Numerical Study on Rotor Performance of Mars Helicopter

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Abstract

Mars helicopter project is now going. 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-rotar. In JAXA, the experimental measurements of the heli-rotar performance at low-Reynolds number condition have been conducted. In the present research, we conduct numerical simulations on the rotational flat-plate-airfoil flow 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

We have conducted the numerical simulation on the rotational flat-plate-airfoil flow. The computational object and conditions are decided based on the experiments at Tohoku University[1]. The computational parameters are the Reynolds number(7380-73800), pitch angle(0-30) and aspect ratio(2-4). Here, the results of AR=4 cases are shown. The flow solver is rFLow3D, which has been developed at JAXA.

Figure 1 shows Ct(thrust coefficient)-Cq(torque coefficient) curves. For the cases with low pitch angles, the trend of Ct-Cq curves is alomost the same. On the other hand, For the cases with high pitch angles, Ct-Cq curve of Re=7380 shows different trend from other cases. Figure 2 shows vortex structures around flat-plate-airfoil for the case with Re=7380, 73800 and pitch angle 20 degrees. The sequential sheddings of leading-edge vortices and their convections can be observed for the case of Re=73800. On the other hand, the relatively large-scale separation vortex is shed from the leading-edge. Figure 3 shows the vortex structures on the cross sections and Cp distributions. From the comparison between the case of Re=7380 and Re=73800, it can be said that the region of the flat Cp becomes larger in Re=7380 than that in Re=73800. This is because the large-scale separation vortex from the leading-edge results in the large reverse flow region above the airfoil in Re=7380.

In addition to the rotational flat-plate-airfoil, now we are conducting the simulation on the "triangle-airfoil". Figure 4 shows the vortex structure around the rotational triangle-airfoil. The separation vortex is clearly different from that of the flat-plate-airfoil. The detailed analysis will be conducted soon.

[1] Okoucuhi, M. "Experimental research on aero-characteristics of rotar at low-Reynolds numer condition", Master Thesis of Tohoku University, (2013).

