Study of complessibility effect on low Reynolds number flow over a plate

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Abstract

Large-eddy simulations (LES) of the compressible flow around the plate with Reynolds number O (10^3) -O (10^4) were performed. The compressibility effects on the laminar flow separation bubble formed around the leading edge of the flat plate and turbulent transition were investigated. The flat plate is one of the basic shapes the same as a sphere and cylinder. Under the incompressible flow condition, the formation of laminar flow separation bubbles and the turbulent transition of the boundary layer occurs in the Reynolds number region investigated in this study. These are important phenomena for the understanding of the low Reynolds number flows. In this study, we will investigate the effect of compressibility on them in detail.

Reasons and benefits of using JAXA Supercomputer System

In the present study, a parametric study by large-eddy simulations is conducted, and thus, a large-scale parallel calculation is required.

Achievements of the Year

We calculated the flowfield at the Reynolds numbers between 5000-15000 and the Mach numbers between 0.2-0.9. Figures 1 and 2 show the flow visualization at the Reynolds numbers 20,000 and 11,000, respectively. The isosurface is the second invariant of the velocity gradient tensor, and the isosurface and contour are colored by the streamwise velocity distribution normalized by the freestream velocity. For high Mach number conditions, the laminar flow separation bubble formed at the leading edge is longer, and the turbulent transition is significantly delayed. The laminalization occurs in lower Mach number conditions for the Reynolds number of 11,000. The similarity in the stabilization effect due to the decrease in the Reynolds number and increase in the Mach number was found.

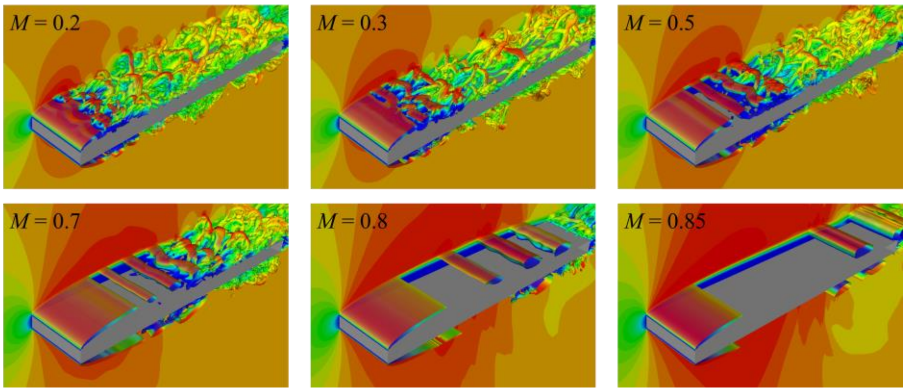

Fig. 1: Mach number effects on the vortex structure and streamwise velocity field at the Reynolds number of 20,000

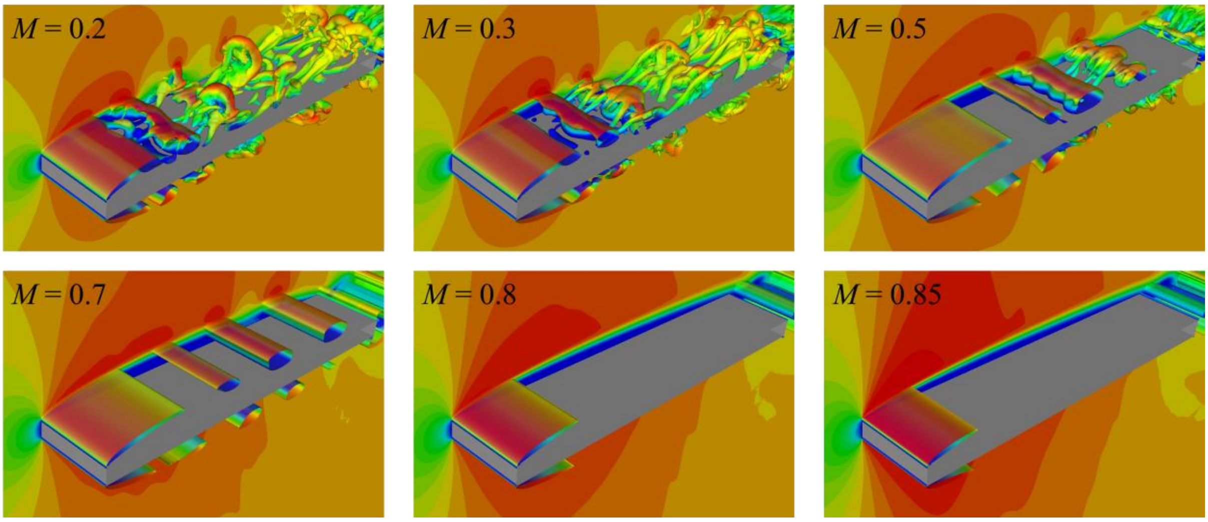

Fig. 2: Mach number effects on the vortex structure and streamwise velocity field at the Reynolds number of 11,000

Publications

- Poster Presentations

Takayuki Nagata and Taku Nonomura "Implicit large-eddy simulation of subsonic compressible low Reynolds number flow over a flat plate at Re = 20,000," 75th Annual Meeting of the Division of Fluid Dynamics, S01.00090, Indianapolis, USA, 2022

Usage of JSS

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	60
Elapsed Time per Case	130 Hour(s)

- **JSS3 Resources Used**

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

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	653,223.93	0.03
TOKI-ST	0.00	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	58.06	0.05
/data and /data2	113,493.33	0.88
/ssd	36.11	0.01

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	32.90	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.

- **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.