The Effect of Protuberant Devices on Aerodynamic Characteristics of Slender Body Vehicle

Report Number：R17EACA20
Subject Category：JSS2 Inter-University Research
URL：https://www.jss.jaxa.jp/ar/e2017/4413/

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Abstract

It is important for rocket developments to quantitatively estimate the influence of protuberances in the flight vehicles which create asymmetry of flow around the vehicles and aerodynamic forces. Using fluid numerical computation, it is expected that we obtain a guideline for the protuberance choice in the future rocket development by conducting systematic and fundamental aerodynamic study on protuberance i) positions and ii) sizes allowed to arbitrary flight vehicles.

http://www.aero.ynu.ac.jp/index_en.html

Reasons for using of JSS2

This study needs expensive numerical fluid analyses around flight vehicles equipped with protuberances. Therefore, it is unrealistic that this scale of numerical calculations be carried out 100 times with workstations in the university, requiring 2.5 million grid points. Therefore, we use JSS2 in order to ensure larger memories and to save the cost of numerical calculations.

Achievements of the Year

The protuberance (Fig. 1) was installed on the surface of rocket (cone -cylinder). Then, by changing its positions (1.front, 2.center of gravity, 3.aft of the rocket), we conducted numerical calculations. We calculated at M =1.5 and angles of attack increased from 0 deg. to 20 deg. with 5 deg. intervals. According to the results, changing the protuberance position affected supersonic aerodynamic characteristics of the vehicle, especially the roll moment, side force, and yaw moment. We found that the roll moment was minimized when the protuberance was located at aft of the rocket because the formation of its wake vortex affected the roll moment.

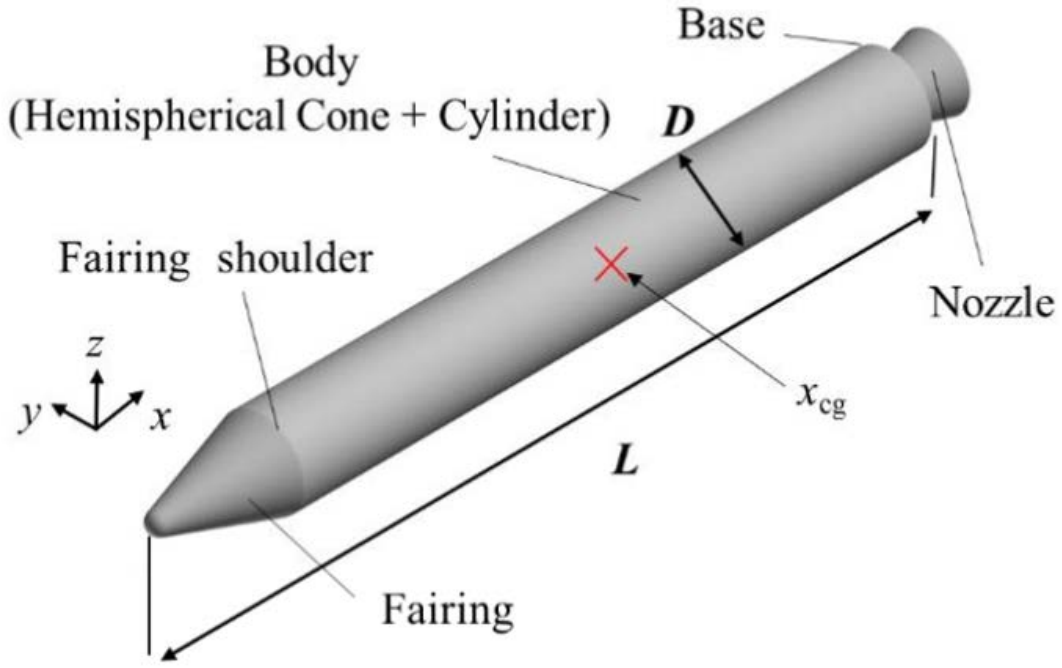
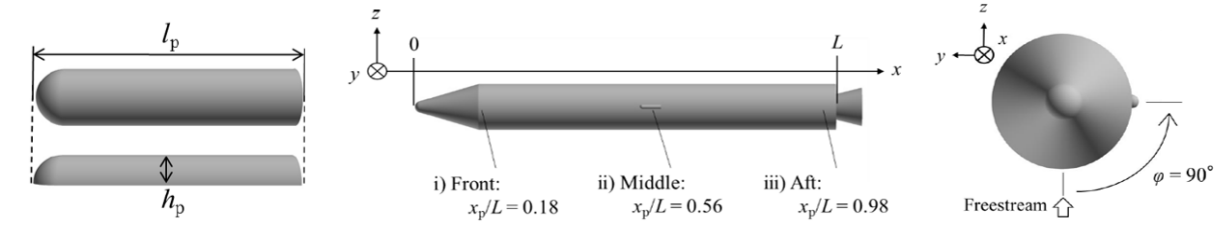


