

Numerical analysis for optimal design of helicopter rotor blades

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● Abstract

As part of a joint research project among JAXA, DLR, and ONERA, efforts are underway to verify/validate helicopter blade analysis tools and optimization methods, and to accumulate knowledge. Blade shape optimization is being pursued using the HART II wind tunnel test helicopter blade as a reference. This year, with the aim of improving acoustic performance under helicopter descending flight conditions and reducing BVI noise, CFD analyses have been carried out for blade design. In helicopter acoustic analysis, accurately resolving the tip vortices generated by the blade is crucial, necessitating high-resolution fluid simulations. Moreover, conducting analyses that account for elastic deformation makes it possible to capture the mutual interference between the blade and the tip vortices more accurately. This report illustrates an example of an acoustic analysis that incorporates elastic deformation.

● 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

Figure 1 shows the azimuthal history of elastic deformation (flap/lead-lag/torsion) for the reference blade under descending flight conditions. The deformation history obtained from the wind tunnel test is also included, and it can be confirmed that the elastic deformation trends are in good agreement.

Figure 2 illustrates the acoustic carpet for the reference blade obtained from a CFD/CSD analysis that takes elastic deformation into account. The rotor plane is represented by a circle, with regions of high sound pressure level shown in red and low levels in blue. Comparing the three analysis results under different descent angles,

which denote the angle between the rotor plane and the flight direction, reveals that as the descent angle increases, blade-vortex interaction intensifies, leading to higher noise levels.

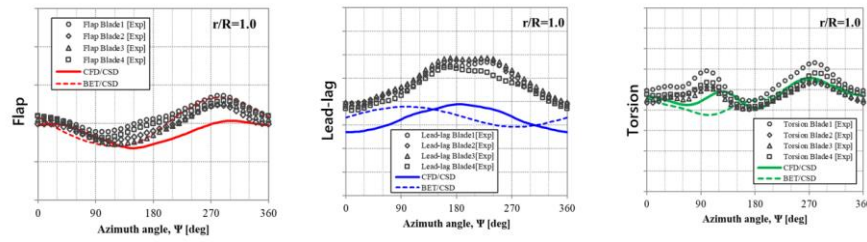


Fig. 1: Blade elastic deformation history (HARTII test vs CFD)

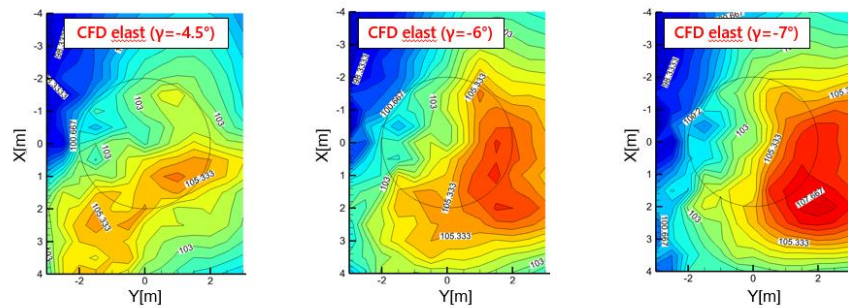


Fig. 2: the acoustic carpet with sweeping the angle of descent (gamma)

Publications

- Oral Presentations

Gunther Wilke, Joelle Bailly, Yves Delrieux, Keita Kimura and Yasutada Tanabe, "JAXA-ONERA-DLR Cooperation: Results From Acoustic Optimizations Of A Rotor In Descent Flight," 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	100 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources*¹(%): 0.17

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage* ² (%)
TOKI-SORA	777,430.48	0.04
TOKI-ST	850,811.89	0.87
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	289,813.40	5.21
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	105,216.29	0.50
/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)	0.00	0.00

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