Study of numerical simulation for three-dimensional buffet

Report Number：R17ETET21
Subject Category：Skills Acquisition System
URL：https://www.jss.jaxa.jp/ar/e2017/4475/

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Abstract

Shock-wave/boundary layer interaction on the suction side of the wing at high Mach number and/or high angle of attack leads to large scale self-sustained motion of the shock wave. This phenomenon is called transonic buffet. The buffet leads to dangerous structural vibrations.

There are many studies of the buffet on a two-dimensional wing which have a uniform shape in the spanwise direction. On the other hand, there are not many studies on the buffet on a three-dimensional wing which resembling realistic aircraft. Several studies have reported that an oscillation of the shock propagates in the spanwise direction on a three-dimensional wing, but its mechanism is not well understood.

The purpose of our project is to clarify the mechanism of the buffet in a three-dimensional wing. The buffet on parallelogram wings with different sweep angle were simulated. As a result, the propagation of shock oscillation in the spanwise direction was simulated. In addition, it was observed that the propagation of the pressure wave in the chordwise direction.

Reasons for using of JSS2

Three-dimensional buffet is a complicated unsteady flow, and its simulation requires large scale calculation resources. Therefore, use of supercomputer is indispensable. Also, large capacity memory is required for analyzing large scale calculation results. Therefore, JSS 2 was used for execution of numerical simulation and analyzing of unsteady data.

Achievements of the Year

(Fig. 1) and (Fig. 2) are movies of surface pressure coefficients in cases with sweep angle of 0 degrees and 15 degrees, respectively. In Fig. 1, the shock front oscillates in the chordwise direction. The oscillation is uniform in the spanwise direction and this is a two-dimensional phenomenon. On the other hand, in Fig. 2, it can be observed that an oscillation of the shock propagates in the spanwise direction, which is a three-dimensional phenomenon. In addition, the propagation occurs from around of the mid-span of the wing.

We observed pressure waves (Kutta wave) generated from the trailing edge of the wing in the case of sweep angle of 15 degrees (Fig. 3). The caption in Fig. 3 indicates dimensionless time. In Fig. 3, it can be observed that the Kutta wave is parallel to the trailing edge and is propagating in the chordwise direction.

In this study, the three-dimensional buffet was well simulated. We also observed propagation of Kutta waves generated at the trailing edge in the chordwise direction.

Fig.1 Time variation of surface pressure fluctuation (AoS 0 degrees)

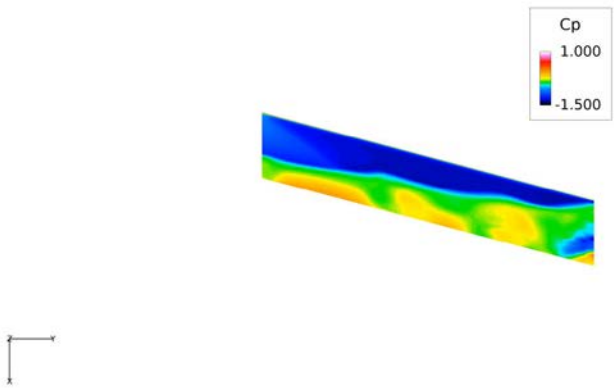

Fig.2 Time variation of surface pressure fluctuation (AoS 15 degrees)

