Discharge-flow coupling analysis of DBD plasma actuator

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Abstract

DBD (Dielectric Barrier Discharge) plasma actuator is a promising candidate as an active flow control device. The purpose of this project is to gain key factors for improvement of the induced-flow velocity and the control of the separation at high speed flow from the perspective of the discharge process.

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Reasons for using JSS2

The use of the super computer is necessary to simulate the induced flow field with the discharge process simulation because the Poisson's equation for electric potential, which requires high computational cost, is solved every time step. The difference of the time scale between the discharge and induced flow also increases the computational cost.

Achievements of the Year

We conducted discharge-flow coupling simulation when nanosecond-pulse-voltage is applied in order to investigate the effect of the pulse polarity on the discharge structure and induced-flow field. The total amount of the deposited energy to the gas depends on the pulse polarity. The large area of the gas is heated for the positive-polarity pulse case, whereas localized hating is observed for the negative-polarity pulse case. The structure of the induced shock wave is also affected by the pulse polarity (Fig. 1). We will conduct discharge-fluid coupling simulation in uniform flow in order to gain the insight into the performance improvement of the plasma actuators as a future work.

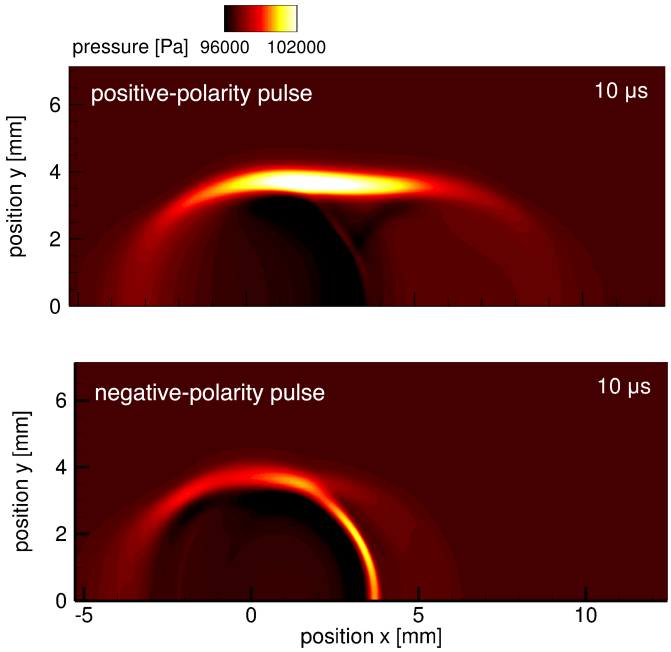

Fig. 1: Spatial distribution of pressure after pulsed discharge
(exposed electrode edge is located at x=0)

Publications

- Non peer-reviewed papers

S. Sato, M. Takahashi, and N. Ohnishi, “Discharge process and gas heating effect in nanosecond-pulse-driven plasma actuator”, AIAA Paper 2019-1001.

- Oral Presentations

S. Sato, M. Takahashi, and N. Ohnishi, “Numerical analysis of discharge and induced flow in nanosecond-pulse-driven plasma actuator”, Miyazaki, July 2018.

S. Sato, H. Furukawa, M. Takahashi, and N. Ohnishi, “Proposal of a plasma actuator for enhancement of electrohydrodynamic force generation”, Osaka, September 2018

S. Sato, M. Takahashi, N. Ohnishi, “Numerical analysis of surface dielectric-barrier-discharge and gas heating effect for application of aerodynamics”, 71st Gaseous Electronics Conference, Portland, Oregon, November 2018.

S. Sato, M. Takahashi, N. Ohnishi, “Discharge process and gas heating effect in nanosecond-pulse-driven plasma actuator”, AIAA SciTech 2019 Forum, San Diego, California, January 2019.

S. Sato, “A study of plasma actuator for high-integration and low-voltage operation”, Sendai, February 2019.

- Poster Presentations

S. Sato, H. Furukawa, M. Takahashi, and N. Ohnishi, “Proposal and demonstration of low-voltage operated and high-integrated plasma actuator”, Tsukuba, November 2018

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	160 - 640
Elapsed Time per Case	72 Hour (s)

Resources Used

Fraction of Usage in Total Resources[*1] (%): 0.12

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2] (%)
SORA-MA	1,067,486.85	0.13
SORA-PP	3,451.39	0.03
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	195.50	0.20
/data	9,813.31	0.17
/ltmp	2,929.69	0.25

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	3.47	0.12

[*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.