Hydrogen Application to Aircraft and Future Space Transportation System

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Abstract

This research aims at the demonstration of the thrust control method of a hypersonic pre-cooled turbojet engine using liquid hydrogen fuel and the aircraft / propulsion integrated control method. We acquire the control characteristics of the hypersonic integrated control experimental aircraft to establish the aircraft / propulsion integrated control method taking into account the mutual interference of hypersonic airframe and hypersonic engines. In addition to defining the required specifications of hypersonic aircraft, we present the design specifications of the hypersonic experimental aircraft for carrying out flight demonstration of hypersonic pre-cooled turbojet engine.

Reasons and benefits of using JAXA Supercomputer System

For reacting flow simulation including NOx, there are many chemical species and calculation cost is high.

We need a long calcularion time to obtain the aerodynamic characteristics of the overall hypersonic experimental aircraft by CFD analyses.

Achievements of the Year

LES of combustion inside the model afterburner of pre-cooled turbojet engine with dual injector. (Fig. 1)

CFD was used to evaluate the aerodynamic characteristics of the High-Mach Integrated Control Experimental Aircraft with a flow-through duct that simulates an air-breathing engine. (Fig. 2)

Acquisition of intake characteristics of ramjet engine for High Mach Integrated Control Experiment (HIMICO) at the mainstream Mach number 5, and CFD analysis for varying intake opening and nozzle opening. (Fig. 3)

The flowfield around the intake during engine switching for TBCC intakes was evaluated by CFD. (Fig. 4)

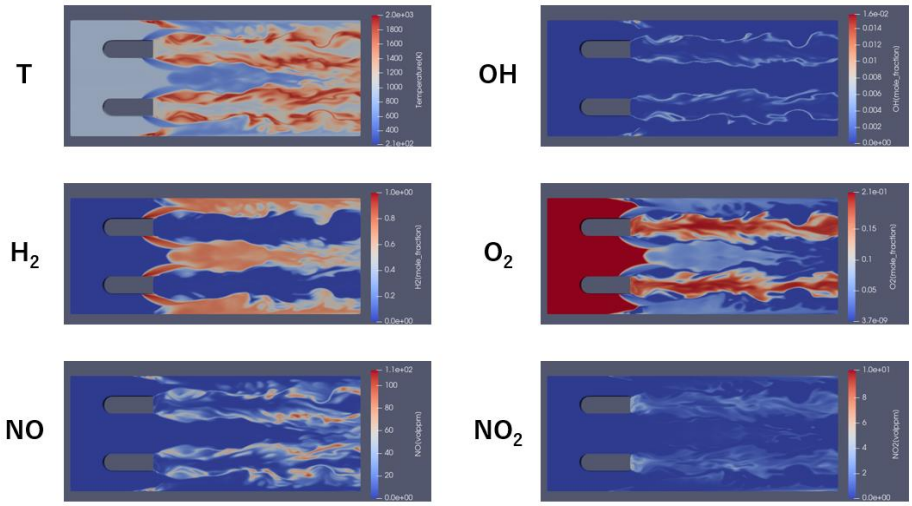

Fig. 1: Combustion Field of Hydrogen Injector (Moler fraction, Temperature distribution)

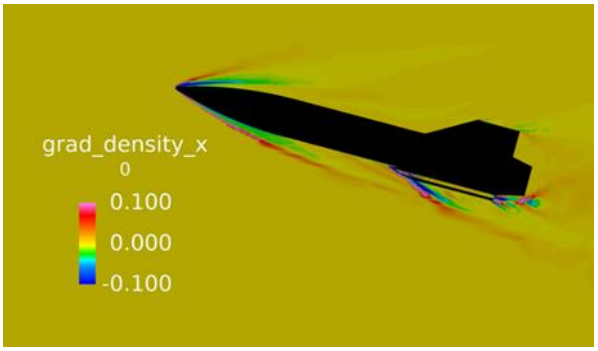

Fig. 2: Flow Field around High-Mach Integrated Control Experimental Aircraft (Density gradient distribution, Mach 5.0, Angle of attack: 15deg)

