Numerical Study on Rotor Performance of Mars Helicopter

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Responsible Representative

Makoto Sato, Associate Professor, Kogakuin University

Contact Information

Makoto Sato, Kogakuin University(msato@cc.kogakuin.ac.jp)

Members

Makoto Sato, Kota Yoshikawa

Abstract

A Mars helicopter "HAMILTON" has been developed by JAXA, Tokyo Metropolitan University and Kogakuin University. Since the atomospheric density on Mars is about 1/100, the sound of speed is about 3/4 compared with those on Earth, we need to develop the high perfmance heli-rotor. In JAXA, the experimental measurements of the heli-rotor performance at low-Reynolds number condition have been conducted. In the present research, we have conducted numerical simulations on the Mars heli-rotor in order to clarify the characteristics of the flow field.

Reasons and benefits of using JAXA Supercomputer System

We need to conduct the large-scale simulations on the rotational wing flow using "rFlow3D", which has been developed in JAXA.

Achievements of the Year

Firstly, the numerical simulation on the Mars-heli rotor in the closed space has been conducted to investigate the closed space effects on the flow fields and rotor performances. Secondly, we have investigated the compressibility effects on the flow fields and rotor performances. The simulation solver is rFlow3D developed by JAXA, and the computational object is the single rotor of "HAMILTON"[1]. Here, we used the two airfoil shapes for the rotor-blade, CLF5605 airfoil and triangular airfoil.

Figure 1 shows the computational grids for the open and closed spaces with the low-pressure tank used in the experiment. Figure 2 shows the aerodynamic performances for the open and closed cases. Here, the experimental results are also shown. As the thrust coefficient increases, the effect of the closed space becomes more significant and the difference between the open space and the closed space becomes larger. On the other hand, for the low thrust coefficient cases, the difference becomes low, and the computational results agree with the experimental results well.

Figure 3 shows the compressibility effects for the heli-rotor with the CLF5605 airfoil blade. The results

indicate that the difference between the high tip Mach number case and the low tip Mach numbe case is very small.

Figure 4 depicts the flow fields for the heli-rotor with the CLF5605 and triangle airfoil. While the compressibility effects are low for both airfoil cases, the flow fields become different due to the airfoil shape.

[1] Sugiura, M., Tanabe, Y., Sugawara, H., Kimura, K., Oyama, A., Sato, M., Yoshikawa, K., Buto, Y., Kanazaki, M., Kishi, Y., Kikuchi, D., and Minajima, T., "Blade Shape Optimization of Mars Helicopter Exploring Pit Craters", VFS Forum 78-paper93, 2022.

