Numerical Analysys on Transition Shock Wave Oscillation to Pulsation around Forward-Facing Concave Cavity

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Responsible Representative

Toshiharu Mizukaki, Dept. of Aeronautics and Astronautics, Tokai University

Contact Information

Toshiharu Mizukaki　mizukaki@keyaki.cc.u-tokai.ac.jp

Members

Toshiharu Mizukaki, Taro Odagiri, Yusuke Higo, Akari Kato

Abstract

Around the supersonic parachute for Mars probing, drastic transformation of shock-wave oscillation has been observed. In the worst case, the shock waves oscillation deforms the parachute to collapse. In this research, we try to revile the mechanism of transformation of the shock waves and develop the design methodology for oscillation-free parachute. At the first step of this research, simplified model of the supersonic parachute is investigated to compare to experimental result.

http://www.ea.u-tokai.ac.jp/mizukaki/

Reasons for using of JSS2

To carry out the computation on flow analysis around the model used in the research subject which include shock waves oscillation, we must solve three-dimensional unsteady compressible flow with microsecond time-resolution. Therefore, we decided that three-dimensional compressible solver, FaSTAR, which had been developed by JAXA, is one of the proper solver for our subject. To analyze shock waves oscillation around our model in three dimensional space and with fine time resolution, more than 10 million mesh must be needed. Farther more, parallel computing was needed to reduce computation time because more that 10 cases were needed to calculate in this subject. All the things described above were our motivation that we needed JSS2.

Achievements of the Year

In this year,　the effects of the ratio of depth (L) of the cavity to diameter (D), L/D on the mode of shock wave oscillation were examined. This analysis has been done to clarify density/pressure profile inside the cavity which experimental method can not visualize. The comparison of density profile between experimental result and numerical one helped us to understand mechanism of shock wave oscillation in detail.

The values of L/D were set for 0.0, 0.2, 0.5, 1.0, and 2.0. Also, spike was installed at bottom of the cavity to generate turbulence in front of detached shock wave to compare behavior of the detached shock wave in the case of quiet flow. Ratio of diameter (d) and outside length (l) of the spike to the cavity, d/D, l/D, were 0.12 and 2.5, respectively. Typical computational domain is shown in FIg.1. The reason for l/D = 2.5 is based on the previous paper that had reported that shock wave oscillation would not occur under the condition l/D more than 2.0.

Computational results said that behavior of shock wave oscillation shifted from oscillation to pulsation at L/D > 0.5 for Mach2.0, and L/D > 1.0 for Mach3.0. The results reproduced the experimental results well. Figure 2 shows one of the numerical results.