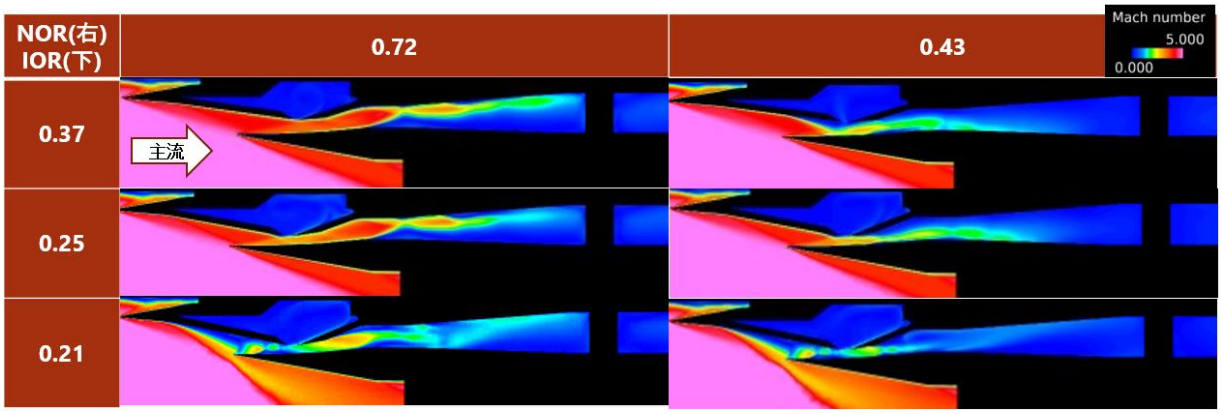

Fig. 3: Flow field in a Ramjet Engine (Mach Number Distribution, Mach 5 Flight Condition)

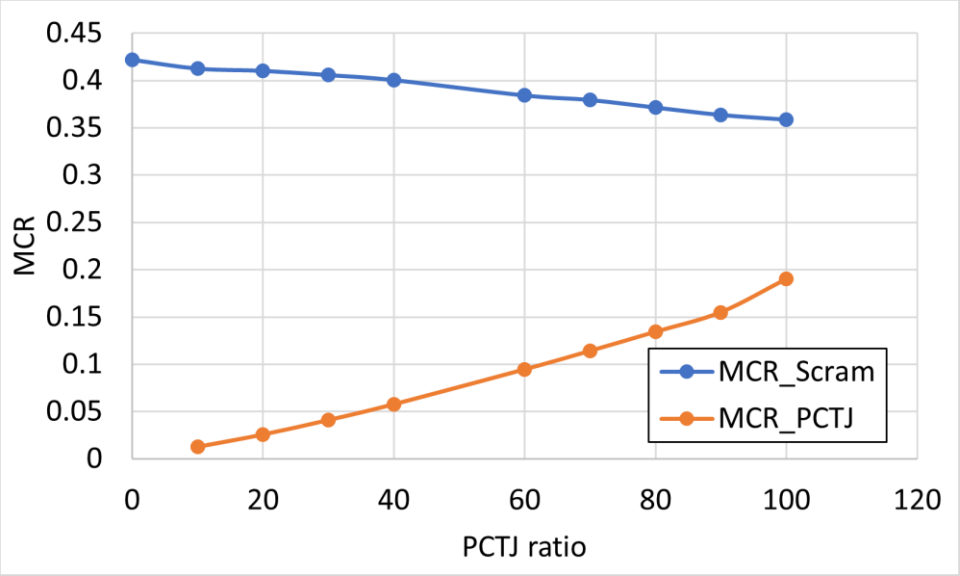

Fig. 4: Intake Performance of Turbojet-Scramjet Combined Engine (Mass Capture Ratio)

Publications

- Oral Presentations

Takahiro Terao, Tomonari Hirotani, Hideyuki Taguchi, Naoyuki Okamura, Asei Tezuka, Evaluation of Aerodynamic Characteristics of High-Mach Integrated Control Experimental Aircraft (HIMICO) with Flow-through Engine, 60th Aircraft Symposium, 2021.

Yusuke Hoshiya, Manami Fuji, Yuki Fujimori, Yuki Kuwabara, Rintaro Tanaka,

Tetsuya Sato, Hidemi Takahashi, Hideyuki Taguchi, The Developmental Progress of the Supersonic Intake for High Mach Integrated Control Experiment (HIMICO), The 2022 Asia-Pacific International Symposium on Aerospace Technology, 2022

Yusuke Hoshiya, Manami Fuji, Yuki Fujimori, Yuki Kuwabara, Rintaro Tanaka,

Tetsuya Sato, Hidemi Takahashi, Hideyuki Taguchi, Tomonari Hirotani, Experimental/Numerical Research of the Performance at Mach 5 of the Ramjet Intake for High Mach Integrated Control Experiment (HIMICO), 2022 Space Transportation Symposium, 2022

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 2
Elapsed Time per Case	30 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 1.33

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	31,567,658.83	1.38
TOKI-ST	1,173,629.29	1.17
TOKI-GP	1,828.40	0.08
TOKI-XM	0.00	0.00
TOKI-LM	8,861.91	0.59
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2] (%)
/home	1,957.92	1.77
/data and /data2	158,580.00	1.22
/ssd	9,550.00	1.32

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	13.77	0.06

[*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.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	4,079.73	2.84

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.