Research on combustor simulation

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Abstract

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

Reasons for using JSS2

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

Achievements of the Year

The laminar flamelet model, which is a tabulated-chemistry calculation method, is effective for reducing the inflexibility of numerical simulation of combustion. However, the recently proposed compressible flamelet model, which is applicable to compressible flow, has some problems related to increased complication of the flamelet table and the pressure-calculation process. To address these problems of the conventional formulation of the compressible flamelet model (method A), we propose two formulations (methods B and C). Method B improves the calculation speed by choosing thermochemical properties of a multicomponent gas and a part of the subgrid-scale term as outputs of the flamelet tables. Method C reduces the memory usage of the flamelet tables drastically by applying the artificial neural networks to the formulation of method B. To evaluate these methods in an actual combustion field, we conducted numerical simulations (Fig. 2, Fig. 3) based on the German Aerospace Center scramjet test-engine combustor (Fig. 1).

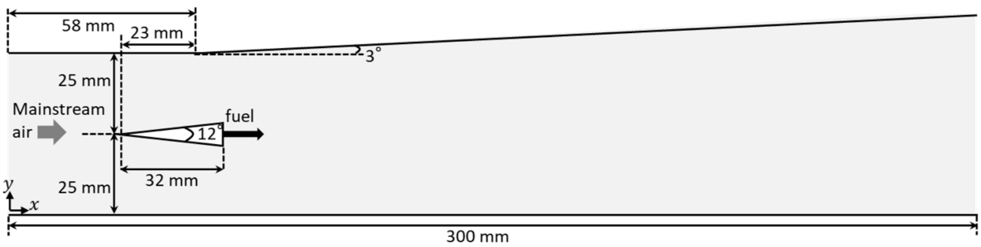
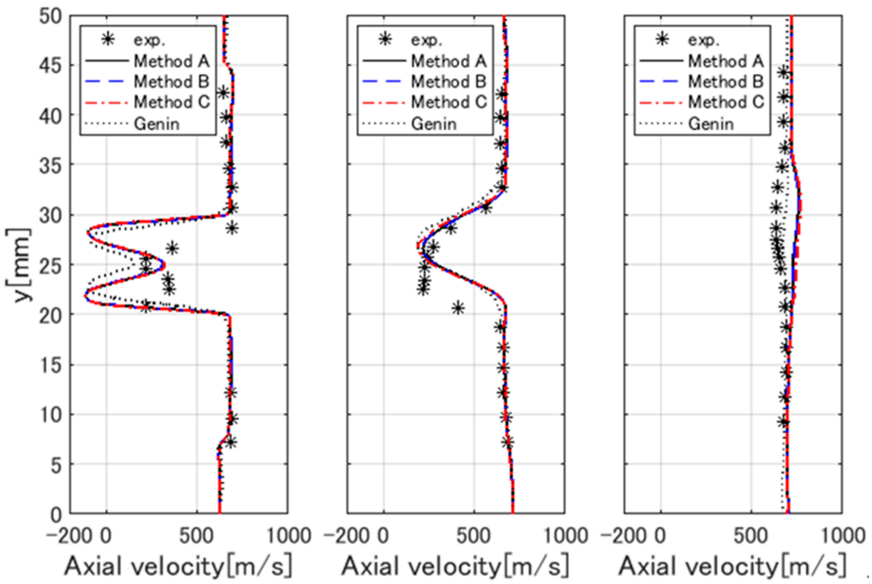


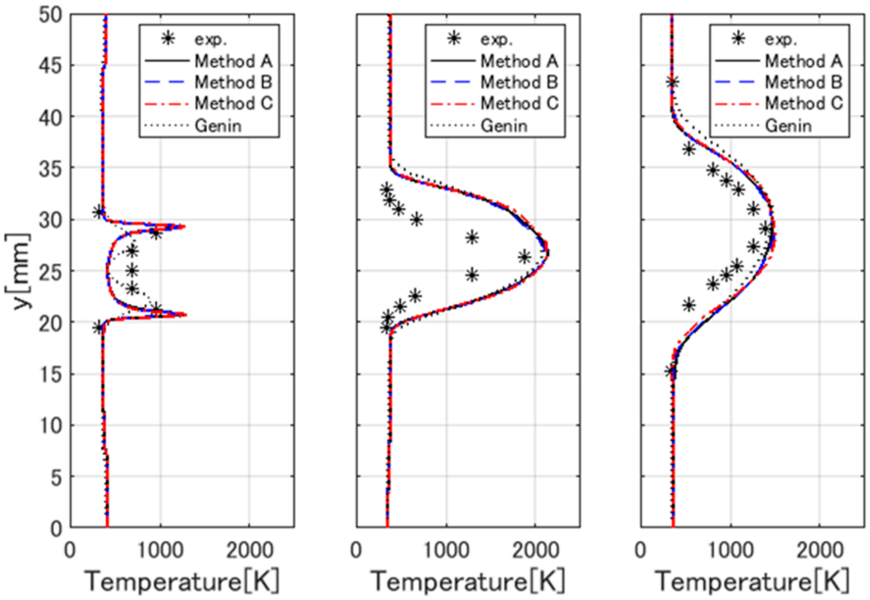
Fig. 1: DLR Scramjet test engine combustor



(a) x = 78 **mm** **(b)** x = 125 **mm** **(c)** x = 207 **mm**

Fig. 2: Axial velocity distribution

(experiment, method A, method B, method C, previous study (F. Genin, 2010))



(a) x = 78 **mm** **(b)** x = 125 **mm** **(c)** x = 233 **mm**

Fig. 3: Temperature distribution

(experiment, method A, method B, method C, previous study (F. Genin, 2010))

Publications

- Peer-reviewed papers

Himeko Yamamoto, Rui Toyonaga, Yusuke Komatsu, Koki Kabayama, Yasuhiro Mizobuchi, Tetsuya Sato, “Improvement of Laminar Flamelet Moedl for Compressible Flows Using Artificial Neural Network”, Aerospace Technology Japan (Online Journal, In Japanese), Japan Society for Aeronautical and Space Sciences (2018.11, accepted)

- Poster Presentations

Himeko Yamamoto, Rui Toyonaga, Yusuke Komatsu, Koki Kabayama, Yasuhiro Mizobuchi, Tetsuya Sato, “Generation of Thermochemical Database Using Artificial Neural Network For Compressible Flamelet Approach”, International Symposium on Combustion, WiPP session, Ireland, 2018.8

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	2 - 1024
Elapsed Time per Case	120 Hour (s)

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.46

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	3,869,594.74	0.47
SORA-PP	31,509.90	0.25
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	476.84	0.49
/data	39,062.52	0.69
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver 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.