

Research on rotor blade optimization between JAXA-ONERA-DLR : Validation of CFD solvers

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● Abstract

In order to verify and accumulate knowledge of the analysis tools and optimization methods of helicopter blades possessed by JAXA, DLR, and ONERA, each organization has been optimizing blade shapes under various flight conditions. In this fiscal year, as the first step, blade optimization under hovering conditions and comparison of numerical simulation results were carried out. In an optimization process, it is necessary to evaluate the performance of the obtained design solution accurately, and the evaluation by CFD is important for the design considering local fluid phenomena. In this report, we share some of the validation results of CFD analysis conducted by each organizations.

● Reasons and benefits of using JAXA Supercomputer System

In the optimization using CFD, it is necessary to conduct many cases with different design variables, and the use of supercomputers is essential. DLR/ONERA also conduct similar process using HPC, and it is appropriate to compare and examine the results using supercomputers.

● Achievements of the Year

As for the CFD solver, which is responsible for the performance evaluation of the design solution in the optimization tool, the validity of the CFD solvers owned by each organizations (JAXA, ONERA and DLR) was confirmed by comparing the CFD simulations of the baseline shape in hovering conditions.

Figure 1 depicts the overview of computational grids in JAXA's cases. Simulations were performed using a moving overlapped grid system solver (rFlow3D) in which the blade grid rotates in a background grid.

Figure 2 shows a comparison of figure-of-merit, a measure of hovering performance. The horizontal axis represents the magnitude of the thrust generated by the blade. Each CFD result were compared with the experimental values and they were confirmed that the hovering performance was comparable over a wide range

of thrust, and that the validity was sufficient for use as a performance prediction tool.

Figure 3 illustrates the skin friction distribution on the blade surface at a representative cross section. The turbulence modeling used by each agency is different, and the variance in friction around the leading edge ($x/c \sim 0.1$) can be seen. It mainly appears in the performance prediction results in Fig.2, and it is confirmed that the difference is within a reasonable range.

