Study on Simulation Technology to Realize Front Loading of Combustor Design Process

Report Number：R17EA1903
Subject Category：Aeronautical Technology
URL：https://www.jss.jaxa.jp/ar/e2017/4375/

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Abstract

Enhancement of front loading of engine design process by simulation technology.

Reasons for using of JSS2

World-level research in this field requires massively parallel huge computational resource and only so-called supercomputer system can provide it.

Achievements of the Year

Separation of a turbulent boundary layer is one of the key phenomena in aeronautical applications such as combustors and airfoils. In the present study, we have performed direct numerical simulation of a pressure-induced separation bubble. The Reynolds number based on inlet momentum thickness and freestream velocity is $Re\_\theta = 1500$, which is the largest Reynolds number ever performed in this configuration. Number of grid points used are 13 billion to resolve the essential motions. Figure 1 shows visualization of vortical structures for $Re\_\theta = 1500$, which highlights the clustering of fine vortical structures in the separated shear layer (see the enlarged view of Fig. 1).

Robustness of an analysis solver　for 2 phase flow was improved, and 4 cases of primary atomization detailed analysis were finished.

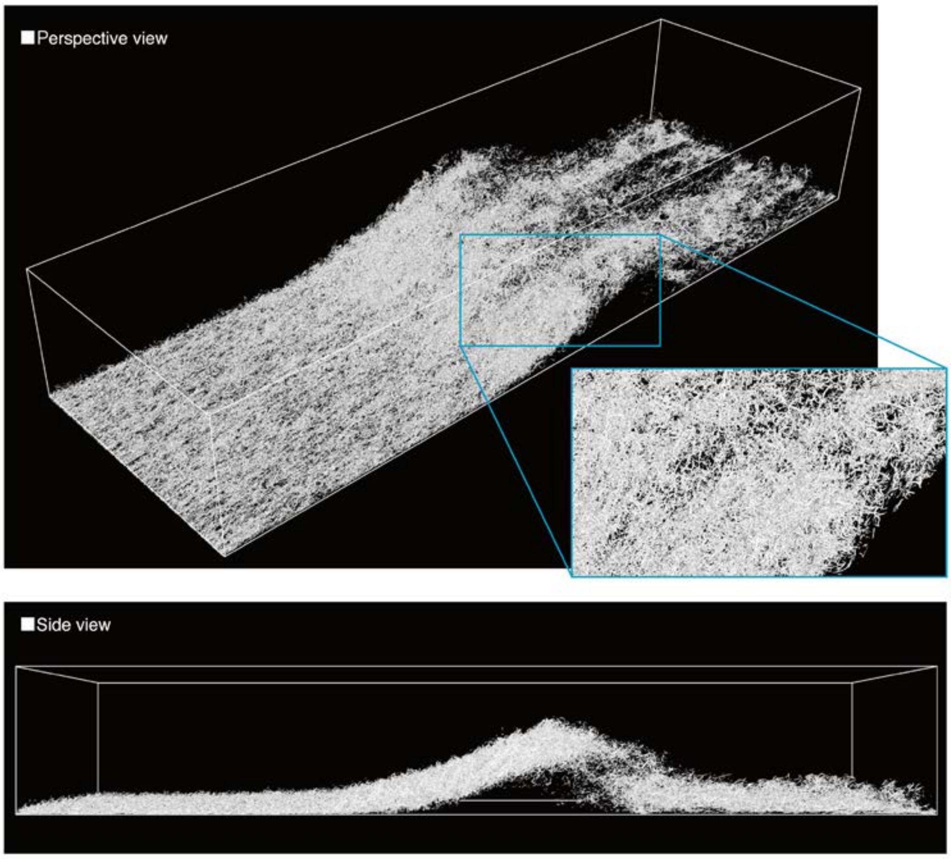

Fig.1 Vortical structures observed in the DNS for Re_ θ =1500 (white: positive values of the second invariant of fluctuating velocity tensor Q). The upper panel denotes the perspective view, whereas the lower panel refers to the side view.

