Numerical Study on Rotor Performance of Mars Helicopter

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Abstract

Mars helicopter project is now going. Since the atmospheric 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 performance 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 conduct numerical simulations on the rotational flat-plate-airfoil flow in order to clarify the characteristics of the flow field.

Reasons for using JSS2

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

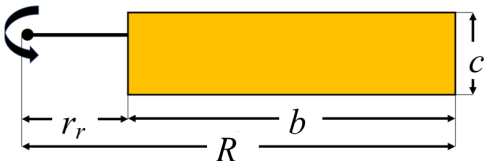
We have conducted the numerical simulation on the rotational flat-plate-airfoil flow. The computational object and conditions are decided based on the experiments at Tohoku University[1].

Figure 1 shows the schematic diagram of computational objects. The computational parameters are the Reynolds number (3,870-77,300), angle of attack (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 2 shows the coefficients of thrust and torque with experimental data. The simulation results are good agreement with those of experiment, except for the large angle of attack cases. Figure 3 shows vortex structures around flat-plate-airfoil. The leading-edge vortex and tip vortex can be observed. These vortices are interacted with each other. Figure 4 shows the coefficients of surface friction with experimental data. The simulation results are good agreement with that of experiment.

These results indicate that the present simulations are sufficiently reliable.

[1] Okoucuhi, M. “Experimental research on aero-characteristics of rotor at low-Reynolds number condition”, Master Thesis of Tohoku University, (2013).



AR	コード長 *c*[mm]	ローター半径 *R*[mm]	スパン長 *b*[mm]	切欠き半径 r_r[mm]	ブレード枚数 N_b
4	31.6	151.5	126.5	25	2

Fig. 1: Schematic diagram of computational object

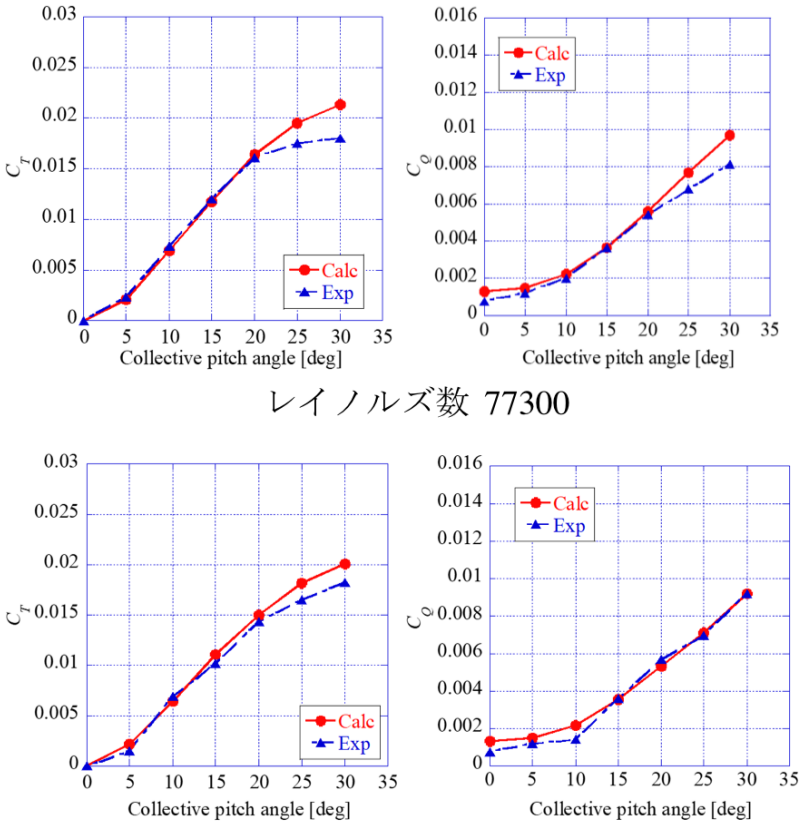


Fig. 2: Thrust and torque coefficients

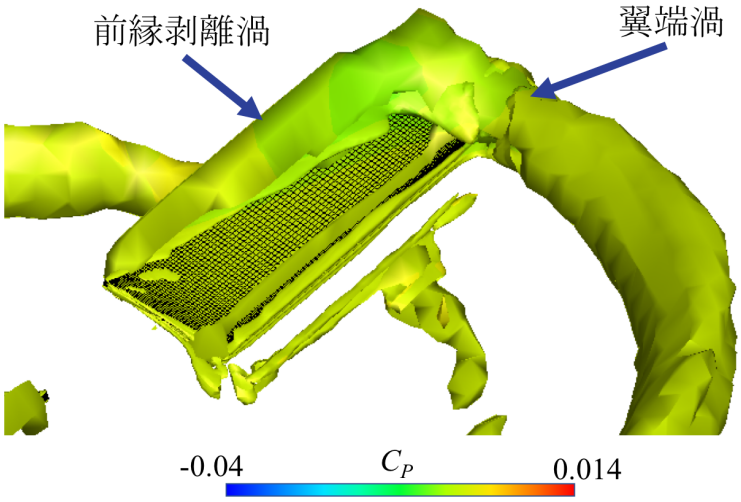


Fig. 3: Vortex structures around airfoil

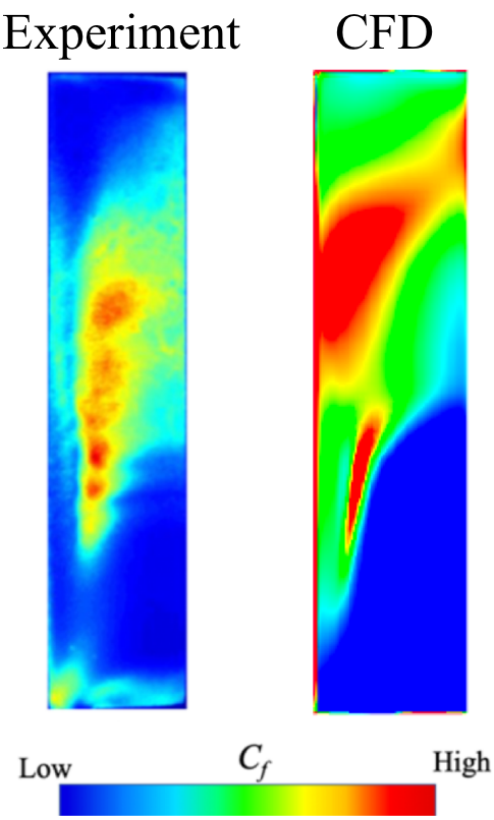


Fig. 4: Friction coefficients

Publications

- Oral Presentations

Daichi Ogasawara, Makoto Sato, Yasutada Tanabe, Hideaki Sugawara, “Numerical simulations on rotational flat-plate-airfoil flow using rFlow3D”, 1st Symposium on Mars helicopter, 2019.

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] (%): 0.17

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2] (%)
SORA-MA	881.82	0.00
SORA-PP	269,181.44	2.15
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	0.34
/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.