Development and application of two-phase flow solver around moving objects

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Abstract

Two-phase flows with moving objects are commonly used in practical engineering products. This study is subject to investigate the effect of the micro particles in the exhausted gas from the rocket engine to the strong pressure waves and the thermal conductance modification due to the water film around the menisci in the heat pipes. These multiphase flows that are important from the points of the industrial application and the academic interest must be solved by the large scaled simulation.

Reasons for using of JSS2

The micro scaled flow is solved by Direct Numerical Simulation for the statistical analysis and modelling to predict the macro scaled flow phenomena and applies to the design of the products. The multiphase flow simulation like a gas-particle flow based on Cartesian mesh and immersed boundary method, however, becomes expensive in order to capture the interaction between particles and flows. Also, the number of the time integration becomes large due to obtain the equilibrium state of the gas-particle flows. The gas-liquid two-phase flow simulation becomes large scale due to the restriction of the time increment from the surface tension.

Achievements of the Year

We conducted large scale numerical simulations of flow including multiple particles at low Reynolds number and high Mach number based on immersed boundary method and Cartesian mesh. Also, accuracy of heat transfer between sphere and fluid was confirmed by comparing with the result by boundary-fitted grid.

In addition, a numerical method to solve gas-liquid two-phase flows in heat pipes was developed and applied to thermos-fluid phenomena in a heat pipe. A rising bubble problem was used to the validation of the flow solver consisting of conservative level set method.

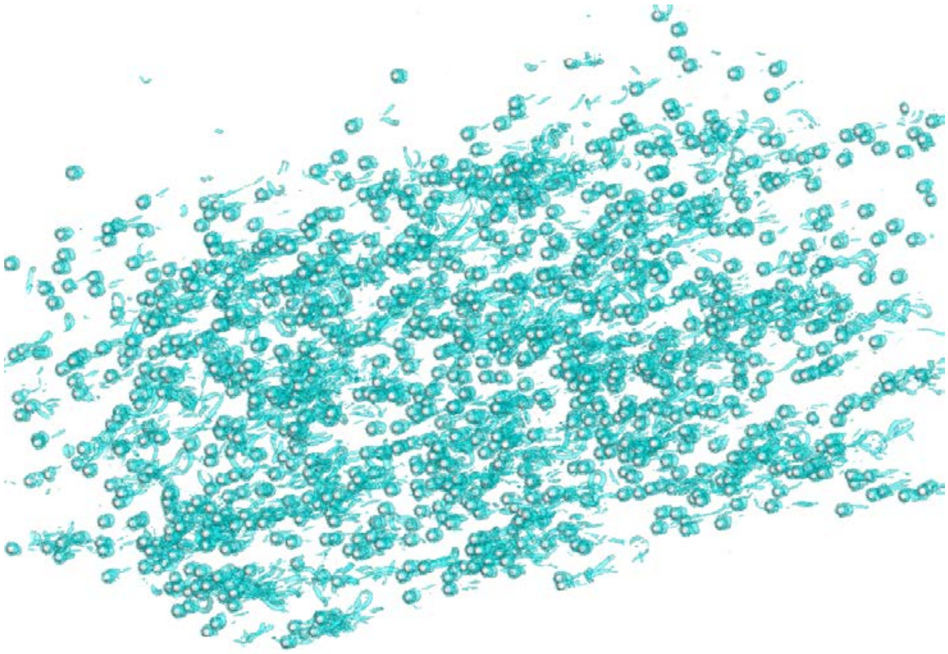

Fig.1 Vortex structure identified by the isosurface of second invariant value of the velocity gradient tensor around multiple particles

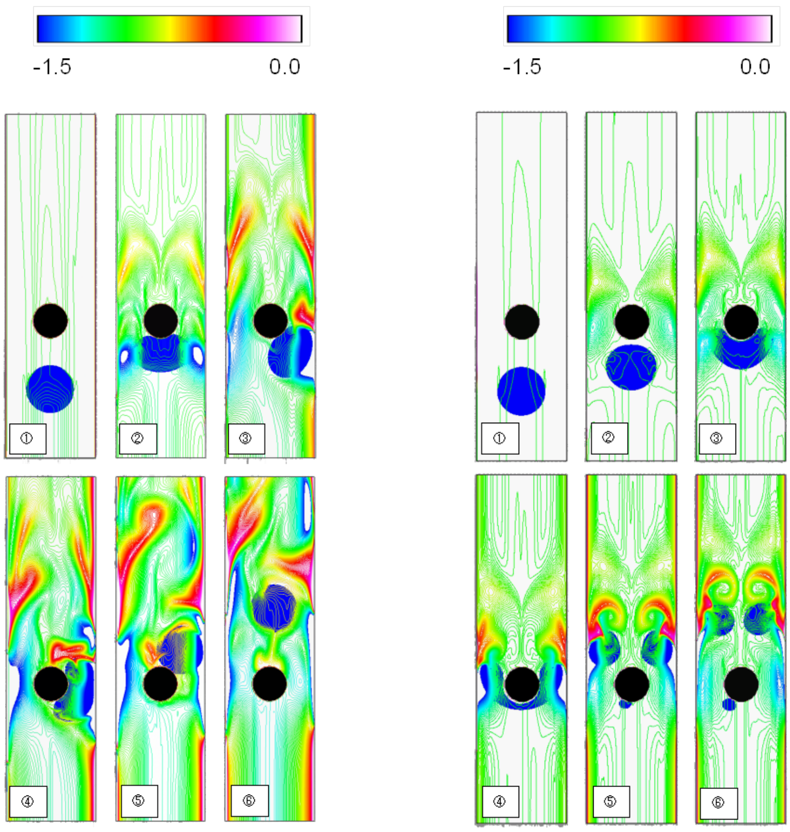

Fig.2 A rising bubble simulation around an obstacle by two-dimensional thermos-fluid analysis.

Publications

- Peer-reviewed papers

1) Nagata, T., Nonomura, T., Takahashi, S., Mizuno, Y., and Fukuda, K, "Direct Numerical Simulation of Flow around a Heated Cooled isolated Sphere up to a Reynolds Number of 300 under Subsonic to Supersonic Conditions", International Journal of Heat and Mass Transfer, Vol. 120, pp. 284-299, 2018.

- Presentations

1) Nagata, T., Nonomura, T., Takahashi, S., Mizuno, Y., and Fukuda, K, Direct numerical simulation of flow past a sphere at a Reynolds number between 500 and 1000 in compressible flows, 56th AIAA Aerospace Sciences Meeting, Gayload Parms, Florida. January 2018.
2) Kuribayashi, T., Hamagata, Y., Mizuno, Y., Takahashi, S., Nonomura, T., Nagata, T., and Fukuda, K. "Investigation of Heat Transfer for a Flow around a Sphere in Cartesian Mesh by using Immersed Boundary Method," MNTC International Symposium 2017, P123, Tokai University, Kanagawa, Japan, August, 2017.

Usage of JSS2

- **Computational Information**

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	289
Elapsed Time per Case	250.00 hours

- **Resources Used**

Fraction of Usage in Total Resources*1 (%): 0.48

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	4,099,214.20	0.52
SORA-PP	0.00	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	039.34	0.03
/data	10,375.98	0.19
/ltmp	2,075.20	0.16

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	13.67	0.59

*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