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

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Responsible Representative

Taku Nonomura, Professor, Nagoya University

Contact Information

Taku Nonomura, Nagoya University(taku.nonomura@mae.nagoya-u.ac.jp)

Members

Taku Nonomura, Takayuki Nagata

Abstract

A large-eddy simulation (LES) of the compressible flow around the plate with Reynolds number O (10^3) -O (10^4) is performed. The compressibility effects on the laminar flow separation bubble formed around the leading edge of the flat plate and turbulent transition are 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 characteristics of 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 5,000-15,000 and the Mach numbers between 0.2-0.95. Figure 1 show the flow structure at the Reynolds numbers from 6,000 to 20,000. The isosurface is drown based on the second invariant of the velocity gradient tensor, and the isosurface and contour are colored by the streamwise velocity 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 even in lower Mach number conditions for the low Reynolds numbers. The similarity in the stabilization effect due to the decrease in the Reynolds number and increase in the Mach number was found. We will conduct a detailed analysis of the obtained database in next year.

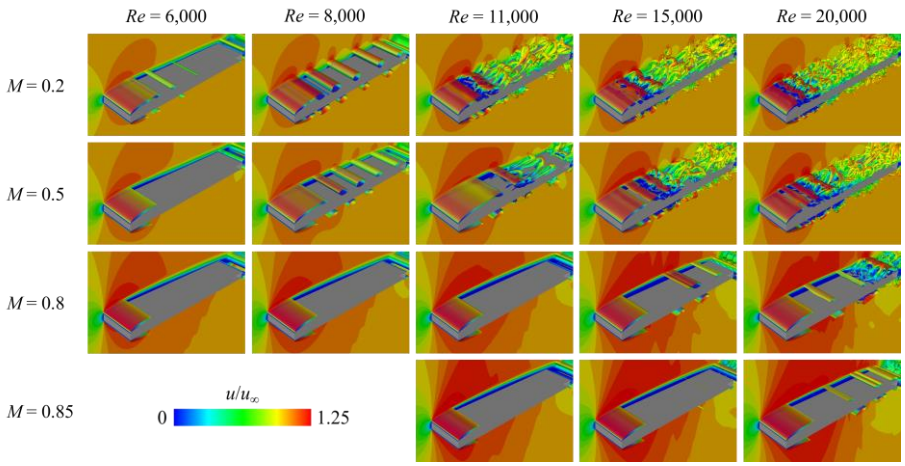

Fig. 1: Mach number effects on the vortex structure and streamwise velocity field at the Reynolds number between 6,000 and 20,000

Publications

- Oral Presentations

Takayuki Nagata and Taku Nonomura "Investigation of Compressibility Effects on Vortical Structures over a Flat Plate by Large-eddy Simulations," 10th International Symposium on Turbulence, Heat and Mass Transfer, Rome, Italy, 2023

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	60
Elapsed Time per Case	100 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.06

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	1,751,359.88	0.08
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	54.45	0.05
/data and /data2	113,457.22	0.70
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	20.55	0.07

[*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.