Physics understanding and modeling based on high-fidelity numerical analysis

Report Number: R23EDA201J01
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2023/23705/

Responsible Representative

NAKAMURA Toshiya, Director, Aviation Technology Directrate, Fundamental Aeronautics Research Unit

Contact Information

Abe Hiroyuki(abe.hiroyuki@jaxa.jp)

Members

Hiroyuki Abe, Manabu Hisida, Ryohei Kirihara, Takuhito Kuwabara, Shingo Matsuyama, Yasuhiro Mizobuchi, Taisuke Nambu, Kei Shimura, Hiroki Yao

Abstract

The aim is to model key phenomena of turbulence, fuel atomization, and combustion based on physics understanding by detailed and high-fidelity simulations and to lead the research.

Reasons and benefits of using JAXA Supercomputer System

World-level research in this field requires massively parallel huge computational resource and only so-called supercomputer system can provide it.

Achievements of the Year

1) We implemented the advanced evaporation model proposed in the previous fiscal year into the combustion flow analysis program HINOCA-AE and confirmed its superiority in the analysis of a lab burner.

In the detailed analysis of atomization, we achieved high-precision analysis through Euler-Lagrange coupling, replacing droplets below grid resolution with the particle model.

2) We have validated the AMM model against the NASA CRM at a flight Reynolds number and also the CRM High-Lift. By using a quadratic constitute relation developed in FY2021 (QCRcorner), the aerodynamic coefficients are improved by approximately 50 percent compared with those obtained with the linear AMM model, which highlights that the AMM QCRcorner model has potential for predicting the wing-body juncture flow. In addition, we have analyzed the model coefficients of the diffusion terms in the k and epsilon equations and made the improvement. Over an airfoil, the correction improves the prediction for the drag coefficient by a few counts.

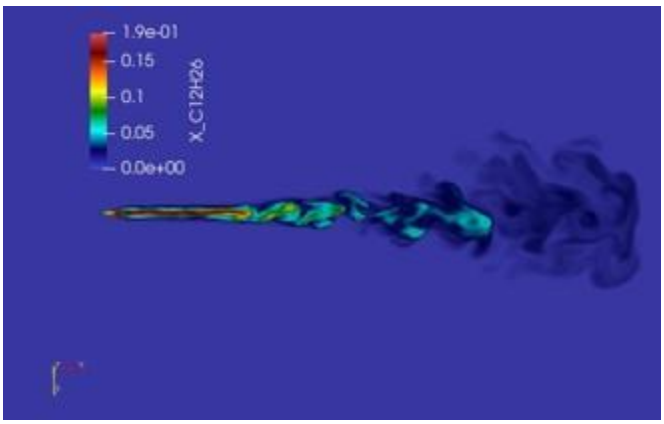

Fig. 1: Analysis result of diesel spray using the advanced evaporation model.

Fig. 2: Analysis result of cross-flow type atomization using the Euler-Lagrange coupling method.

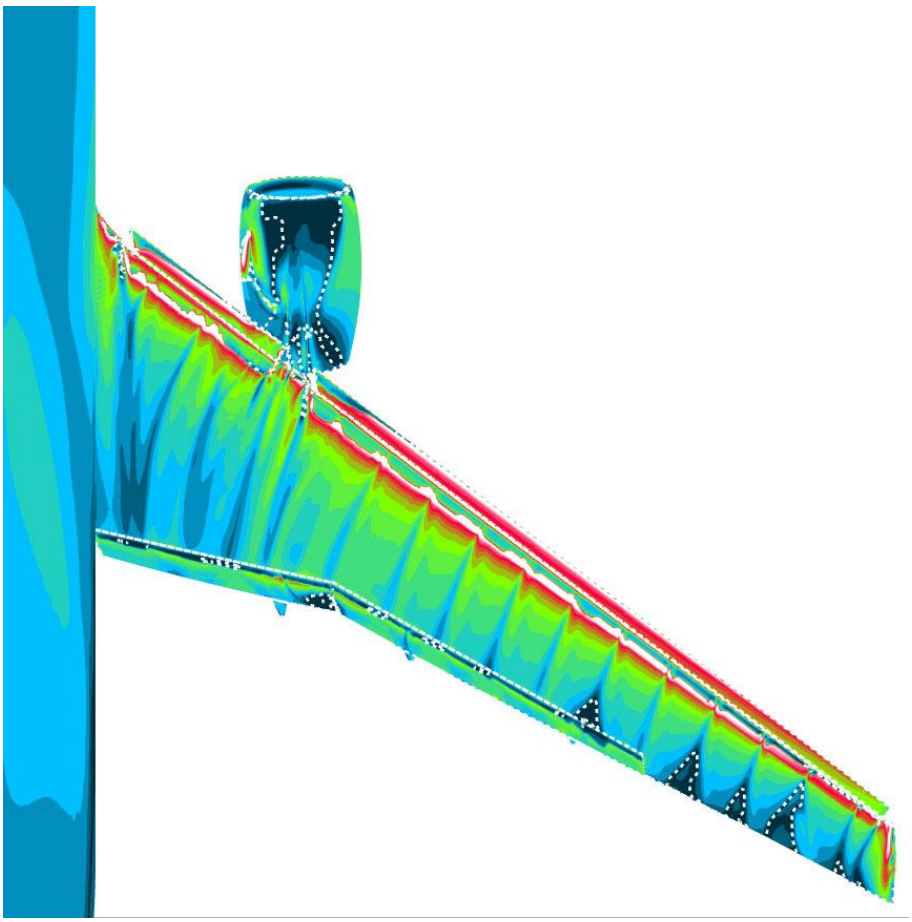

Fig. 3: Prediction for the CRM High-Lift using the AMM-QCR model

Publications

- Peer-reviewed papers

1) H. Abe, T. Nambu, Y. Mizobuchi and P.R. Spalart, "Edge Behavior of the k-epsilon Model in Boundary Layers: Analysis and Improvement", AIAA Journal, Vol. 61, No. 12, pp. 5532-5547.

- Oral Presentations

1) T. Nambu et.al., "Verification of a Droplet Evaporation Model through a Comparison with the Results of the Detailed Analysis of Droplet Group Evaporation and Proposal of an Improved Method," The 61st Symposium (Japanese) on Combustion

2) H. Abe, T. Nambu and Y. Mizobuchi, "Contribution to the 7th AIAA CFD Drag Prediction Workshop Using FaSTAR-AMM," AIAA 2023-3398 (AIAA Aviation 2023, Special Session: 7th AIAA CFD Drag Prediction Workshop, June 11, 2023, San Diego, CA).

3) H. Abe, T. Nambu, Y. Mizobuchi, "Prediction of aerodynamic characteristics of HL-CRM using the AMM model," 55th FDC/41th ANSS, Ninth Aerodynamics Prediction Challenge (APC-9), 1A06, July, 2023.

4) H. Abe, T. Nambu, Y. Mizobuchi, "Prediction of aerodynamic characteristics of NASA CRM using the AMM model," 55th FDC/41th ANSS, 2E03, July, 2023.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	8 - 512
Elapsed Time per Case	300 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 3.15

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	85,409,844.87	3.86
TOKI-ST	19,080.14	0.02
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	8,555.74	0.65
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	318.94	0.26
/data and /data2	129,740.57	0.80
/ssd	2,537.89	0.24

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	30.01	0.11

*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)	338.62	0.15

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