Development of Robust Numerical Scheme for Kerosene Turbulent Combustion

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Abstract

When carrying out a combustion simulation using a detailed reaction mechanism for a hydrocarbon fuel, the number of chemical species to be considered and the stiffness due to a chemical reaction become problems. In this study, by combining skeletal reaction mechanism and dynamic stiffness removal, we developed a robust numerical scheme which enables combustion simulation with large scale detailed reaction mechanism.

Reasons for using of JSS2

When performing turbulent combustion simulation on kerosene fuel widely used in gas turbine engines, a large scale reaction model including over 100 chemical species and over 900 chemical reactions must be solved. In order to perform LES and DNS for kerosene combustion, a huge number of grid points of the order of 100 million is necessary and the number of governing equations and chemical reactions increase in proportion to the number of chemical species. Therefore, supercomputers are indispensable for carrying out such large scale combustion simulations in this research.

Achievements of the Year

In this study, a skeletal reaction model and dynamic stiffness removal was applied to perform a combustion simulation of a partially premixed flame of n-decane (Fig.1). Dynamic stiffness removal showed that combustion simulation using a large scale detailed reaction mechanism can be performed stably even with time-steps of 10^{-8} s that is more than 100 times larger than a characteristic time scale of chemical reaction.

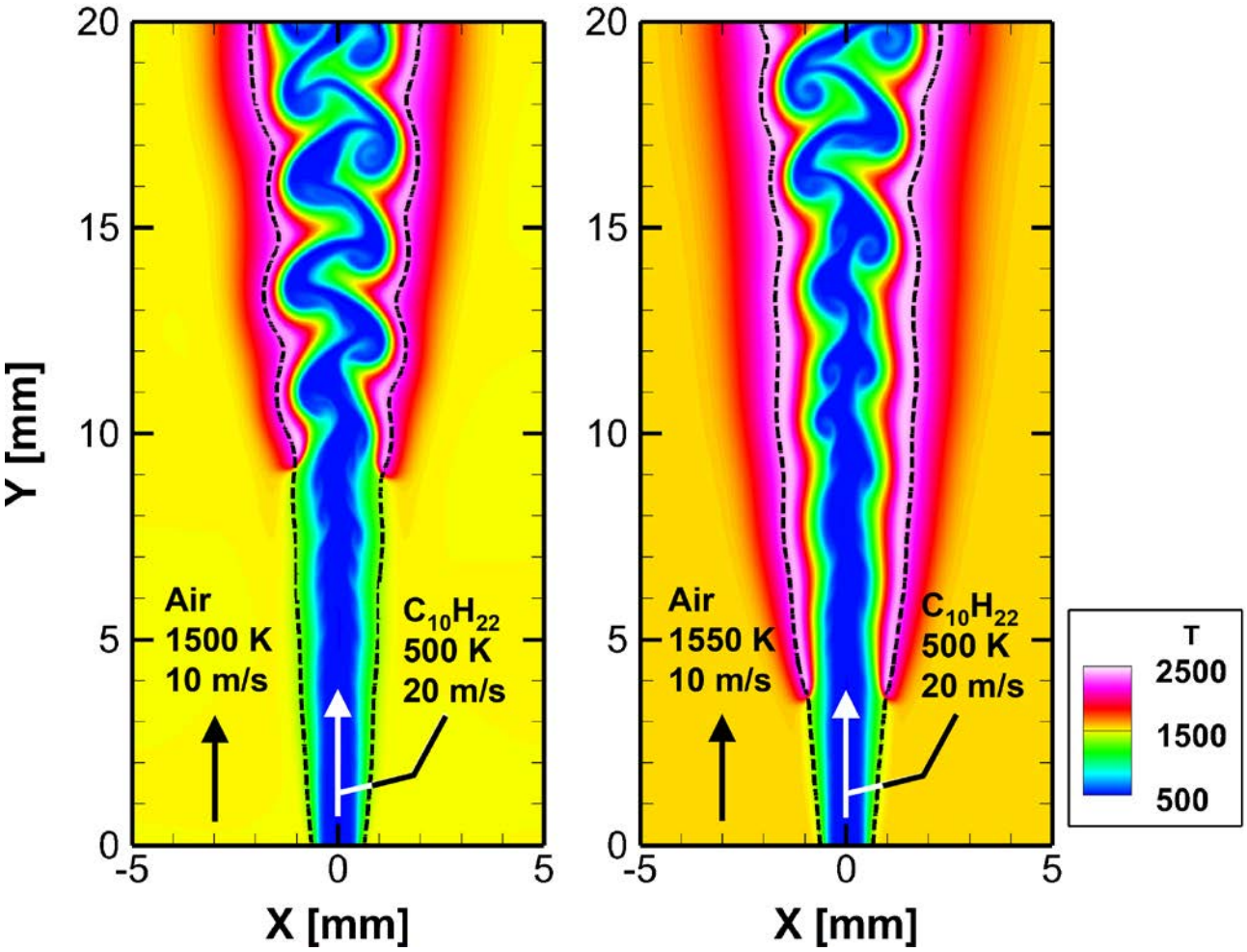

Fig.1 Snapshots of instantaneous contours of temperature (in K) for a partially premixed flame of n-$C_{10}H_{22}$. The dashed line indicates the stoichiometric locations. Cited from non peer-reviewed paper [1]

Publications

- Non peer-reviewed papers

1) Shingo Matsuyama, "Unsteady Simulation of Kerosene Partially Premixed Flame with Detailed Chemical Reaction Model", proceedings of the fifty-fifth symposium (Japanese) on combustion, E221, 2017.
2) Shingo Matsuyama, "Development of Turbulent Combustion Analysis Code CHARIOT", proceedings of the 49th JSASS annual meeting, 2C05, 2018.

- Presentations

1) Shingo Matsuyama, "Unsteady Simulation of Kerosene Partially Premixed Flame with Detailed Chemical Reaction Model", the fifty-fifth symposium (Japanese) on combustion, 2017.
2) Shingo Matsuyama, "Development of Turbulent Combustion Analysis Code CHARIOT", the 49th JSASS annual meeting, 2018.

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	25 - 75
Elapsed Time per Case	120.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.02

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	128,996.00	0.02
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	598.94	0.41
/data	2,849.03	0.05
/ltmp	488.28	0.04

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