Computational Study on Aerodynamic Characteristics of Slender Body Configurations

Report Number: R19EACA12
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11539/

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Abstract

In this study, we conducted CFD on the aerodynamics of the RV-X with a double-cone nose. In particular, we forcused on the side-force characteristics at high-angles of attack, and we performed large-scale calculations. The side-force characteristics betweeen wind tunnel testing and CFD at 60° angle-of-attack were qualitatively matched, and the flow field by CFD was qualitatively consistent with the surface flow field visualized by an oil-flow technique. In addition, we succeeded in clarifing the side force mechanism at 60° angle-of-attack. In the future, we try to clarify the side force mechanism at 90° and 120° angle-of-attack.

Reasons and benefits of using JAXA Supercomputer System

Goal

We clarify the mechanism of the side-force generation on slender-body such as the reusable rockets at high angles of attack, and give insights on actual flight.

Nesessity

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. However, in the side force analysis, 180 million elements are needed to resolve the vortices near the boundary layer. 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 performed the calculations about the reusable rocket experimental vehicle RV-X, and we obtained the

aerodynamic coefficients and flow fields. Especially, we focused on the mecanism of the side-force generations at high angles of attack. Fig. 1 shows the mesh configuration, we reproduced both the body part and the sting part in the experimental setup. Fig. 2 shows the validations about the pitching moment and the side-force characteristics, and the calculated and exparimental results were qualitatively in good agreement. Particulary, we focused on the side-force generation mechanism at angle of attack 60°. We found that the side-force was gradually generated with the separated vortices at both first and second cones, and side-force increased toward the aft of the body (Fig. 3, Fig. 4).

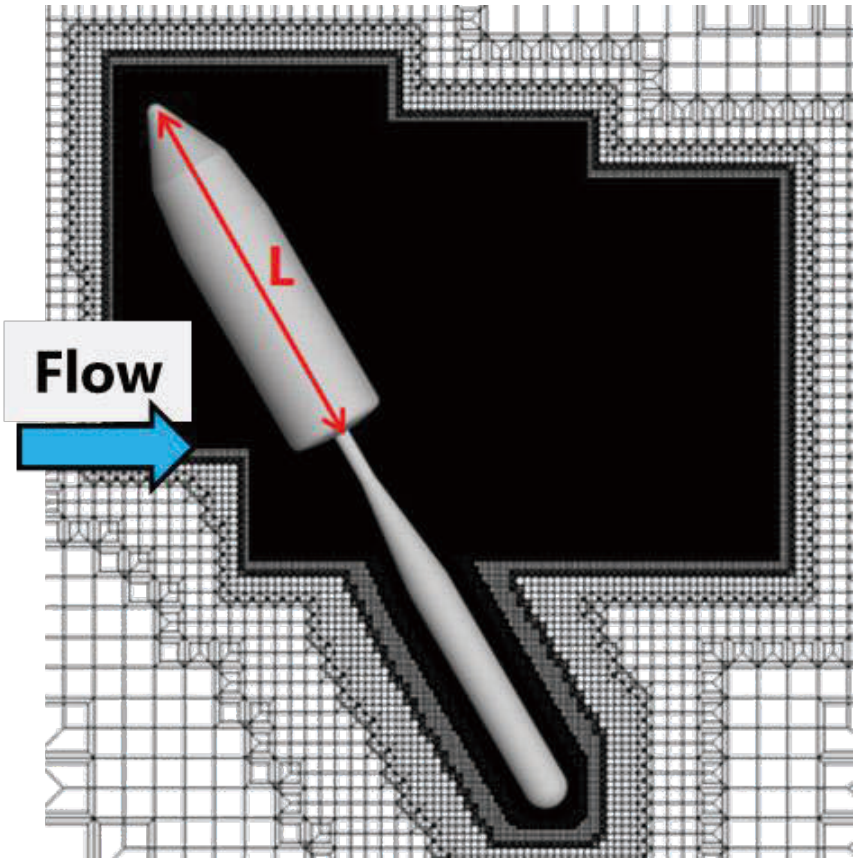

Fig. 1: Mesh Configuration.

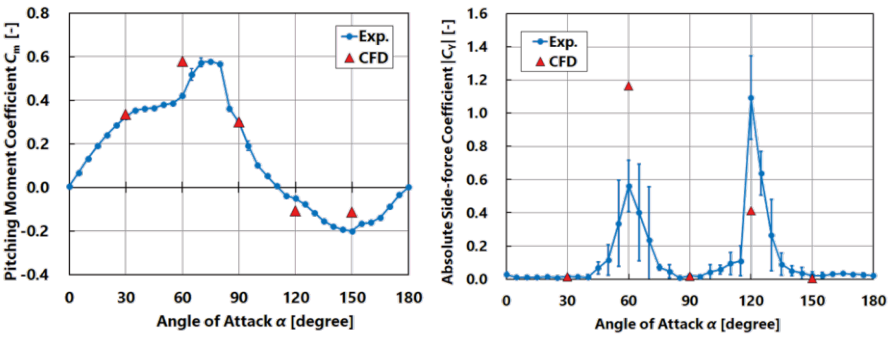

Fig. 2: Comparisons of Aerodynamic Coefficient between Calculated and Experimental results.

