CFD simulation of compound helicopter flight test

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Abstract

JAXA has been conducting a research for the demonstration of a high-speed compound helicopter it has proposed, under various flight conditions. The high-speed compound helicopter is expected to fly at about twice the speed of conventional helicopters, necessitating different design and operational approaches. Until last fiscal year, CFD analysis corresponding to the flight tests of the 1/7 scale model conducted in FY2022 was performed, and comparisons with the test results have been underway. This fiscal year, CFD simulations have been conducted on lift offset technology, which improves the performance of the main rotor by shifting its thrust center toward advancing side.

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 fiscal year, an analysis of forward flight conditions was conducted on the 1/7 scale compound helicopter owned by JAXA, applying lift offset technology. Lift offset is a technique that primarily generates lift by utilizing the high dynamic pressure on the advancing side of the main rotor, thereby enhancing rotor efficiency. As a result, the center of lift shifts forward from the center of rotation, hence the term lift offset.

Figure 1 illustrates the appearance of a compound helicopter in a lift offset state. In the rotorcraft configuration proposed by JAXA, lift is generated by the main rotor and the main wing, with the lift of the main rotor shifting toward advancing side and the lift center on the wing side shifting in the opposite direction accordingly. This shift can be achieved by moving the main wing flaps in opposite directions on each side.

Figure 2 shows an example of the visualization of CFD analysis focused on the main rotor during forward flight. The analysis has been conducted under high advance ratio conditions, confirming a strong asymmetry in the flow field around the rotor.

Figure 3 presents an example of the lift distribution on the surface of the main rotor analyzed under a lift offset condition. With the application of lift offset, a stronger lift generation on the advancing side can be observed. Such a lift distribution is achieved with a smaller amount of cyclic pitch control, resulting in smaller variations in the pitch angle used.

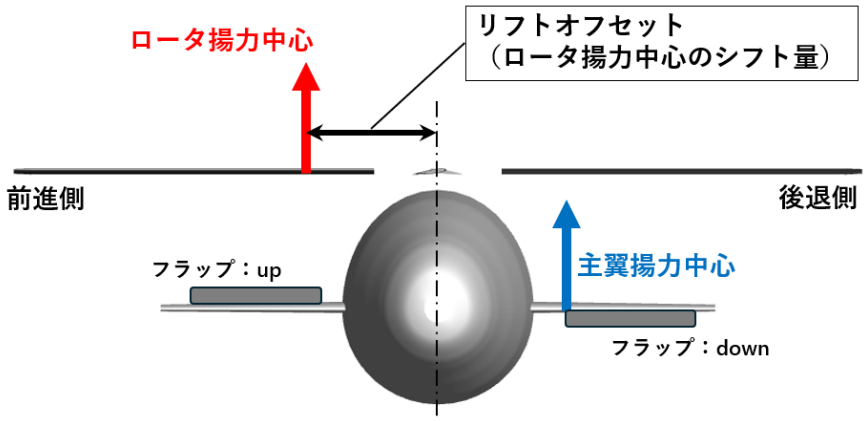

Fig. 1: Lift offset in winged compound helicopters

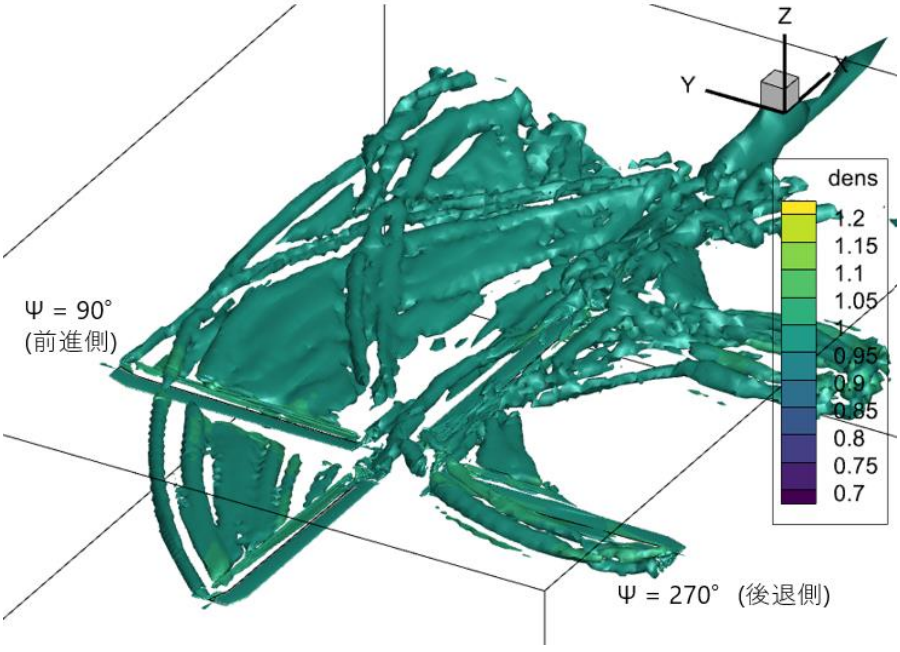

Fig. 2: Example of CFD analysis results (visualization of tip vortex)

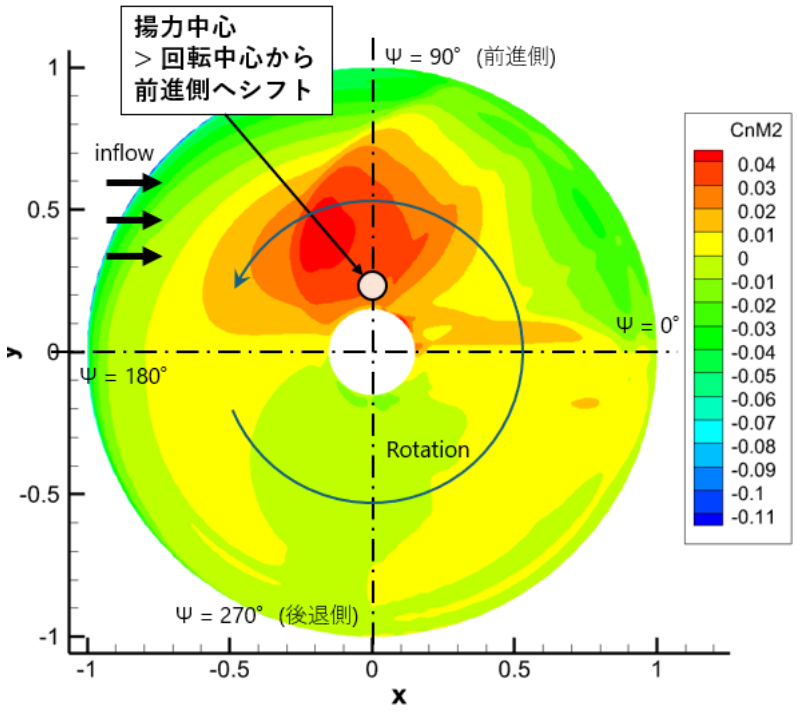

Fig. 3: Lift force distribution on rotor surface

- **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	72 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.07

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	700,850.99	0.03
TOKI-ST	382,228.68	0.41
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	94.99	0.08
/data and /data2	20,940.74	0.13
/ssd	586.95	0.06

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)	2.25	0.00

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