Study of calculation method for chemical reactions in turbulent combustion

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Abstract

For the purpose of realization of hypersonic transport, research and development aiming at demonstration of integrated control technology for aircraft / propulsion under hypersonic conditions is under way. It is difficult to acquire the data necessary for the performance evaluation of the ramjet engine mounted on the experimental aircraft only by the combustion test. Therefore, numerical analysis is necessary to interpolate the experimental data and to understand the phenomena in the combustor. Then, we develop a reacting flow solver with detailed chemical kinetics based on the CFD solver FaSTAR developed by JAXA. In addition, a verification calculation of this solver is conducted on the two-dimensional shape.

Reasons for using of JSS2

When numerical analysis including chemical reactions is performed on the actual combustor scale, the calculation cost becomes very large. Therefore, we used JSS2 which can parallelize.

Achievements of the Year

We developed a reacting flow solver with detailed chemical kinetics by implementing species transport equations and Arrhenius equation in the CFD solver FaSTAR developed by JAXA. We also implemented a time integration method combining LU-SGS method and Point-Implicit method.

Numerical analysis was carried out with this solver for the premixed flow in the two-dimensional channel as a verification calculation, and the result quantitatively agreed with the analytical solution(Fig. 1). In addition, in the analysis of the supersonic diffusion combustion experiment conducted by Burrows and Kurkov, relatively large errors occurred in the distribution of species mass fraction and temperature, but their maximum values agreed with the experimental results(Fig. 2, 3).

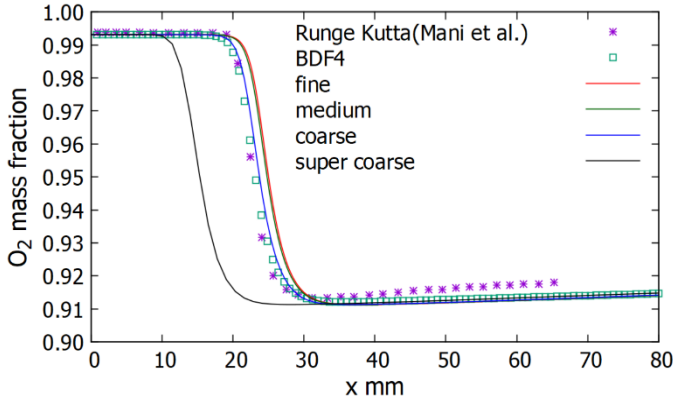

Fig.1 O2 mass fractions along the main flow direction
(line : Numerical solution, plot : analytical solution)

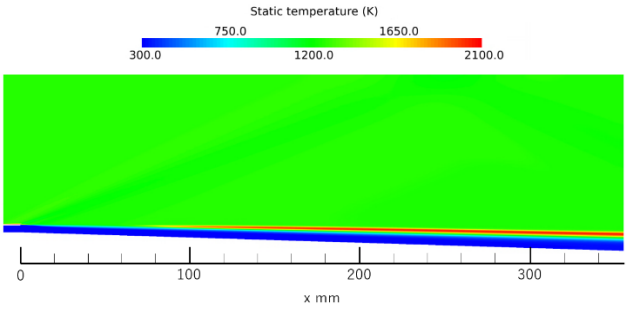

Fig.2 Static temperature contours in test section

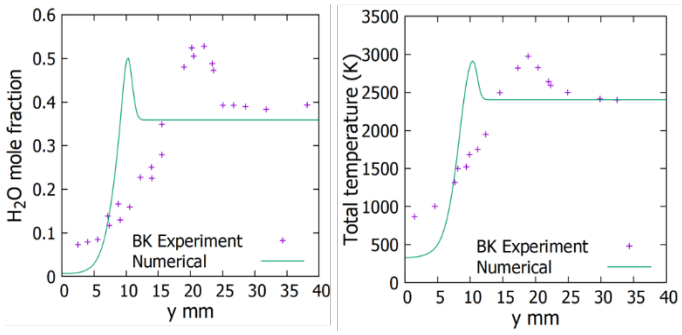

Fig.3 H2O mole fractions and total temperature at test section exit

Publications

N/A

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32 - 64
Elapsed Time per Case	120.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.68

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	5,618,850.84	0.75
SORA-PP	3,882.99	0.05
SORA-LM	1.60	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	476.84	0.33
/data	9,765.63	0.18
/ltmp	1,953.13	0.15

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