Computational Study on Aerodynamic Characteristics of Slender Body Configurations

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Abstract

In this study, we attempted to improve the aerodynamic characteristics by attaching delta-wings and vortex-flaps to a slender body. Since the thickness of the fins is small, it is difficult to carry out the wind tunnel experiment. However, we succeeded in acquiring aerodynamic characterisitics and flow visualizations by numerical analysis. In the future, it is a goal to study better aerodynamic devices such as the shape of fins.

Reasons for using JSS2

Goal

We clarify the mechanism by which aerodynamic device affects a slender body, and we propose an excellent shape.

Necessity

According to the previous studies, in order to resolve vortices generated around the body and fins, it is known that the unsteady calculation needs at least 30 million elements. Therefore, we used JSS2 so as to reduce computational time.

Use

Since it was necessary to reduce the computational time for large-scale calculation, we used JSS2.

Achievements of the Year

We attached delta-wings and vortex-flaps on a slender body, and acquired an aerodynamic coefficient and visualize a flow field. Fig. 1 shows the fin shapes. We calculated three cases and we calld the case of only body as Body-alone, the case of not deflected fins as Flap _ 0, and the case of the flap deflacted by -30 degrees as Flap_-30, respectively. Fig. 2 shows Cm characteristics. Comparing Body-alone and Flap_0, Flap_0 was totally able to reduce Cm, however absolute value increased at the backward angles (angles of attack from 90 degrees to 180 degrees). Therefore, comparing Flap_0 and Flap_-30 in the backward angles, Flap_-30 can reduce the absolute value because, by deflecting flaps, the pressure difference between upper and lower surface of the fins became smaller and then the normal force became smaller (Fig. 3 and 4).

