High-Speed Rotorcraft Research

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Responsible Representative

Yoshikazu Makino, Aeronautical Technology Directorate, Aviation Systems Research Unit

Contact Information

Masahiko Sugiura(sugiura.masahiko@jaxa.jp)

Members

Masahiko Sugiura, Keita Kimura, Hideaki Sugawara, Yasutada Tanabe, Kuniyuki Takekawa

Abstract

Compound helicopter is a one of the high-speed rotorcraft concepts. In high-speed compound helicopter, the rotor revolution is slower than the conventional helicopters, considering the effect of compressibility at the blade advancing side. In this case, a reverse flow region whose inflow comes from the trailing edge spread at the blade retreating side. Blade shapes which balance hovering performance and high-speed performance is desired in this complicated flow. This study aims to evaluate the aerodynamic performances of the optimal blade shapes designed by JAXA through numerical simulations.

Ref. URL: https://www.aero.jaxa.jp/eng/research/star/rotary/

Reasons and benefits of using JAXA Supercomputer System

Reason: There are many simulation cases, and the system is needed to get results efficiently.

Advantage: Large-scale simulation that requires much memory can be performed, and the results can be obtained efficiently.

Achievements of the Year

Numerical simulation regading blade tip shapes of the optimal rotor (high mu rotor) is conducted. Rotorcraft CFD code rFlow3D developed by JAXA is utilized in the simulations. The numerical grids are moving overlapped grids. Figure 1 shows grids used in the simulations. Overlapped grids consist of blade grids, inner/outer background grids.

Blade tips of three kinds of high mu rotors and the conventional helicopter rotor are computed to understand aerodynamic characteristics. Mach number and angle of attack of the blade tips are varied, considering rotor trim conditions. One of computational examples with experimental values is shown

in Fig. 2. It is seen from this figure that the pressure distributions of computation correspond extremely well with experiment. And figure 3 describes an example of the drag coefficient differences by turbulence models. The tendency that the drag coefficient computed by the transition model approaches the experimental results is confirmed.

In this numerical simulation, it is found that high mu rotor with swept back angle shows the highest performance, comparing aerodyanmic performances of the rotors comprehensively.

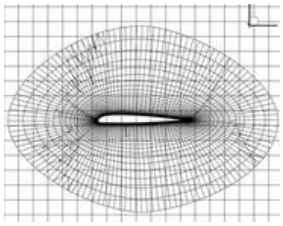

Fig. 1: Computational grid used in the simukations

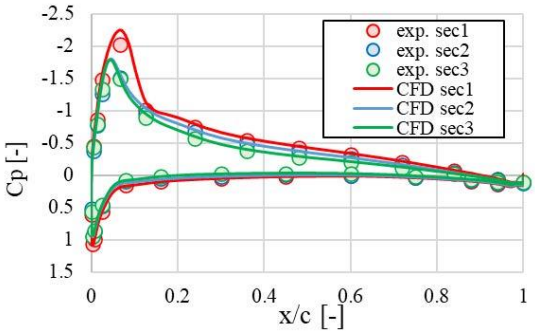

Fig. 2: Sample result of the pressure distribution

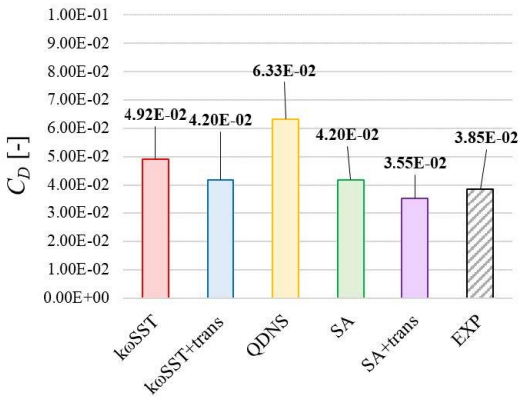

Fig. 3: Sample result of the drag coefficients by turbulence models

Publications

- Oral Presentations

Keita Kimura, Masahiko Sugiura, Yasutada Tanabe, Noboru Kobiki (JAXA), Hidemasa Yasuda, and Takuya Furumoto (KHI), "An Experimental and Numerical Study on Aerodynamic Performance of Blades for a High-Speed Compound Helicopter," 59th Aircraft Symposium (online), Dec. 2, 2021.

Usage of JSS

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	140 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.59

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	545,327.93	0.03
TOKI-ST	3,842,356.25	4.73
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	305,074.90	6.40
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	1,527.81	1.52
/data and /data2	12,287.23	0.13
/ssd	1,518.94	0.39

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	9.18	0.06

*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)	152.74	0.11

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