

Numerical Study of Hypersonic Intake

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● Abstract

JAXA is developing a hypersonic turbojet which work at less than Mach 1 to Mach 5. The intake of the hypersonic turbojet reduces air speed and compresses air. We conducted the CFD analysis to understand these flow field and operating conditions and develop a higher efficiency hypersonic turbojet.

<http://www.aero.jaxa.jp/eng/research/frontier/hst/>

● Reasons for using of JSS2

We need to calculate about 30 unsteady or steady three dimensional models to investigate the performance of the inlet for High Mach Integrated Control experiment. We use fast flow solver FaSTAR developed by JAXA for the CFD analysis.

● Achievements of the Year

The inlet for High Mach Integrated Control experiment; HIMICO has a variable geometry inlet and the height of inlet throat can be changed by moving the 2nd and 3rd ramps. The inlet has a clearance between the 2nd or 3rd ramps and the side wall to avoid interference between them. We call this side-clearance and define the width of side-clearance as w_{side} . Numerical simulation has been conducted to investigate the side-clearance effect on the Inlet performance of HIMICO by comparing several cases each of which has different w_{side} .

(Fig.1) and (fig.2) show Mach number contours along the center line (Upper) and the line 16.5 mm away from the center line (Lower). (Fig.1) is the case at the nozzle height =13 mm and (fig.2) is the case at the nozzle height=9 mm. From (fig.1), we can see that a large flow separation at the 2nd ramp occurs only when $w_{side}=1$ mm at the center line. On the other hand, it occurs when $w_{side}=0.5$ mm, 0.75 mm, and

1 mm nearby the side wall and an oblique shock from the 2nd ramp leaks to out of the inlet. From (fig.2), we can see the same flow separation when $w_{side}=0.5$ mm, 0.75 mm, and 1 mm at the center line.

(Fig.3) shows performance maps each w_{side} . The performance map of the case $w_{side}=1$ mm agrees with EFD results within 5% errors of mass capture ratio; MCR and that of the case $w_{side}=0$ mm agrees with theoretical value within 2% errors of MCR. From these results we concluded that the cause of the MCR difference between EFD results and theoretical value is the side-clearance and the leaking to out of the inlet of an oblique shock from 2nd ramp causes the MCR reduction of EFD results compared with theoretical value.

