Research on combustor simulation

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Abstract

For the development of a jet engine combustor with high environmental compatibility, we develop the combustion calculation code that can capture the pressure propagation and chemical reaction with practical calculation cost. In addition, a verification calculation of this calculation code is conducted on the scramjet test engine of DLR.

Reasons for using of JSS2

It is necessary to use supercomputer to conduct development and verification of the combustion calculation code.

Achievements of the Year

In this research, the implementation of the combustion calculation code based on compressible flamelet model to a density-based fluid analysis solver, FaSTAR (FAST Aerodynamic Routines) was conducted. Then, an artificial neural network (ANN) model was applied to reduce the calculation cost when referring to the flamelet library. The ANN model has 2 input units (mixture fraction and scalar dissipation rate), 3 hidden units, and output units corresponding to mass fraction of each chemical species (As an example, Fig.1 shows the ANN model of OH mass fraction). Approximation of the flamelet library using this model achieved reduction of memory usage (more than 50%) during numerical simulation compared with conventional linear interpolation. For evaluation of this combustion calculation code in actual combustion field, a numerical simulation of the hydrogen combustion in a scramjet test engine of the German Aerospace Center (DLR) was conducted (Fig.2 shows time-averaged density distribution by ANN model).

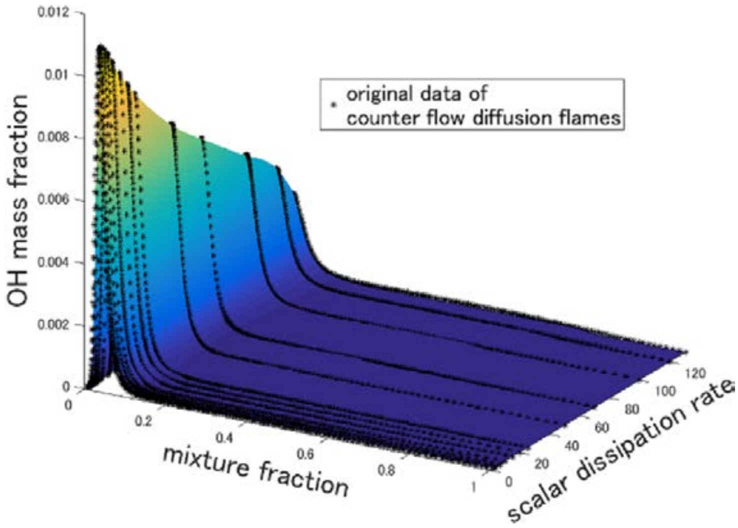

Fig.1 OH mass fraction generated by ANN

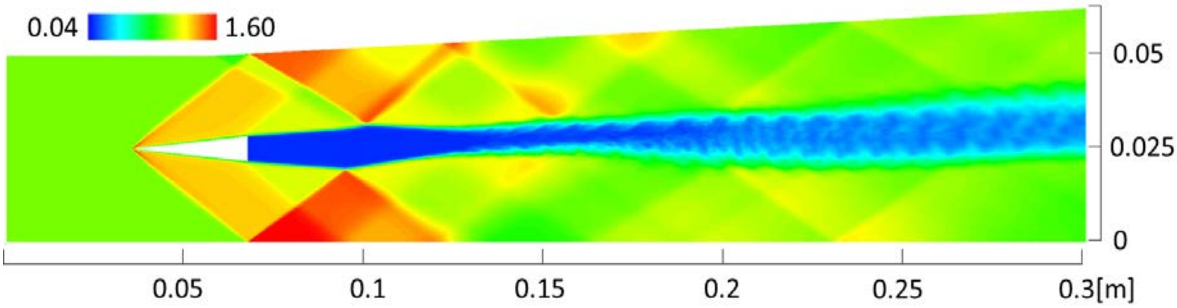

Fig.2 Time-averaged density distribution [kg/m3]

Publications

- Non peer-reviewed papers

1) Himeko Yamamoto, Rui Toyonaga, Yasuhiro Mizobuchi, Tetsuya Sato, Numerical analysis of jet lifted flames using G-equation, JAXA Special Publication, 2017.12
2) Rui Toyonaga, Himeko Yamamoto, Yasuhiro Mizobuchi, Tetsuya Sato, Numerical investigation on supersonic combustion in SCRAMJET engine by FaSTAR, JAXA Special Publication, 2017.12

- Presentations

1) Himeko Yamamoto, Rui Toyonaga, Yasuhiro Mizobuchi, Tetsuya Sato, Numerical study on flame structure of jet lifted flames by FaSTAR, 57th Aerospace Propulsion Conference of Japan Society for Aeronautical and Space Science, 2017.3
2) Himeko Yamamoto, Rui Toyonaga, Yasuhiro Mizobuchi, Tetsuya Sato, Numerical analysis of jet lifted flames using G-equation, 49th Fluid Dynamics Conference/ 35th Aerospace Numerical Simulation Symposium, 2017.6
3) Himeko Yamamoto, Rui Toyonaga, Yusuke Komatsu, Koki Kabayama, Yasuhiro Mizobuchi, Tetsuya Sato, Improvement of compressible flamelet model using artificial neural network, The Asian Joint Conference on Propulsion and Power, 2018.3

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	2 - 1024
Elapsed Time per Case	120.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.60

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	4,907,710.77	0.65
SORA-PP	4,541.23	0.06
SORA-LM	1.66	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	19,531.26	0.36
/ltmp	1,953.13	0.15

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	0.48	0.02

*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