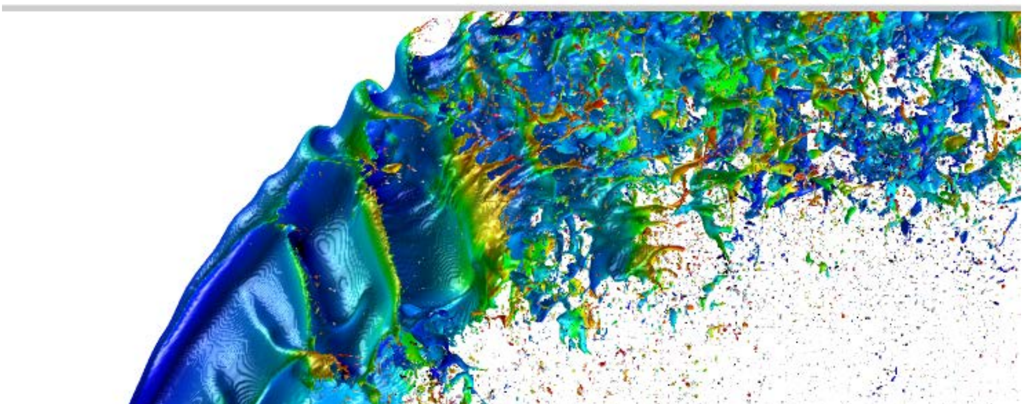

Fig.2 Visualization of air-liquid interface.

Publications

- Peer-reviewed papers

1) H. Abe, "Reynolds-number dependence of wall-pressure fluctuations in a pressure-induced turbulent separation bubble," J. Fluid Mech., Vol. 833, pp. 563-598 (2017).
2) H. Abe and R.A. Antonia, "Relationship between the heat transfer law and the scalar dissipation function in a turbulent channel flow," J. Fluid Mech., Vol. 830, pp. 300-325 (2017).
3) Y.Mizobuchi and T. Takeno, "A numerical study on the detailed structure of hydrogen/air Bunsen flame," J. Comb. Society of Japan, vol.59, No.190, pp.303-311(2017).

- Presentations

1) H. Abe, Y. Mizobuchi and Y. Matsuo, "DNS study on Reynolds-number dependence of a turbulent boundary layer with separation and reattachment," Proc. of the 16th European Turbulence Conference (Stockholm, Sweden, August 21-24, 2017).
2) H. Abe, "DNS and modeling of a turbulent boundary layer with separation and reattachment," The 47th LES reserch meeting(Institute of Industrial Science, the University of Tokyo, Sept. 12, 2017).
3) H. Abe, "Direct numerical simulation of a turbulent boundary layer with separation and reattachment over a wide range of Reynolds numbers," CTR Tea Seminar, Center for Turbulence Research, Stanford University, USA, November 10, 2017.
4) Y. Mizobuchi, T. Takeno, "Investigation on Tip Opening phenomenon of hydrogen/air Bunsen flame by use of detailed numerical simulation," 55th Japanese Combustion Symposium, Toyama International Conference Center, Nov. 13, 2017.
5) H. Abe, "Direct numerical simulation of a turbulent boundary layer with separation and reattachment at Re_ θ =1500," Bulletin of the American Physical Society 70th Annual Meeting of the APS Division of Fluid Dynamics (Denver, CO, November 19-21, 2017), Vol. 62, No. 14, p. 208.
6) T. Nambu, Y. Mizobuchi, "Numerical Simulation of Liquid Fuel Atomization in a Cross-flow involved with Wall Impingement," 26th ILASS-Japan Symposium, AIST Tokyo Waterfront, Dec. 20, 2017
7) .H. Abe, "DNS of a turbulent boundary layer with separation and reattachment: Study of effects of Reynolds number and pressure gradient," Prof. of the 33th TSFD symposium(Institute of Industrial Science, the University of Tokyo, March 5, 2018).

Usage of JSS2

Computational Information

Parallelization Methods	Both of MPI and XPFortran
Thread Parallelization Methods	OpenMP
Number of Processes	8 - 384
Elapsed Time per Case	2,000.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 7.60

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	63,631,143.11	8.47
SORA-PP	42,086.56	0.53
SORA-LM	386.11	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	764.37	0.53
/data	32,676.13	0.60
/ltmp	5,214.42	0.39

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	39.10	1.68

*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