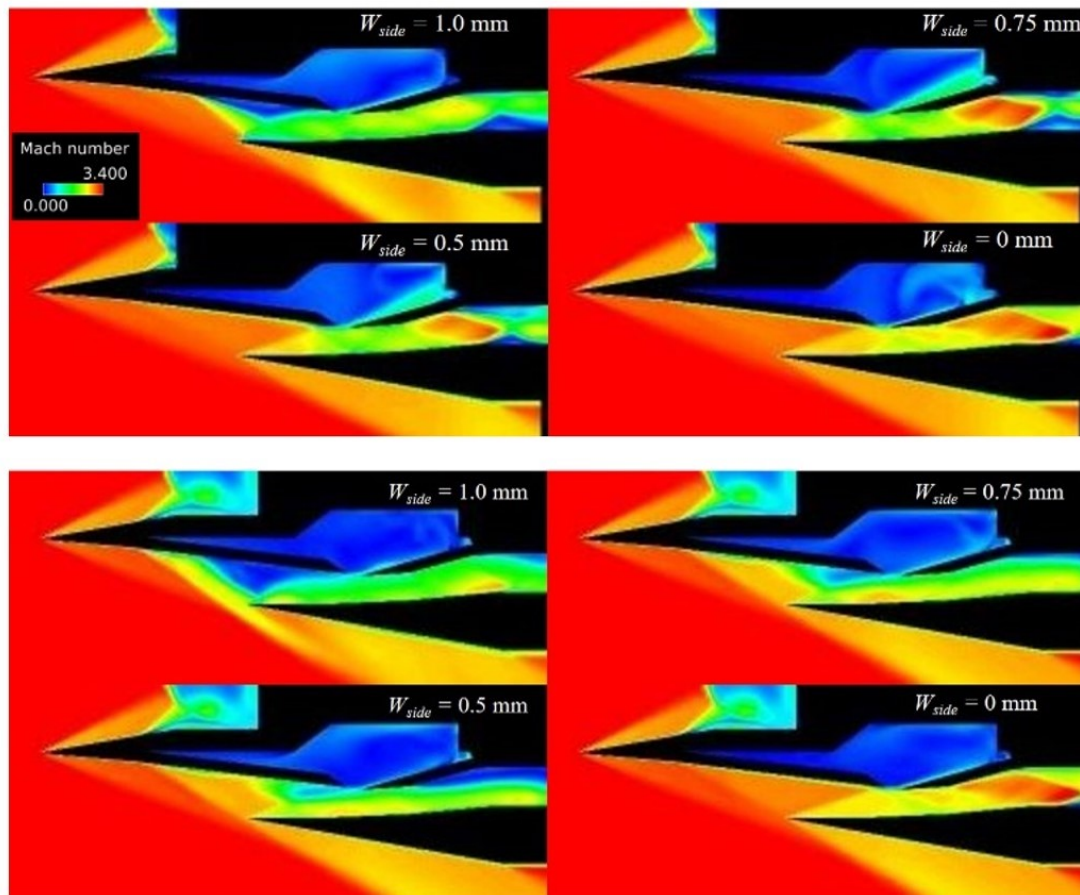


Fig.1 Mach Number Contour along center line (Upper) and nearby the side wall (Lower) at height of nozzle= 13 mm

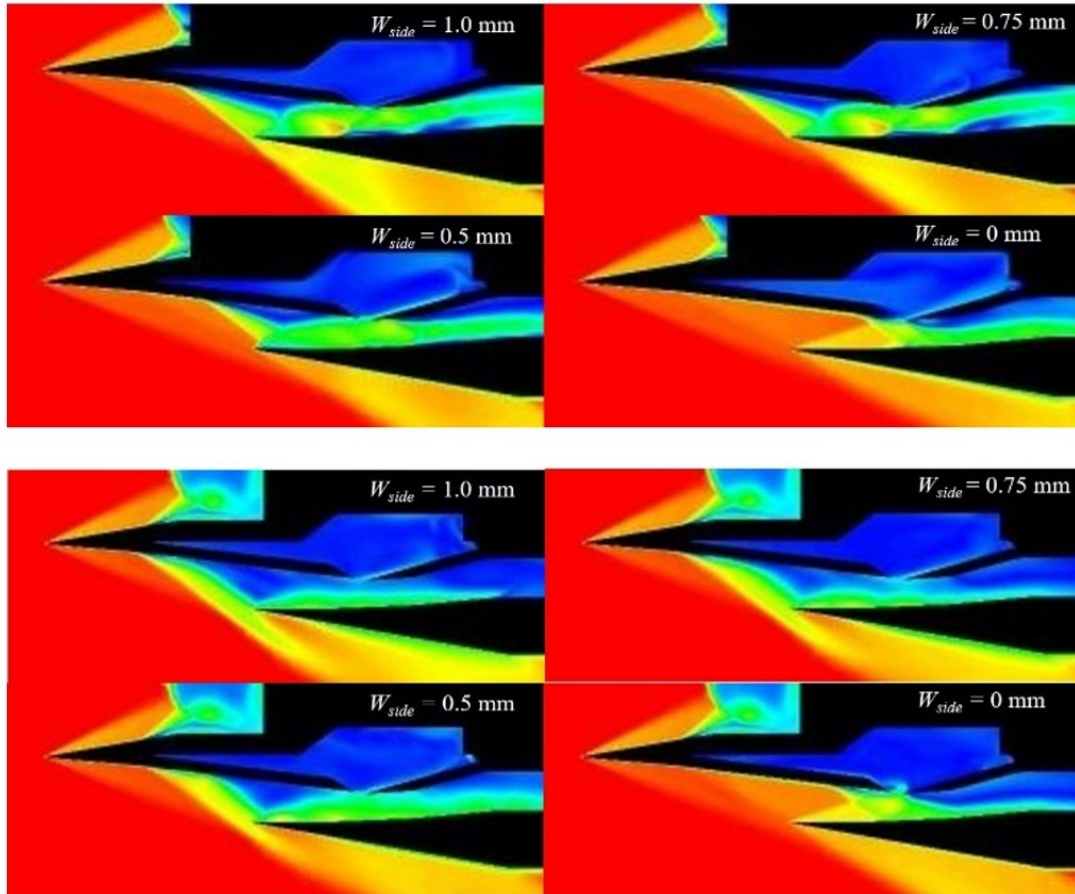


Fig.2 Mach Number Contour along center line (Upper) and nearby the side wall (Lower) at height of nozzle= 9 mm