Fig. 1: Computational object and computational grid

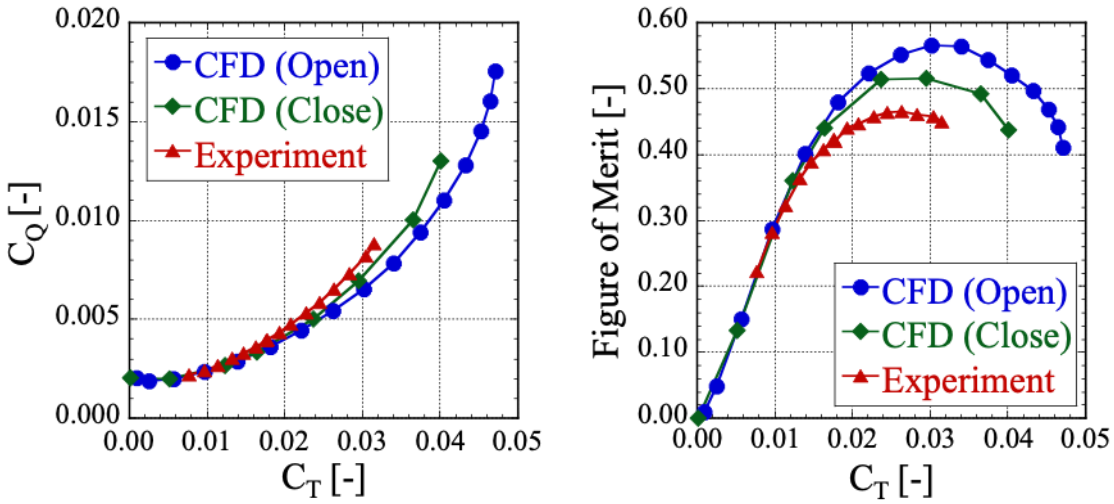

Fig. 2: Aerodynamic performances for open and closed space

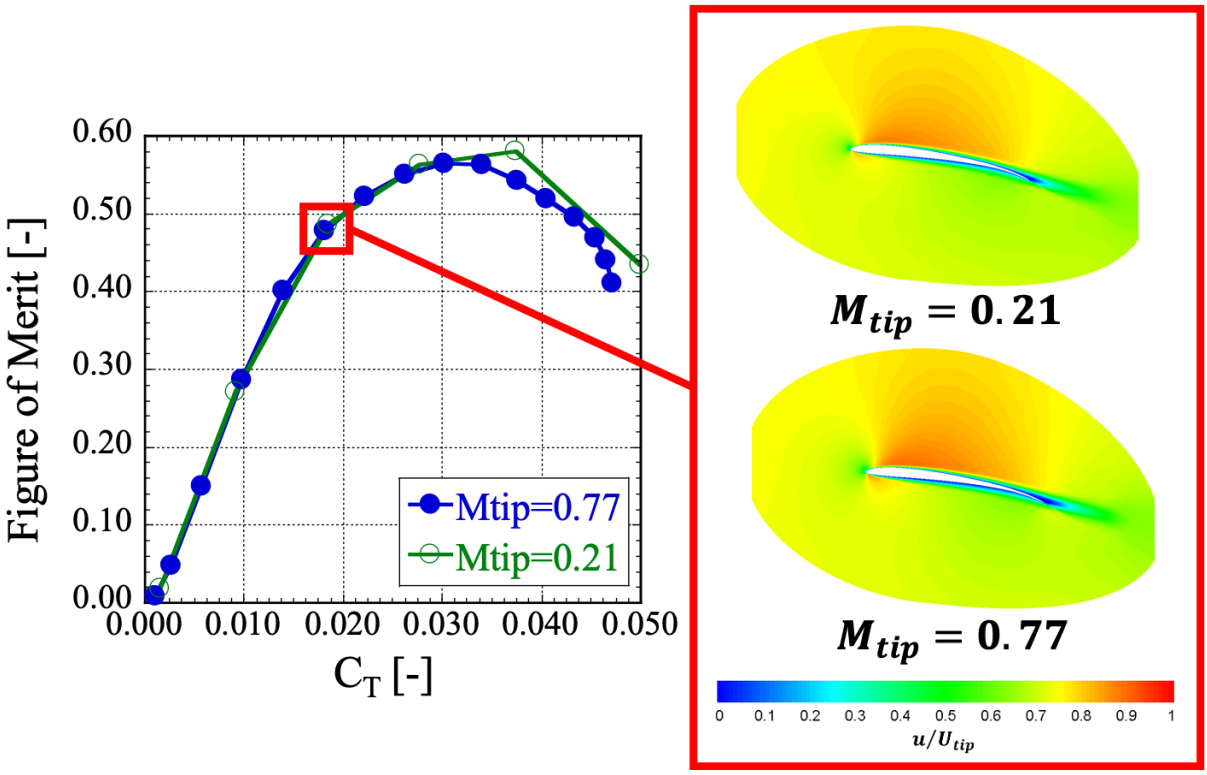

Fig. 3: Mtip effect on aerodynamic performance and flow field

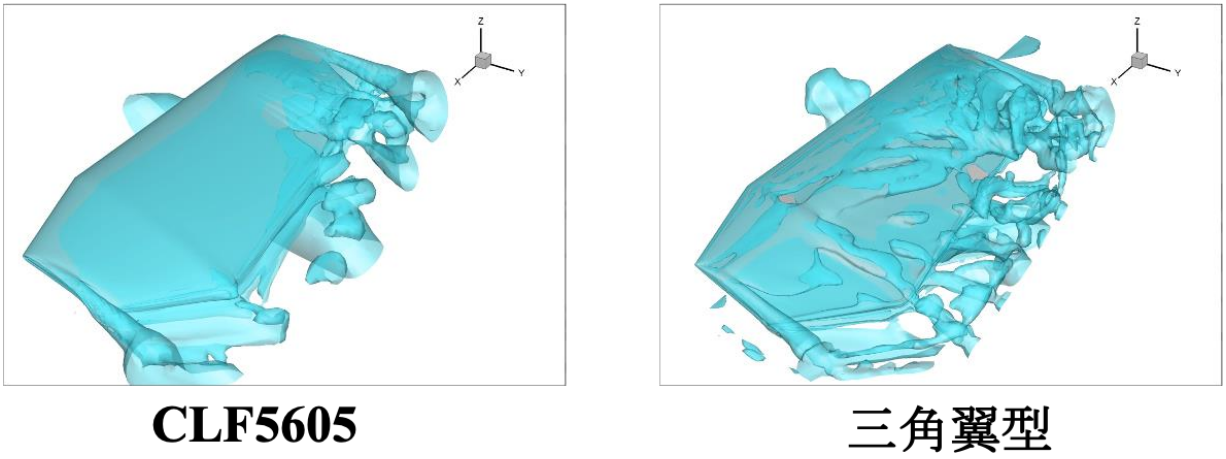

Fig. 4: Airfoil shape effect on flow field

- **Publications**

  N/A

- **Usage of JSS**

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	1920 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.02

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	568,031.81	0.02
TOKI-ST	2.00	0.00
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	15.00	0.01
/data and /data2	35,840.00	0.28
/ssd	150.00	0.02

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.