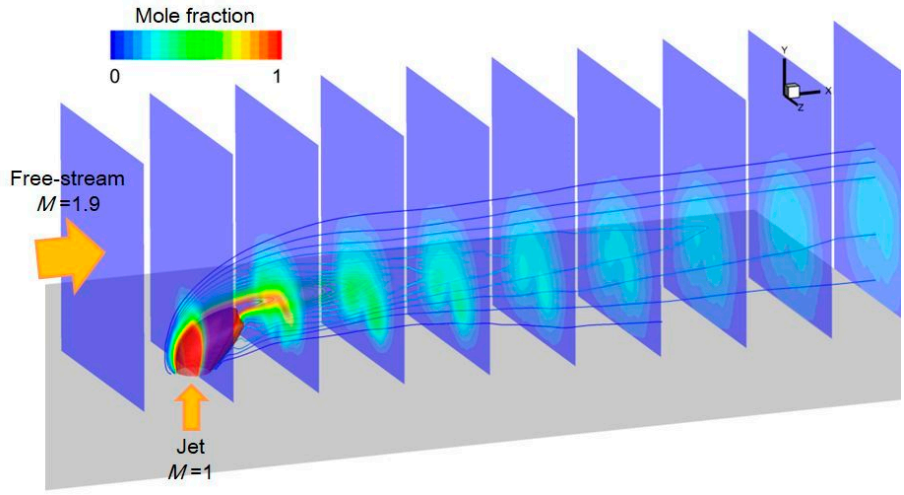

Fig. 1: Mean jet mole fraction distribution of supersonic jet mixing field (nitrogen gas for free-stream and jet, 0.8 mm in jet hole diameter)

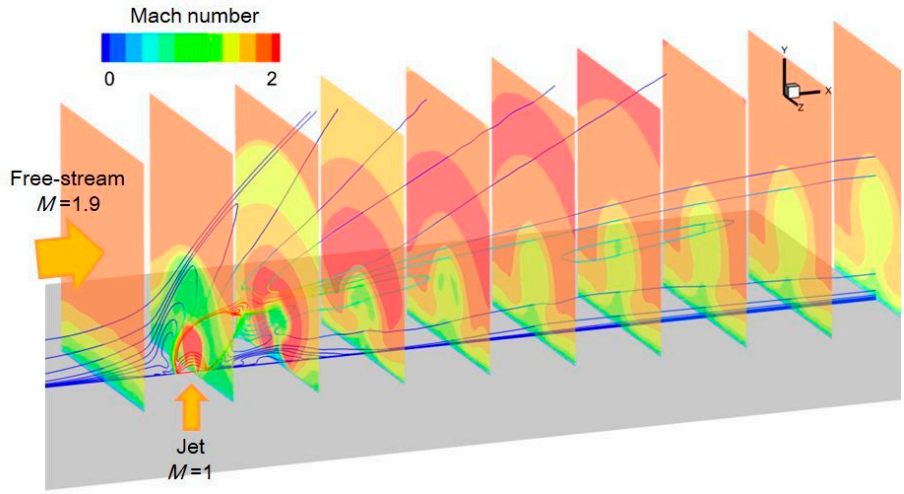

Fig. 2: Mean Mach number distribution of supersonic jet mixing field (nitrogen gas for free-stream and jet, 0.8 mm in jet hole diameter)

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 64
Elapsed Time per Case	100 Hour (s)

Resources Used

Fraction of Usage in Total Resources[*1] (%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2] (%)
SORA-MA	86,464.31	0.01
SORA-PP	0.00	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	10.73	0.01
/data	1,316.07	0.02
/ltmp	2,197.27	0.19

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.18	0.01

[*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.