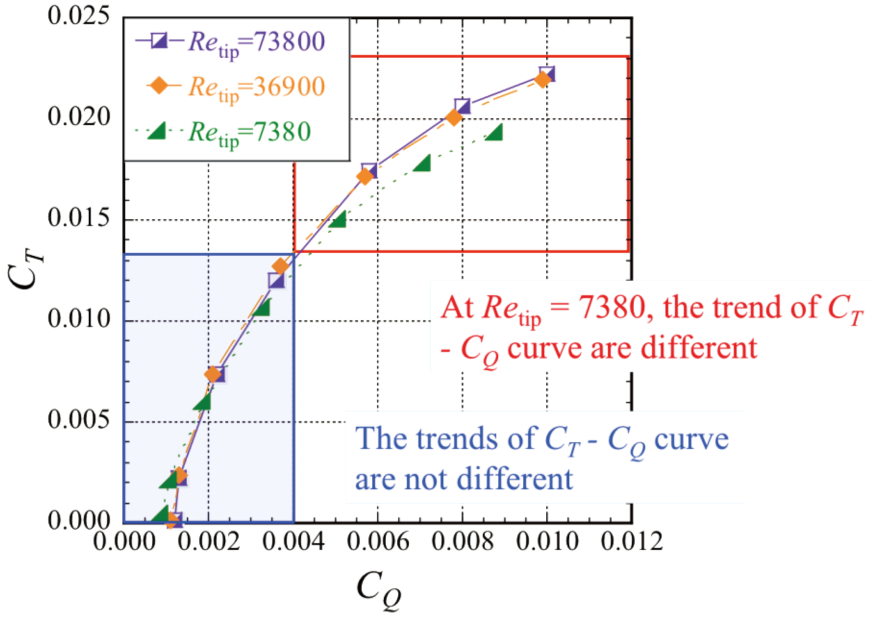

Fig. 1: Reynolds effect of Ct-Cq curve

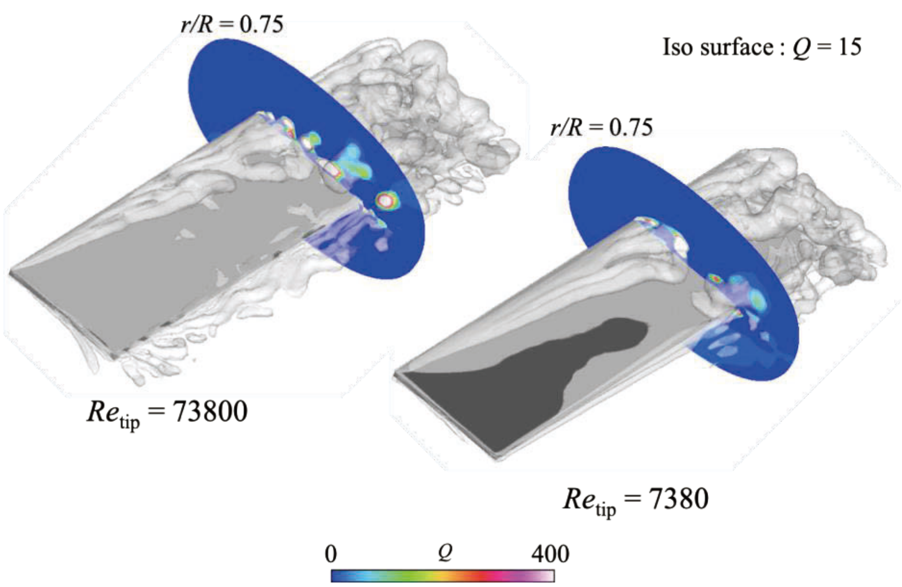

Fig. 2: Vortex structures around rotational flat-plate airfoil

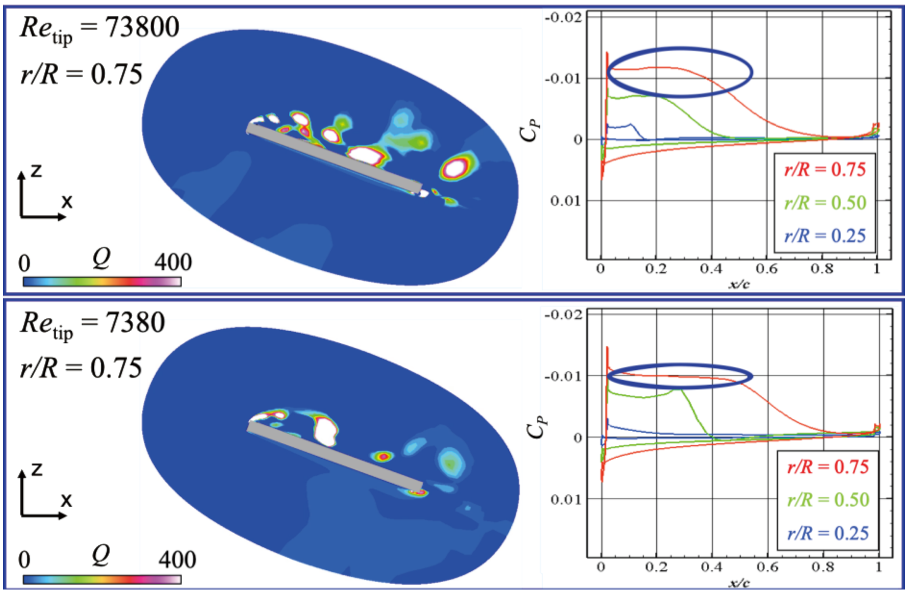

Fig. 3: Vortex structures and Cp distributions

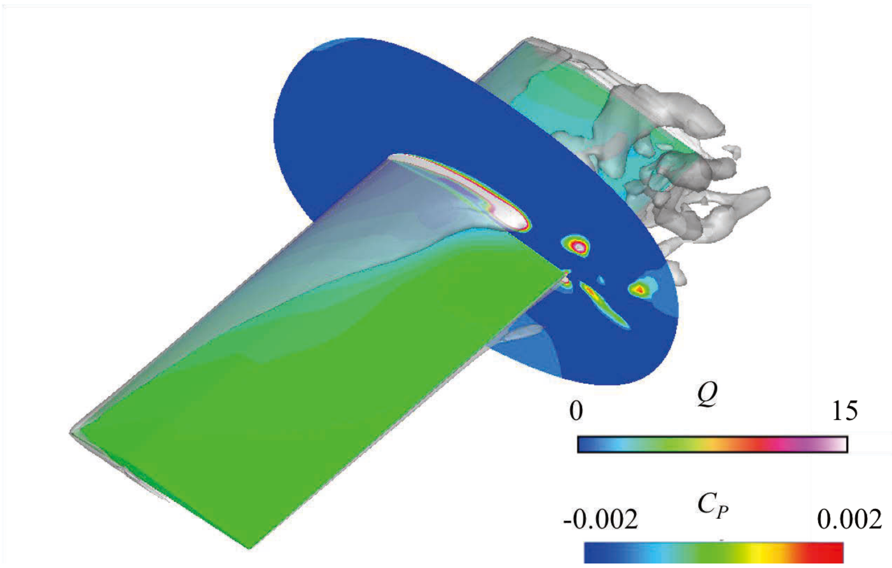

Fig. 4: Vortex structures around rotational triangle airfoil

Publications

- Oral Presentations

D. Ogasawara, M. Sato, H. Sugawara, Y. Tanabe, "Numerical simulation of a rotating blade using a flat-plate airfoil at low Reynolds numbers for Mars helicopter", 72nd Annual Meeting of the American Physical Society Division of Fluid Dynamics

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	400 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.18

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	469,490.28	3.04
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	19.07	0.02
/data	19,531.26	0.33
/ltmp	3,906.25	0.33

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.