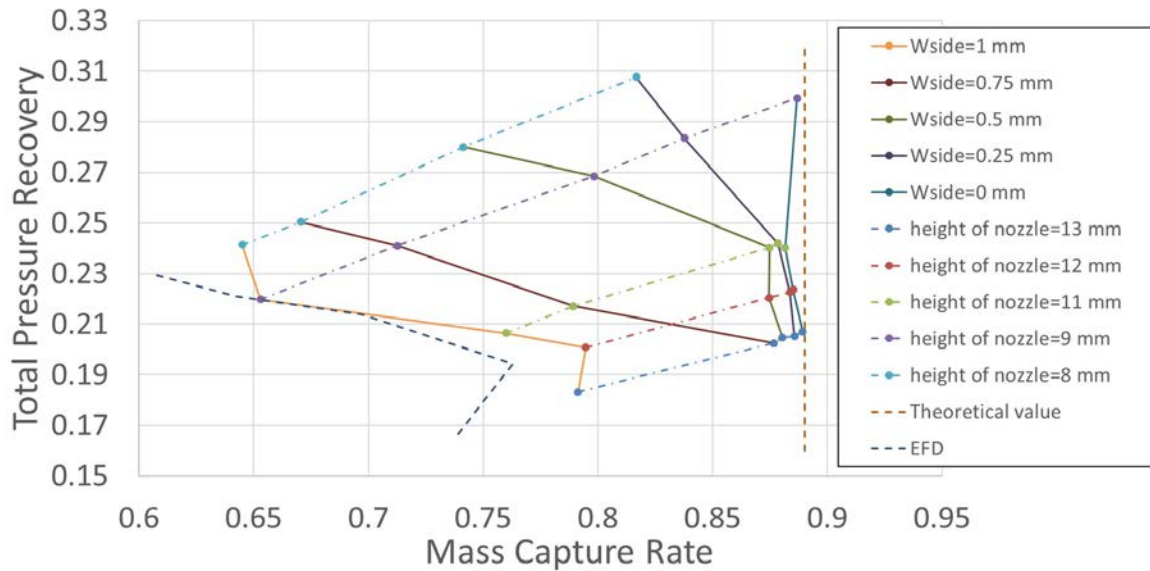


Fig.3 Performance map

● Publications

● Peer-reviewed papers

- 1) Nagao, T., et al., "Numerical analysis on Supersonic Inlet Buzz", The Japan Society for Aeronautical and Space Science (submitted)

● Presentations

- 1) Yoshida, H., et al., "Numerical Study of Hypersonic Air Intake Aerodynamics Performance for High Mach Integrated Control Experiment "HIMICO"", AIAA Propulsion and Energy Forum 2017
- 2) Yoshida, H., et al., "Numerical Study of Inlet Buzz Prediction for the Silent Supersonic Transport", 55th Aircraft Symposium
- 3) SANO, M., et al., "Influence of the side clearance on the inlet for Hi-Mach Integrated Control Experiment (HIMICO)", Space Transportation Symposium FY2017
- 4) Yoshida, H., et al., "Numerical Study of Inlet Performance with Airframe/Propulsion Interference for High Mach Integrated Control Experiment "HIMICO"", AJCPP2018
- 5) SANO, M., et al., "Numerical Analysis of Supersonic Air-Intake Buzz", Aerospace Fluid Science Summer School 2017

● Usage of JSS2

● Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512 - 1024
Elapsed Time per Case	12.00 hours

● Resources Used

Fraction of Usage in Total Resources*1 (%): 0.93

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	7,438,629.22	0.99
SORA-PP	26,731.96	0.33
SORA-LM	2,995.19	1.54
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	495.91	0.34
/data	29,296.89	0.54
/ltmp	5,859.38	0.44

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	3.56	0.15

*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