Numerical analysis for optimal design of helicopter rotor blades

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Abstract

JAXA, DLR, and ONERA are collaborating on research as to blade optimization under various flight conditions for the purpose of validating and accumulating knowledge on the helicopter blade analysis tools and optimization methods owned by the three institutions. This fiscal year, acoustic analysis has been conducted based on the pressure distribution obtained from CFD analysis under helicopter descent flight conditions, and optimization for blades with quieter noise level has been progressed. In acoustic analysis of helicopters, it is crucial to accurately resolve tip vortices generated by the blades, demanding high-resolution fluid analysis. This report will present some examples of results.

Reasons and benefits of using JAXA Supercomputer System

In CFD-based optimization, a large number of cases with several design variables need to be performed in the CFD analysis, and the use of a supercomputer is essential; DLR/ONERA is conducting a similar HPC-based optimization, and comparison and study using results obtained using a supercomputer is appropriate.

Achievements of the Year

In a collaborative effort among JAXA, DLR, and ONERA, a common optimization problem for helicopter descent flight has been established, and shape optimization using CFD has been pursued. The initial step involved conducting acoustic analysis on the baseline HART II blade and comparing the analysis results from each organization. Subsequently, optimization of the blade shape is going to be carried out.

Figure 1 illustrates the CFD results under a descent flight condition. It is known that significant noise occurs when the tip vortices generated by the rotor blades interfere with another blade (Blade Vortex Interaction).

Figure 2 shows an example of acquiring the noise carpet on the under of the rotor plane using the pressure distribution on the blade surfaces obtained by CFD, calculated by the FWH method. It can be observed that the

noise generated by the rotor blades significantly varies depending on the azimuth angle.

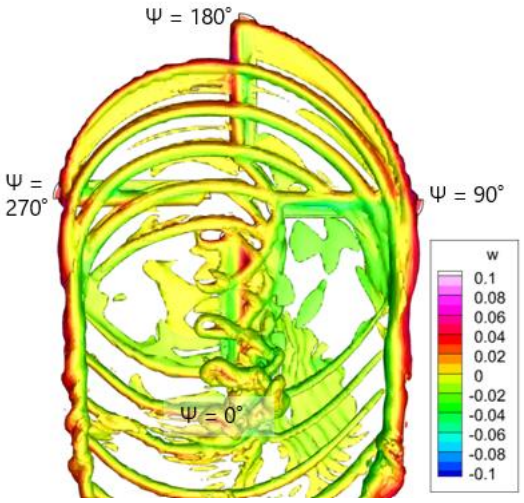

Fig. 1: visualization of tip-vortex

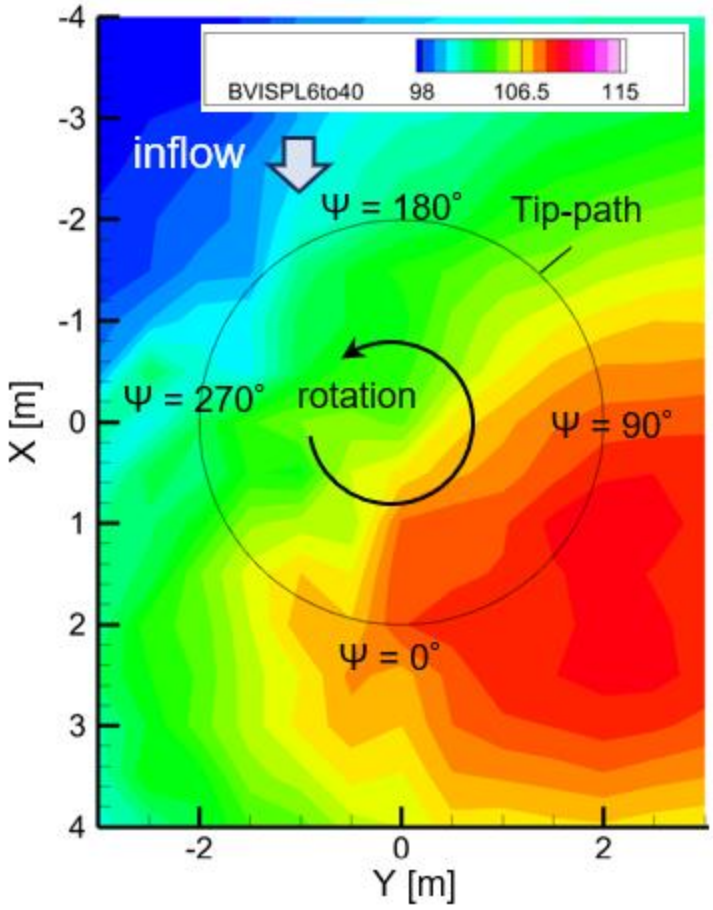

Fig. 2: sample result of acoustic simulation

Publications

- Oral Presentations

J. Bailly, G. Wilke, K. Kimura , Y. Tanabe, "JAXA-ONERA-DLR COOPERATION: RESULTS FROM MULTI-POINT AERODYNAMIC OPTIMIZATION OF A ROTOR IN HOVER AND FORWARD FLIGHT," 49th European Rotorcraft Forum, Buckeburg, Germany, 2023.

Usage of JSS

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	100 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.08

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	544,252.68	0.02
TOKI-ST	508,656.60	0.55
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	1,118.98	0.93
/data and /data2	115,685.73	0.71
/ssd	31,306.95	2.96

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)	0.00	0.00

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