Fig.1 Outline of the flight vehicle (Body + Nozzle)



(a) Protuberance (hemisphere-cylinder). (b) Protuberance position (x axis). (c) Protuberance position (roll angle).

Fig.2 Outline and position of the protuberance

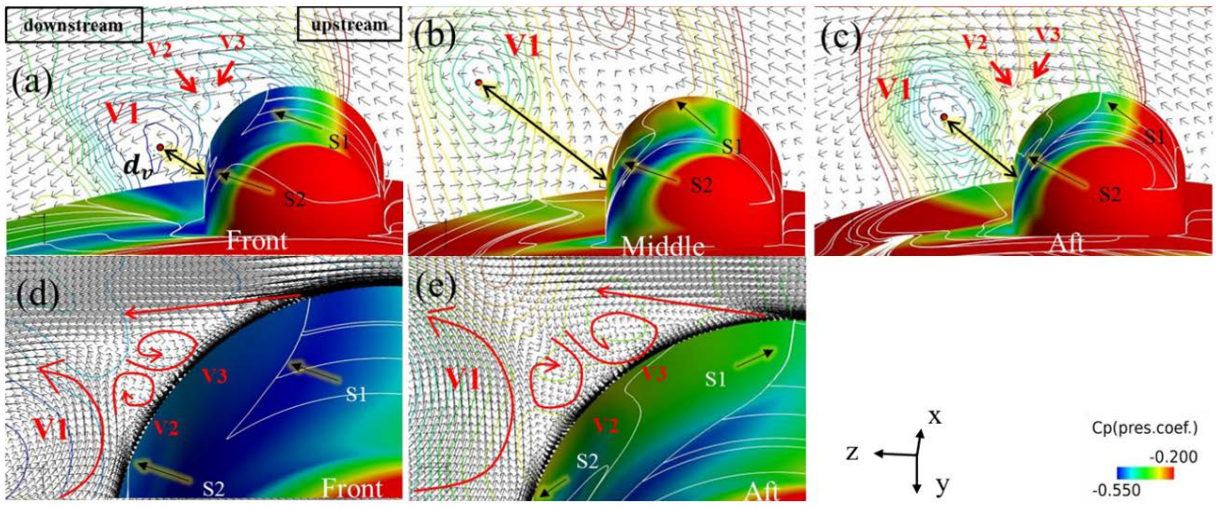


Fig.3 Difference of wake vortex structures due to protuberance position
[(a)front, (b) middle, (c)aft, (d) front (close-up), (e) aft (close-up)]

Publications

- Peer-reviewed papers

1) Toshiaki Harada, Keiichi Kitamura, Satoshi Nonaka: Roll Moment Characteristics of Supersonic Flight Vehicle Equipped with Asymmetric Protuberance, The 31st ISTS Special Issue of Transaction of JSASS (Accepted).

- Presentations

1) Toshiaki Harada, Keiichi Kitamura, Satoshi Nonaka: The Effect on Flight Vehicle Aerodynamic Characteristics with Protuberant Devices, 2C04, The 48th JSASS Anual Meeting, Tokyo, Japan, Apr. 2017 (in Japanese).
2) Toshiaki Harada, Keiichi Kitamura, Satoshi Nonaka: Aerodynamic Analysis on Flight Vehicle with Protuberant Devices, 2017-e-29, 31st International Symposium on Space Technology and Science, Ehime, Japan, Jun. 2017.

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	320
Elapsed Time per Case	6.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.02

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	190,500.20	0.03
SORA-PP	1,848.02	0.02
SORA-LM	74.93	0.04
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	007.15	0.00
/data	071.53	0.00
/ltmp	1,464.84	0.11

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	0.24	0.01

*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