Numerical analysis on fuel injector design

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Abstract

Numerical simulations of thermofluid dynamics are performed to optimize fuel injector design.

Reasons and benefits of using JAXA Supercomputer System

The use of supercomputer is necessary due to high computational load of thermofluid analysis on fuel injectors in complex design.

Achievements of the Year

Numerical simulations were performed on thermal protection of a coaxially-staged lean-burn fuel injector, in order to avoid fuel coking in its fuel circuits. Combustion experiments were also conducted at simulated flight conditions and temperatures at several locations in metal regions close to the fuel circuits were measured by thermocouples. The experimental results were compared with those by the simulations. The results of experiments and of the simulations were in good agreement, and the latter were slightly higher, meaning inclusion of safety margin which is preferable as a design evaluation tool.

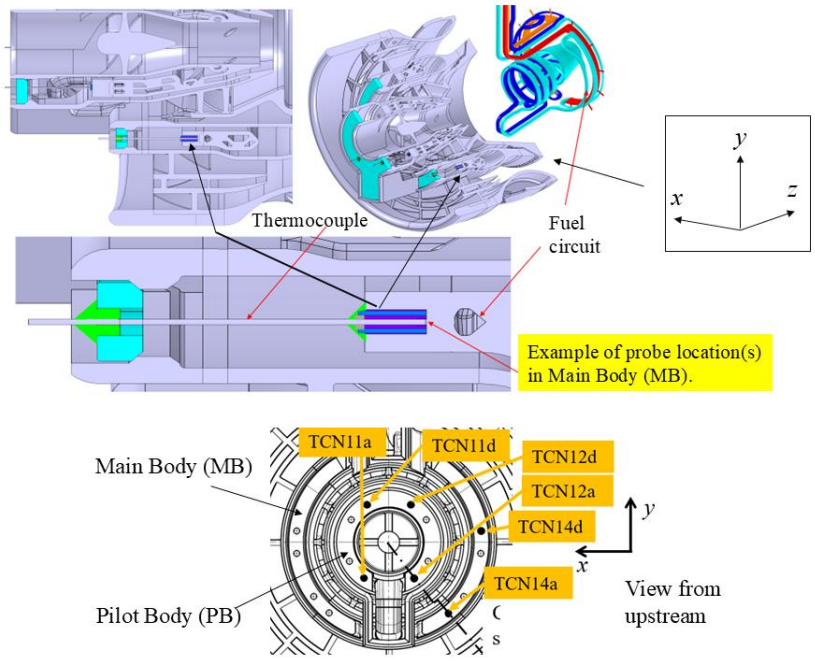

Fig. 1: Probe locations of temperature measurements in the fuel injector.

$$\Delta T_{n,p} = (T_{p,EXP} - T_{p,CHT}) / (T3 - T_{f,in})$$

	Pilot Body				Main Body	
	TCN 11a	TCN 12a	TCN 11d	TCN 12d	TCN 14a	TCN 14d
IDL-E	-0.016	-0.013	-0.027	-0.023	-0.041	-0.045
FIDL-E	-0.020	-0.018	-0.029	-0.026	-0.046	-0.047
APP-E	-0.005	-0.003	-0.016	-0.015	-0.029	-0.036
APP060-E	-0.009	-0.008	-0.020	-0.019	-0.037	-0.043
CRZ020-E	-0.028	-0.026	-0.039	-0.037	-0.048	-0.053
MCL-E*	-0.018	-0.019	-0.024	-0.020	-0.047	-0.049

EXP: Experiment
CHT: Conjugate heat transfer simulation

Fig. 2: Normalized temperature deviation between experiments and simulations at probe locations.

Publications

- Non peer-reviewed papers

MATSUURA, K. and YAMAMOTO, T. : Development of anti-coking thermal management technologies for a coaxially-staged lean-burn fuel injector for high-pressure-ratio aero-engines. ~ First report: Evaluation of thermal

protection performance and validation of numerical analysis by experiments in realistic environments. ~, JAXA-RM-24-008E (2025).

- Web

https://jaxa.repo.nii.ac.jp/records/2001693

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1024
Elapsed Time per Case	144 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 1.30

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	34,088,448.35	1.56
TOKI-ST	350,998.79	0.36
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
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	228.45	0.15
/data and /data2	170,521.67	0.82
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.09	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.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2 (%)
ISV Software Licenses (Total)	0.00	0.00

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