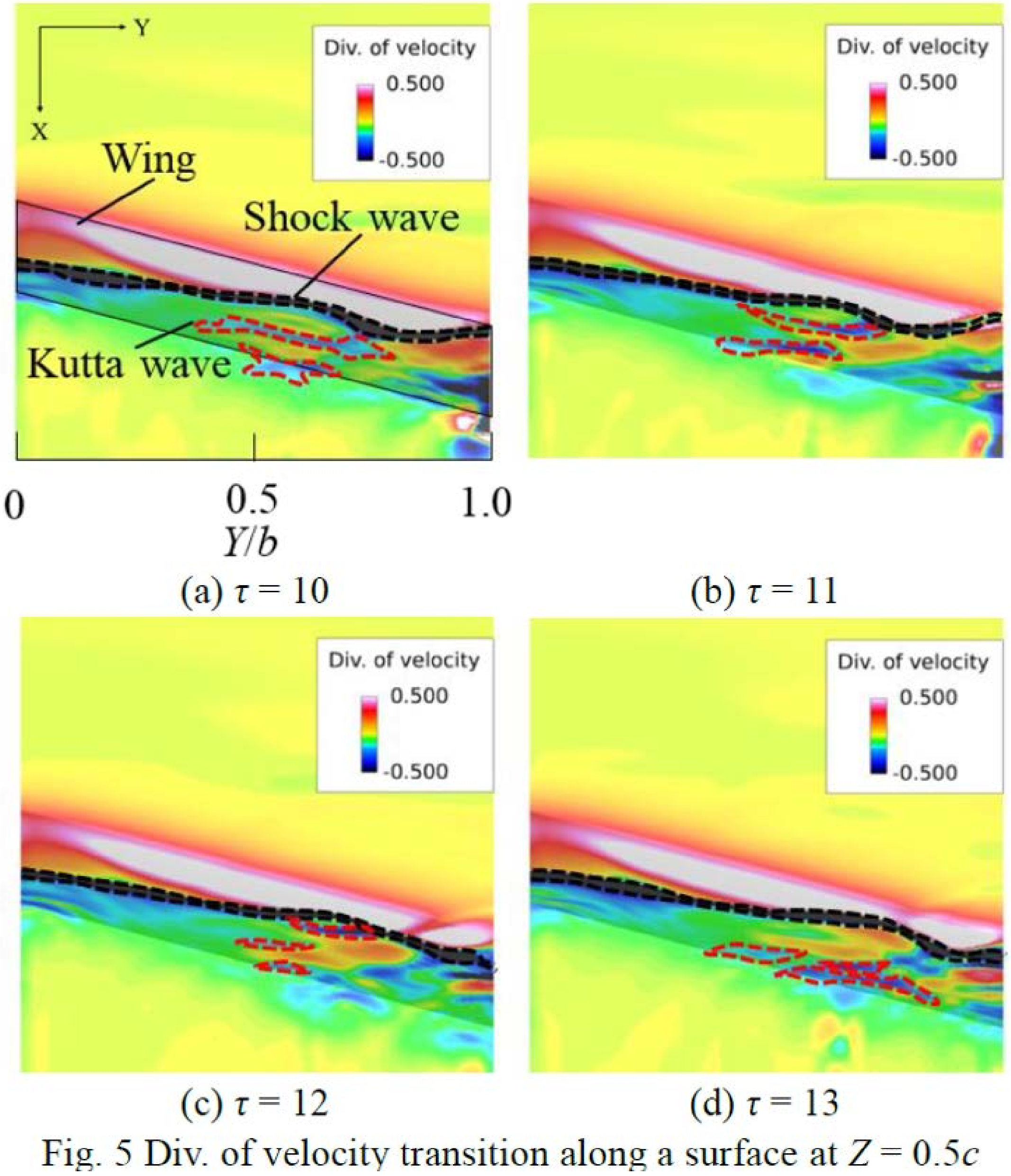

Fig.3 Propagation of Kutta waves generated at the trailing edge

Publications

- ■ Peer-reviewed papers

1) Yoimi Kojima, Atsushi Hashimoto, Takashi Aoyama and Masaharu Kameda, "Variation in Spanwise Direction of Transonic Buffet on a Three-dimensional Wing," Journal of the Japan Society for Aeronautical and Space Sciences, Vol. 66, No. 1, pp. 39-45, (2018). (In japanese)

- Presentations

1) Yoimi Kojima, Atsushi Hashimoto, Takashi Aoyama and Masaharu Kameda, "Variation in spanwise direction of transonic buffet on a three-dimensional wing," 31st International symposium on shock waves, Nagoya, Japan, (2017).

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	320
Elapsed Time per Case	60.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.92

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	7,331,969.95	0.96
SORA-PP	40,867.27	0.51
SORA-LM	180.59	0.09
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	104.90	0.07
/data	19,531.26	0.36
/ltmp	3,906.25	0.29

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	93.24	4.01

*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