Optimal design of propellers for compound helicopters

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Abstract

In this project, optimal design study has been conducted to improve the performance of the side and tail propellers for compound helicopters proposed by JAXA. CFD analysis is utilized to match the design flight conditions, and the performance of the propellers is evaluated based on the objective function. By optimizing the objective function, the desired shape has been obtained. For the side propeller design, we aimed to create a design that would maintain hovering performance while also having high forward flight performance, and for the tail propeller, it is aimed to generate large thrust, so that it would be possible to fly at twice the speed of conventional helicopters. This year, analyses has been conducted in response to the wind tunnel test of the designed propeller, and the results are compared with the test data.

Reasons and benefits of using JAXA Supercomputer System

In the optimal design of propeller blades, it is necessary to conduct performance analysis of a large number of shapes within a set design variable space. In order to perform this concurrently, it is essential to utilize the computational power of a supercomputer.

Achievements of the Year

Figure 1 presents the setup of the propeller wind tunnel test conducted in this study and provides an overview of the CFD analysis. In the wind tunnel test, models of both the baseline and optimized propeller shapes were fabricated, and measurements were carried out with specified wind speed, rotational speed, and pitch angle. A corresponding CFD analysis was then performed, and a comparison of results for propeller performance has been made.

Figure 2 shows a comparison of the propeller thrust and efficiency obtained from the wind tunnel test and the CFD simulations on JSS3. For the side propeller, data were acquired for three blades: the baseline and two

optimized shapes (left and right), while for the tail propeller, obtained for the baseline and a optimized. The wind tunnel test and CFD analysis shows good agreement, confirming the validity of both methods and demonstrating a trend toward improved performance for the optimized propeller.

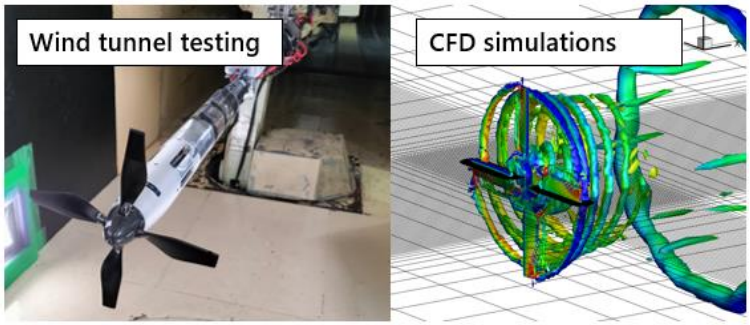

Fig. 1: Appearance of wind tunnel testing and CFD analysis

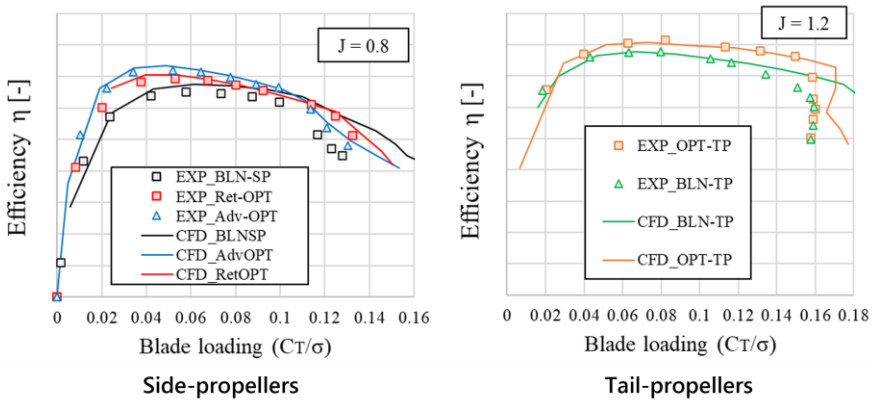

Fig. 2: Example of thrust vs. propeller efficiency (side propeller and tail propeller)

Publications

- Oral Presentations

Keita Kimura, Hideaki Sugawara and Yasutada Tanabe, "Optimal Design and Wind Tunnel Testing of Propellers for a Winged Compound Helicopter," 50th European Rotorcraft Forum, September 10th 2024, Marseille, France

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](%): 0.34

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	929,882.60	0.04
TOKI-ST	2,440,001.24	2.50
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	108.01	0.01
TOKI-TST	154,695.09	2.78
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	1,061.69	0.72
/data and /data2	111,340.29	0.53
/ssd	31,106.15	1.67

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)	7.22	0.00

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