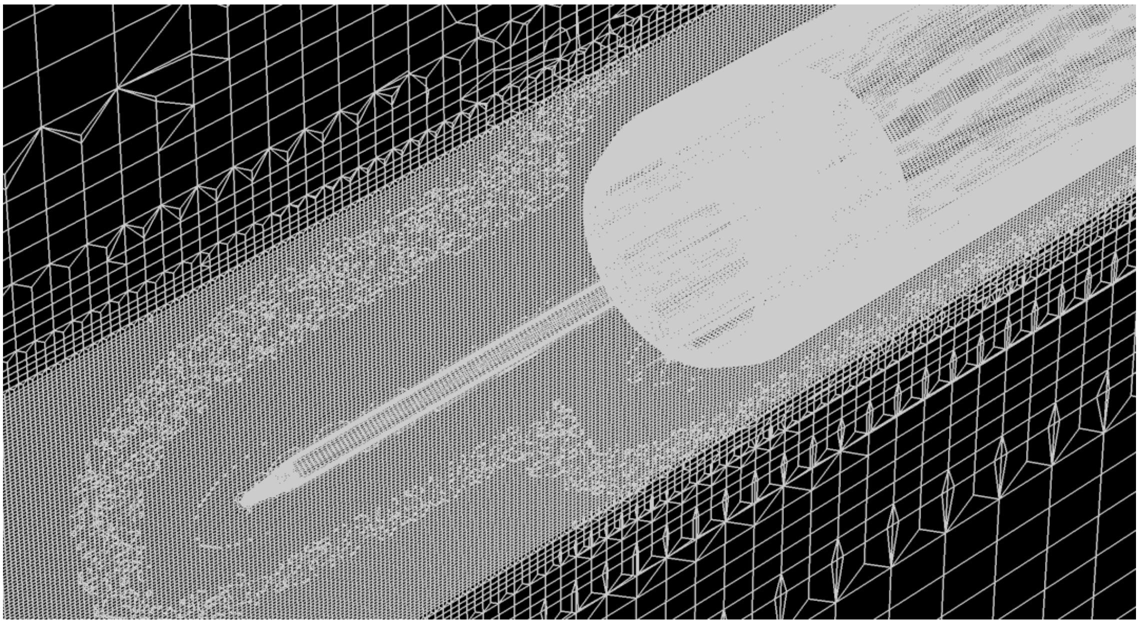

Fig.1 Computational domain

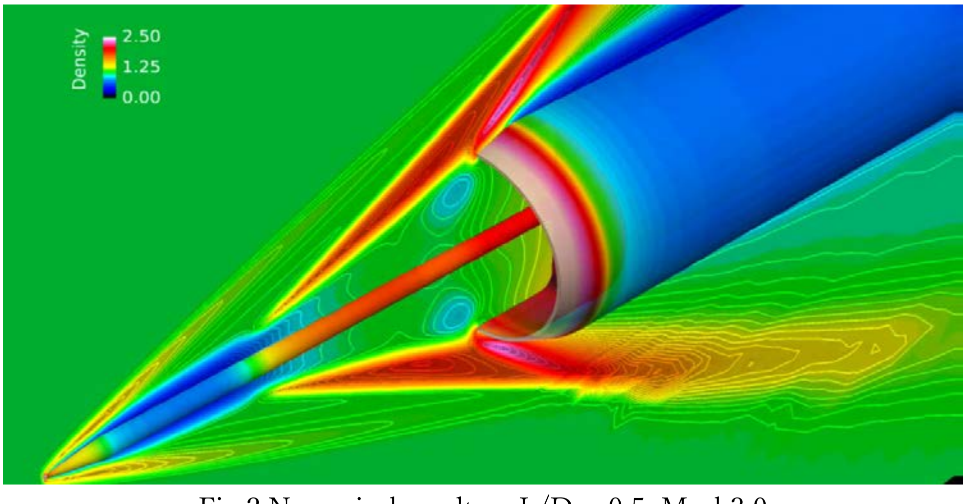

Fig.2 Numerical result on L/D = 0.5, Mach3.0

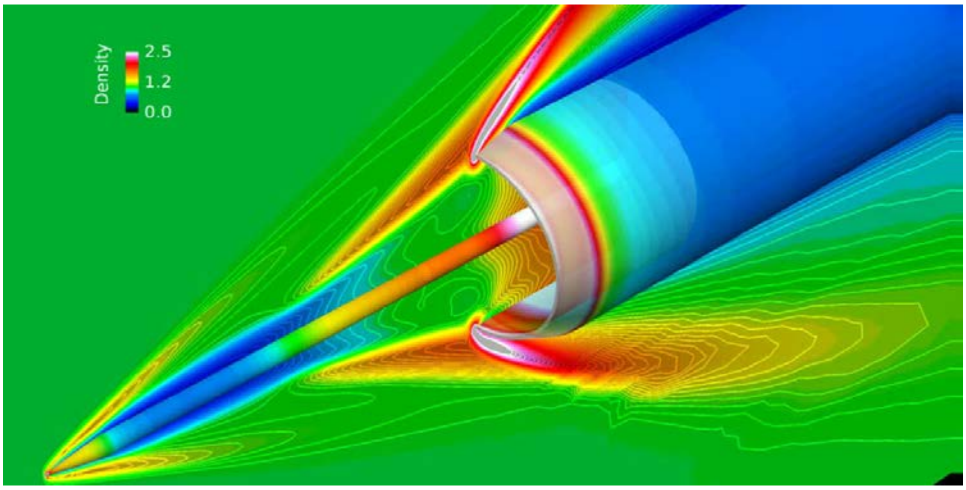

Fig.3 Numerical result on L/D = 1.0, Mach3.0

Publications

- Peer-reviewed papers

1) Mizukaki, T. and Yamada, K.*Transition Behavior of Shock Waves from Oscillation to Pulsation around a Forward-Facing Concave with Spike, AIAA (2018)

Usage of JSS2

- **Computational Information**

Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32
Elapsed Time per Case	15.00 hours

- **Resources Used**

Fraction of Usage in Total Resources*1 (%): 0.01

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	25,933.40	0.00
SORA-PP	179.05	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	491.14	0.34
/data	9,908.68	0.18
/ltmp	4,882.81	0.37

Archiver Resources		
Archiver System 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