Research and Development of Highly Efficient Propellers Covering a Wide Range of Speeds

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Abstract

Currently, SLT is developing a tilt-wing VTOL aircraft. It is necessary to develop a propeller that can demonstrate high efficiency over a wide range of speeds from low to high to meet the requirements of this aircraft. The propeller is designed using the vortex method, and the validity of the design is confirmed by wind tunnel testing. In this study, the validity of the design is verified by CFD along with the wind tunnel testing.

Reasons and benefits of using JAXA Supercomputer System

The purpose of using JAXA's supercomputer is to achieve high-speed computation and massive parallelization, enabling large-scale calculations to be performed in a short time. In the analysis of the flow field around the tilt-wing VTOL aircraft propeller, which is the subject of this study, the computational domain is extensive, and analyses of different flight modes are also required. Therefore, to conduct the analysis within the limited project period, it was essential to perform large-scale calculations in a short time. The obtained numerical analysis results will be utilized for evaluating the propeller design methodology and elucidating the flow structure around the propeller, contributing to the development of a high-efficiency tilt-wing VTOL aircraft propeller.

Achievements of the Year

The purpose of this study is to develop a propeller for tilt-wing VTOL aircraft that can achieve high efficiency across a wide speed range, from low to high speeds. Two types of propellers are being considered for actual implementation: a variable-speed propeller, which reduces its rotational speed during cruise compared to hovering, and a fixed-speed propeller, which maintains the same rotational speed in both flight modes. In this study, a design methodology for these high-efficiency propellers was developed, and its validity was verified by designing and manufacturing an 18-inch diameter propeller model. Furthermore, aerodynamic performance tests were conducted, along with three-dimensional numerical simulations of the airflow around the propeller using TOKI, to evaluate

the accuracy of the design methodology. A steady-state analysis using the SST k-ω model was employed for the numerical simulations. As a result, the experimental results and aerodynamic performance closely matched the design values, confirming the validity of the proposed design methodology. On the other hand, while the numerical simulations faced challenges in quantitative analysis due to mesh resolution issues, they successfully clarified the qualitative flow characteristics around the propeller blades during both hovering and cruising.

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 8
Elapsed Time per Case	40 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.01

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.00	0.00
TOKI-ST	12,953.67	0.01
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	11,100.75	0.80
TOKI-TST	0.20	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	0.00	0.00
/data and /data2	0.00	0.00
/ssd	0.00	0.00

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)	506.92	0.35

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