Aerodynamics of Re-entry Capsule with Hyperbolic Contours

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Abstract

For deleveopment of future sample return capsule, we applied the hyperbolic contours to design the front shape of the capsue. To find the optimal shape of the capsule, we perfomed CFD analyses.

Reasons and benefits of using JAXA Supercomputer System

There have been many shapes depending on the parameter for hyperbolic curves with various flight conditions such as Mach number and AoA.

Achievements of the Year

In order to select an aerodynamically superior capsule shape for the development of a future sample return capsule, a capsule frontal shape was designed using a hyperbolic shape that would be similar to the Hayabusa capsule, and the aerodynamic characteristics of this shape were investigated. For the analysis, the JSS version of FaSTAR was used, and HexaGrid v1.1 was used for mesh generation. The pressure distribution on the symmetrical surface of the capsule was measured in ISAS supersonic wind tunnel and compared with the analytical results. The results of the comparison of the surface pressure distribution are shown in Figure 1. In the case of the Hayabusa shape, the pressure reaches its maximum value at the stagnation point and decreases toward the shoulder, but there is a minimum value in the middle of the pressure distribution. This position is the connection region between the sphere head and the cone. On the other hand, in the case of a hyperbolic shape, there is no minimum value and the pressure decreases monotonically toward the shoulder. This trend was confirmed for all Mach numbers in the supersonic region. This trend is maintained even when the angle of attack is changed, confirming that the frontal pressure distribution can be adjusted by using the hyperbolic shape.

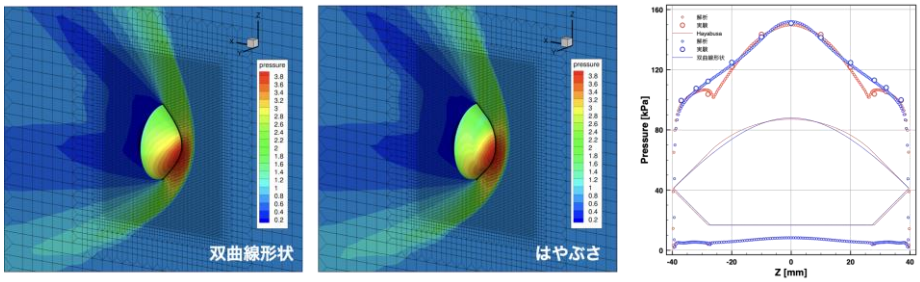

Fig. 1: Comparison of pressure distribution for Hayabusa capsule and the capsule with hyperbolic contour

Publications

- Oral Presentations

"Fabrication of experimental wind tunnel model using 3D printer and its application to supersonic wind tunnel experiments," ISAS2022-SFMA-046

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	64
Elapsed Time per Case	30 Minute(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	25.25	0.00
TOKI-ST	47.87	0.00
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	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	25.00	0.02
/data and /data2	250.00	0.00
/ssd	250.00	0.03

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)	0.00	0.00

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