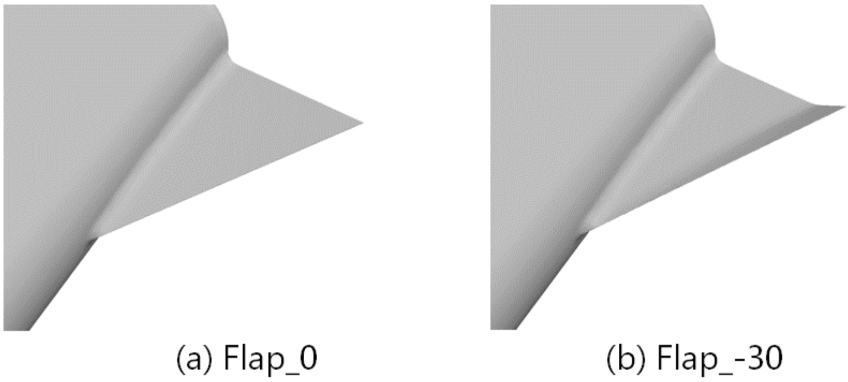

Fig. 1: Fin shape with each flap angles

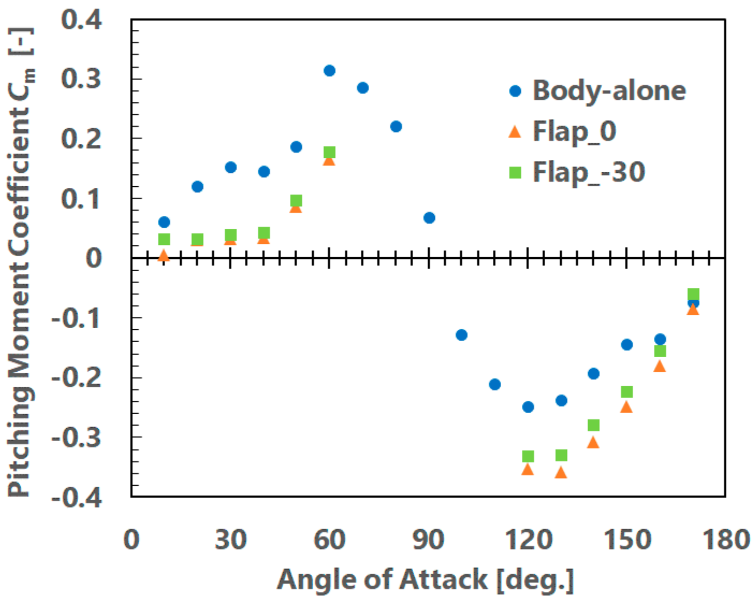

Fig. 2: Pitching Moment Coefficient (Cm) Characteristics

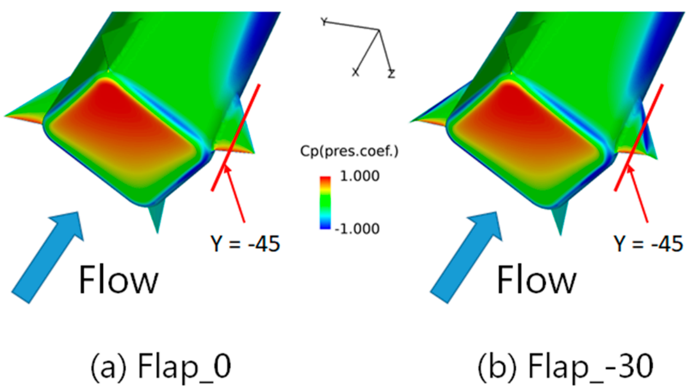

Fig. 3: Cp distribution of the body

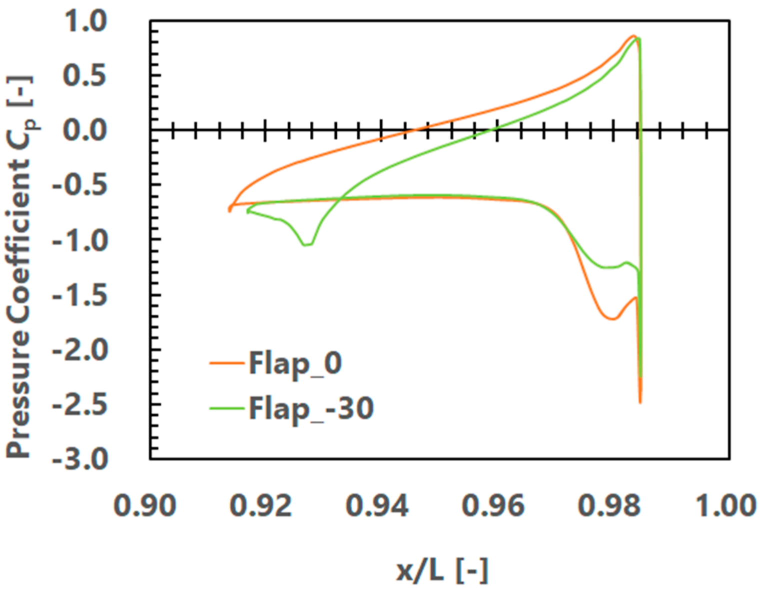

Fig. 4: Plane Cp distribution at Y = -45

Publications

- Oral Presentations

Takagi, Y., Aogaki, T., Kitamura, K., and Nonaka, S.: Numerical Study on Aerodynamic Improvement of Slender-bodied Reusable Rocket by Fins and Vortex Flaps, 15th International Space Conference of Pacific-basin Societies, Montreal, Canada, 2018.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512 - 1024
Elapsed Time per Case	100 Hour (s)

- **Resources Used**

Fraction of Usage in Total Resources[*1] (%): 0.28

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2] (%)
SORA-MA	2,289,004.68	0.28
SORA-PP	20,758.14	0.17
SORA-LM	13,224.09	6.17
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	25.75	0.03
/data	4,901.89	0.09
/ltmp	1,367.19	0.12

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	1.22	0.04

[*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.