CFD simulation of compound helicopter flight test

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Abstract

CFD analysis of the aerodynamic performance and feasibility of JAXA's proposed compound helicopter with a main rotor + wing + propeller configuration will be conducted in this project. In particular, CFD analysis will be conducted to analyze the performance of the optimum high-mu rotor blades (mu is advance ratio) for high-speed flight, and to investigate cases corresponding to the flight test of the model compound helicopter conducted in FY2022. Through these simulations, we will proceed to demonstrate the elemental technologies related to the feasibility of the proposed helicopter.

Reasons and benefits of using JAXA Supercomputer System

In the analysis of simulated flight tests, it is necessary to understand the performance under a wide range of flight conditions that may occur during the test as well as the target cruise conditions, and it is considered appropriate to analyze a large number of cases using a supercomputer.

Achievements of the Year

This year, we conducted a replicated analysis of a model compound helicopter flight test conducted in Taiki Town, Hokkaido, Japan. In this test, the performance of the optimal rotor blades designed by JAXA for high-speed helicopters and the blades of conventional helicopters were compared, and this was followed up with CFD verification.

Figure 1 shows the appearance of the computational grid used in the CFD analysis. In this simulations, the fuselage is included in the computational space in addition to the rotor to increase the fidelity. This allows the analysis to take into account the interference between the blades and the fuselage.

Figure 2 shows a visualization of the flow field around the fuselage during forward flight (based on Q values). CFD simulations can investigate the performance of the rotorcraft while taking such aerodynamic interference problems into account.

Figure 3 shows the rotor performance (effective lift-drag ratio) based on the aerodynamic distribution obtained by CFD. The horizontal axis uses the advance ratio, which is the ratio of blade tip speed to flight speed. Conventional helicopters would operate up to about mu = 0.3, but a high-speed helicopter is expected to operate under higher advance ratios than that, and analysis in this region is important. The key to rotor design is how to extract performance from these severe aerodynamic conditions, where the asymmetry between the advancing and retreating sides becomes noticable.

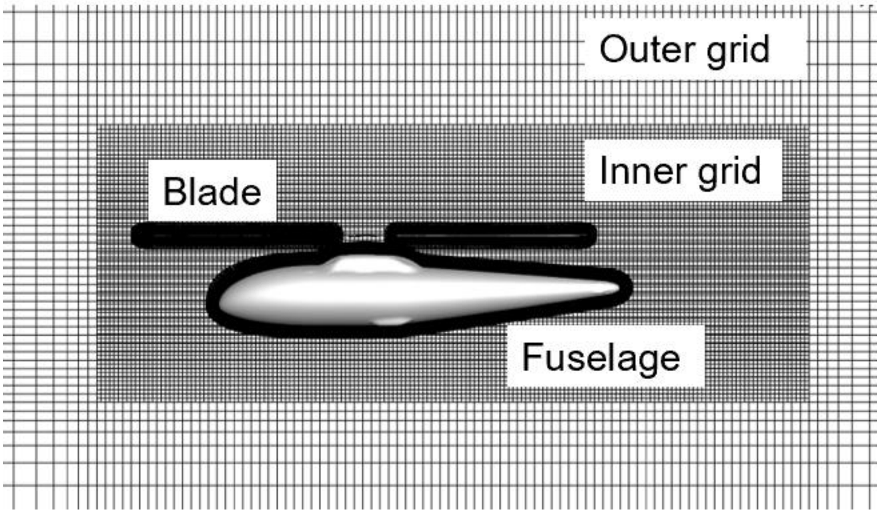

Fig. 1: Appearance of computational grid

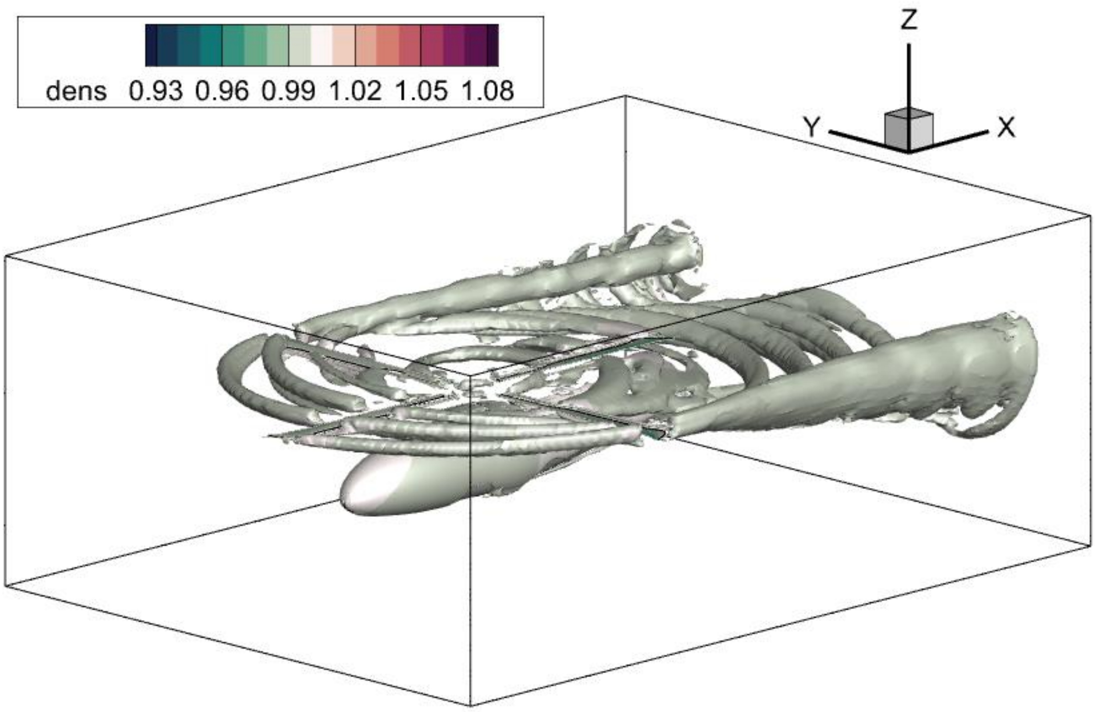

Fig. 2: View of flow field around rotor + fuselage

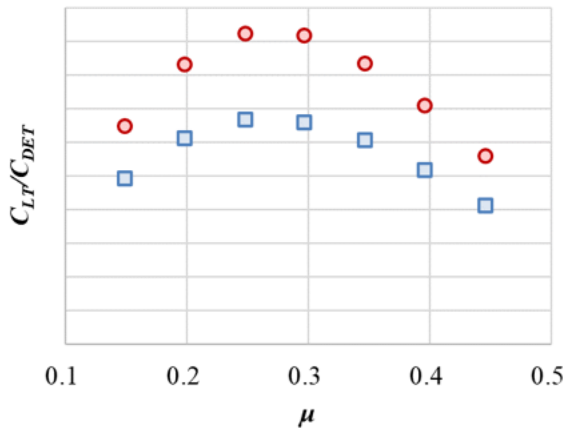

Fig. 3: Example of analysis results (advance ratio vs. effective lift-drag ratio)

- **Publications**

N/A

- **Usage of JSS**

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	200 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.43

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	1,575,436.51	0.07
TOKI-ST	2,883,486.05	2.88
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	63,552.59	1.67
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	104.16	0.09
/data and /data2	21,146.11	0.16
/ssd	679.15	0.09

Archiver Resources		
Archiver 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.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	57.43	0.04

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