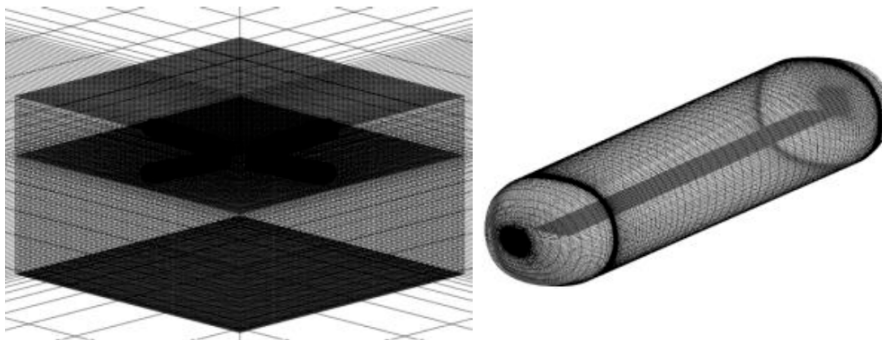


Fig. 1: computational grid

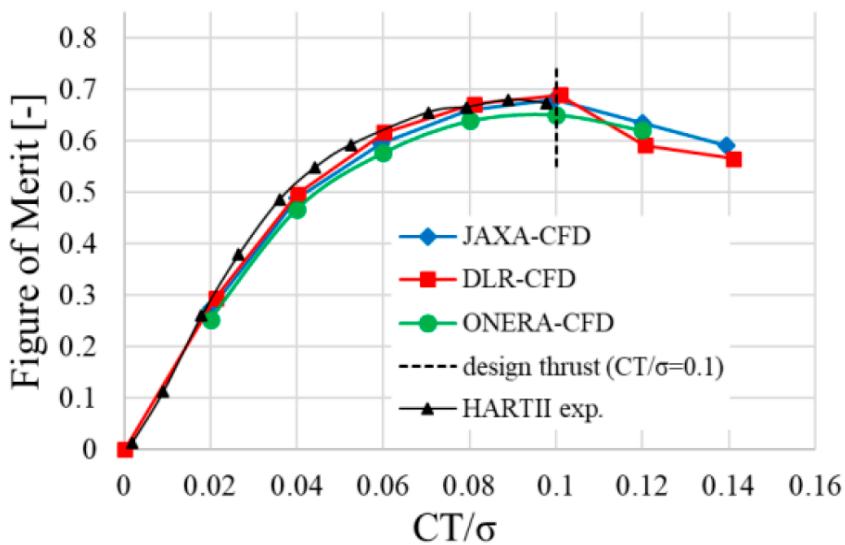


Fig. 2: Rotor thrust vs Figure of Merit (efficiency)

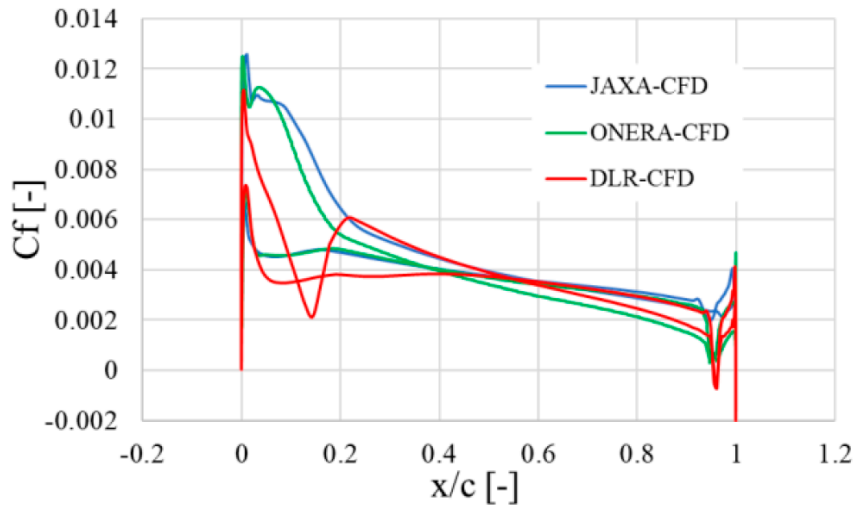


Fig. 3: Skin frictional coefficient

● **Publications**

- Non peer-reviewed papers

KIMURA Keita , SUGIURA Masahiko , SUGAWARA Hideaki , TANABE Yasutada , WILKE Gunther , BAILLY Joelle , TAKEKAWA Kuniyuki, "Cooperative Research on Rotor Blade Optimization between JAXA-ONERA-DLR: Results of Phase I",JAXA Special Publication: Proceedings of Fluid Dynamics Conference / Aerospace Numerical Simulation Symposium 2020 Online,JAXA-SP-20-008,59-67 (2021-02-08)

- Oral Presentations

KIMURA Keita , SUGIURA Masahiko , SUGAWARA Hideaki , TANABE Yasutada , WILKE Gunther , BAILLY Joelle , TAKEKAWA Kuniyuki, "Cooperative Research on Rotor Blade Optimization between JAXA-ONERA-DLR: Results of Phase I",Fluid Dynamics Conference / Aerospace Numerical Simulation Symposium 2020 Online, September 28-30, 2020.

● **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)

- **Resources Used(JSS2)**

Fraction of Usage in Total Resources^{*1}(%): 0.60

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage ^{*2} (%)
SORA-MA	689,493.57	0.13
SORA-PP	563,193.90	4.41
SORA-LM	1,583.29	0.93
SORA-TPP	104,624.97	9.87

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage ^{*2} (%)
/home	3,603.33	3.30
/data	6,886.43	0.13
/ltmp	955.59	0.08

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage ^{*2} (%)
J-SPACE	6.24	0.21

^{*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.

- **Resources Used(JSS3)**

Fraction of Usage in Total Resources*1(%): 0.77

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
TOKI-SORA	422,205.40	0.09
TOKI-RURI	1,031,095.38	5.90
TOKI-TRURI	140,829.28	11.35

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	4,602.21	3.15
/data	12,181.43	0.20
/ssd	1,082.17	0.57

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	6.24	0.21

*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.