Study on Conceptual Design and Blade Shape Optimization of Mars Helicopter

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Abstract

The purpose of this study is to propose a concept of a Martian helicopter and to obtain an aerodynamically optimal rotor blade shape based on the conceptual design of the Martian helicopter to propose an optimal helicopter airframe shape and blade shape in the Martian atmospheric environment. The obtained blade shape is evaluated by the computational fluid dynamics.

Reasons and benefits of using JAXA Supercomputer System

A large number of CFD calculations are required for the design optimization of the rotor blade shape. Besides, a highly accurate 3D CFD is required to evaluate the aerodynamics of the conceptual design results. For these reasons, we selected the JAXA supercomputer.

Achievements of the Year

In this study, the design optimization of the rotor blades and 3D CFD for a six-rotor concept were conducted. In the design optimization, the optimum blade shape was obtained under low Reynolds number flow conditions by employing the evolutionary algorithm and the CFD software, FaSTAR. The airfoil shape obtained by the optimization has a concave surface on the leading edge of the upper surface. This indicates that the flow structure utilizes the recirculation region to obtain lift. In the 3D CFD of the six-rotor conceptual model, the flow structure as shown in Fig. 1 was obtained using rFlow3D. Based on these results, rotor blades' performances were evaluated. It was found that the efficiency per rotor was lower with the six-rotor of the conceptual design than that with the single rotor. The efficiency of each rotor was improved by modifying the rotor arrangement, and the design knowledge for the detailed design for the concept was obtained.

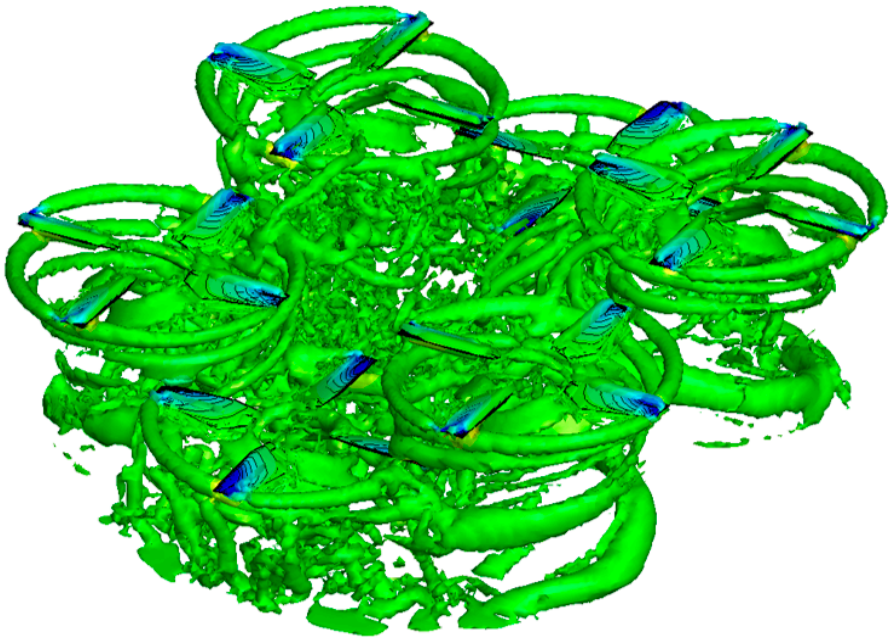

Fig. 1: Visualization of the flow obtained by the CFD for the six-rotor conceptual model

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	480 Hour(s)

- **Resources Used(JSS2)**

Fraction of Usage in Total Resources[*1](%): 0.14

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	348,521.34	0.07
SORA-PP	59,052.97	0.46
SORA-LM	38.37	0.02
SORA-TPP	26,516.46	2.50

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	4,241.50	3.89
/data	25,603.88	0.49
/ltmp	4,048.04	0.34

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2](%)
J-SPACE	7.74	0.26

[*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](%): 0.49

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.00	0.00
TOKI-RURI	688,095.49	3.94
TOKI-TRURI	161,728.55	13.03

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	5,240.38	3.59
/data	34,154.09	0.57
/ssd	1,233.17	0.64

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2](%)
J-SPACE	7.74	0.26

[*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.