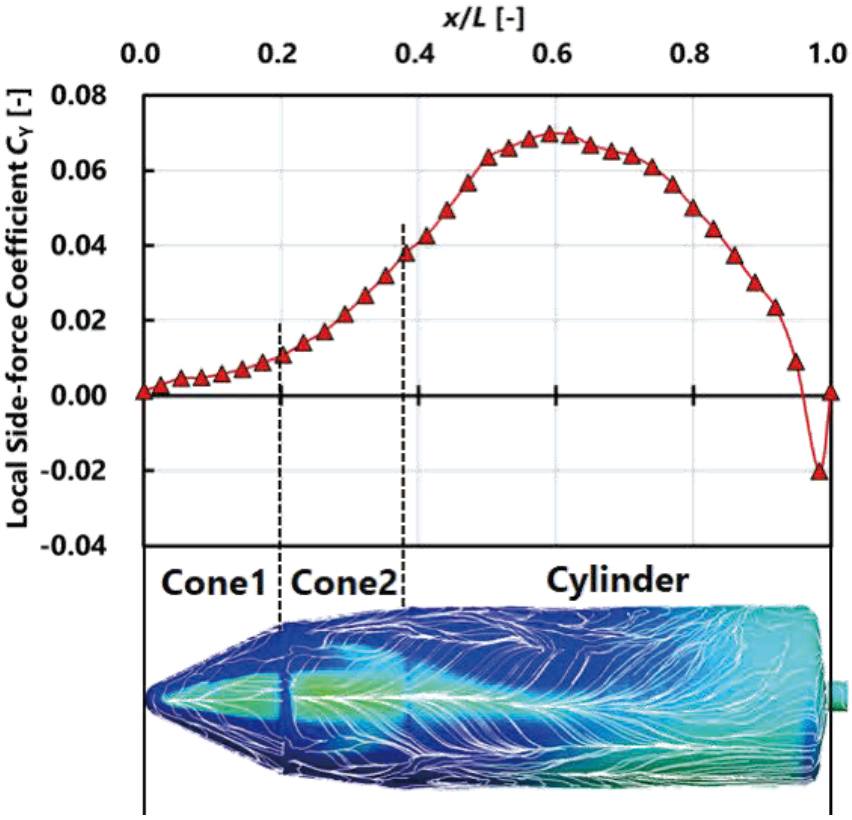

Fig. 3: Local Side-Force Coefficient and Pressure Distribution at AOA 60°

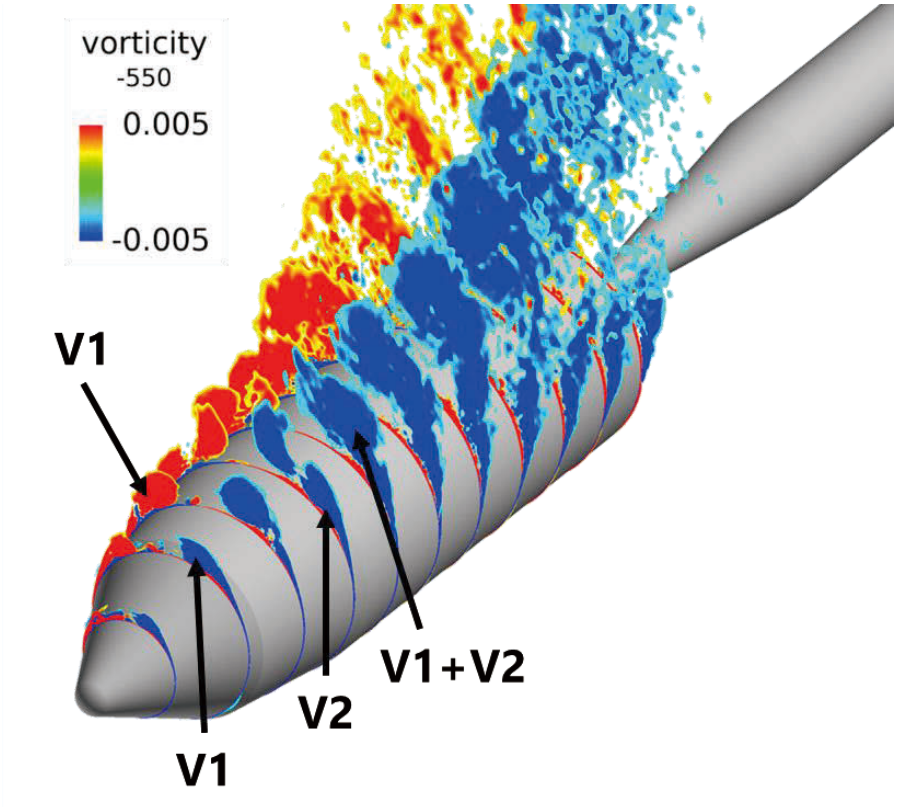

Fig. 4: Vorticity Magnitude at AOA 60°

Publications

- Oral Presentations

Yuya Takagi, Keiichi Kitamura, and Satoshi Nonaka: Delayed Detached-Eddy-Simulation on High Angle-of-Attack Aerodynamic Characteristics of Slender-Bodied Reusable Rocket with Fins and Vortex Flaps, 50th JSASS Annual Meeting, Meguro, 1C09, 2019 (in Japanese).

Yuya Takagi, Tomotaro Muto, Keiichi Kitamura, and Satoshi Nonaka: Wind Tunnel Testing and Numerical Analysis on High Angle-of-Attack Characteristics of Double-Cone Reusable Rocket, 63rd Space Sciences and Technology Conference, Tokushima, 1H-04, 2019 (in Japanese).

- Poster Presentations

Yuya Takagi, Keiichi Kitamura, and Satoshi Nonaka: Delayed Detached-Eddy-Simulations on High Angle-of-Attack Aerodynamic Characteristics of Slender-Bodied Reusable Rocket with Vortex Flaps at Different Deflection Angles, 63rd Space Sciences and Technology Conference, Tokushima, P71, 2019 (in Japanese).

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512 - 4096
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.30

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,883,212.00	0.23
SORA-PP	28,132.33	0.18
SORA-LM	29,529.45	12.33
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	240.33	0.20
/data	4,901.89	0.08
/ltmp	1,367.19	0.12

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.