Feedback Control of Flow Separation Using DBD Plasma Actuator

Report Number: R18EACA26
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2018/9100/

Responsible Representative

Kengo Asada, Tokyo University of Science, Department of Information and Computer Technology, Postdoctoral Researcher

Contact Information

Kengo Asada (asada@rs.tus.ac.jp)

Members

Kengo Asada, Takuto Ogawa

Abstract

The project develops flow control technic by using dielectric barrier discharge (DBD) plasma actuator to establish high efficient and robust vehicle systems such as rockets, aircrafts, and motor vehicles. We propose and demonstrate feedback control methods to adapt unsteady flows over the vehicles through a series of high-fidelity unsteady simulations.

Reasons for using JSS2

To conduct the large eddy simulations using the LANS3D as a computational solver.

Achievements of the Year

High-fidelity LESs of a NACA0015 airfoil flow controlled by a DBD plasma actuator were performed to verify the effectiveness of a feedback control model which we propose. The present feedback model (Fig. 1) drives the actuator located in the vicinity of the leading edge according to the passing of vortices above a pressure sensor (x/c = 40%) on the upper side of the airfoil. The passing of vortices is detected by abrupt pressure decrease compared to a moving-averaged pressure value. In the present model, the time range of moving average is unsteadily varied according to FFT analysis. We investigated the effectiveness of the feedback control model at AoA=12 deg last year. In addition to the AoA=12 deg, we performed the LESs of the flows at AoA=14, 16, and 18 deg this year. Figure 2 shows the lift coefficient CL at each angle of attack. The proposing control model case (DTM) shows greater CL value than the baseline case (Baseline) at each angle of attack. Additionally, the present control model achieves steady aerodynamic performance than the non-feedback control case (Burst). Figures 3 shows the vortex structures by iso-surface of Q-criterion colored by pressure coefficient at AoA=14 deg. The spanwise vortex structures pass along the airfoil surface. The plasma actuator is driven once when the spanwise vortex structure is passing above the pressure sensor, and the additional vortex structures are generated by actuation. These processes orderly arrange the vortices and contribute to keeping the steady aerodynamic performance.

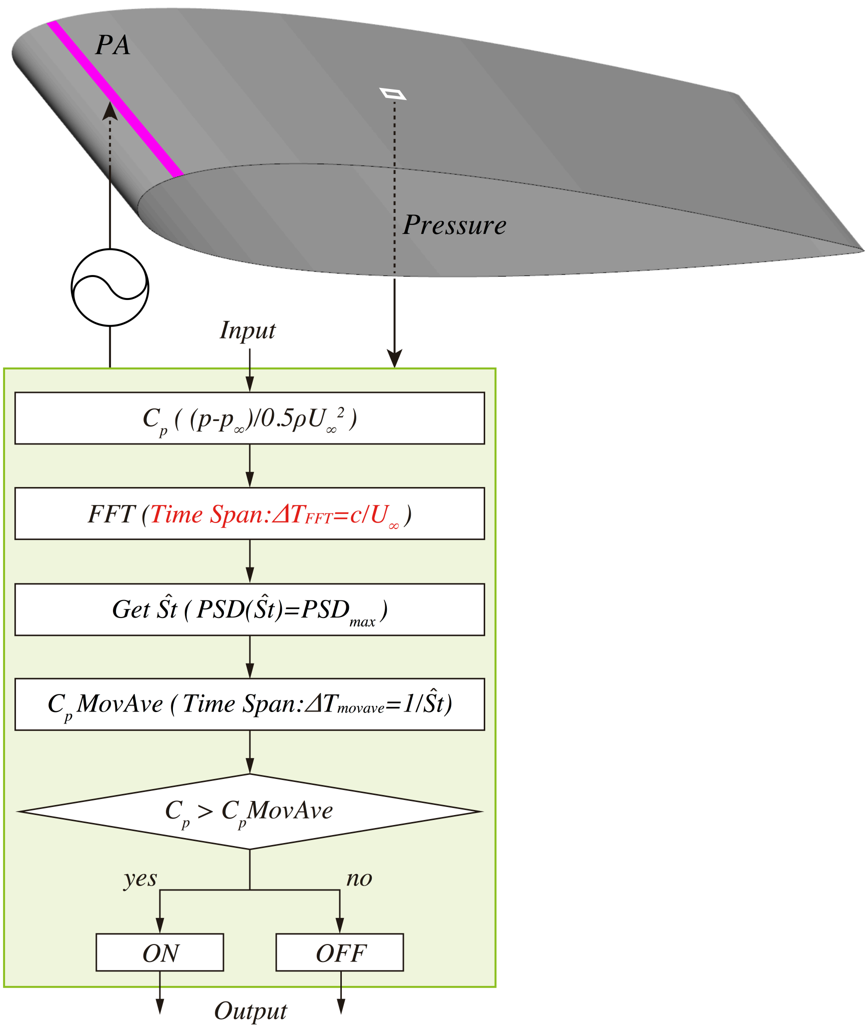

Fig. 1: Proposing feedback control model of separated flows.

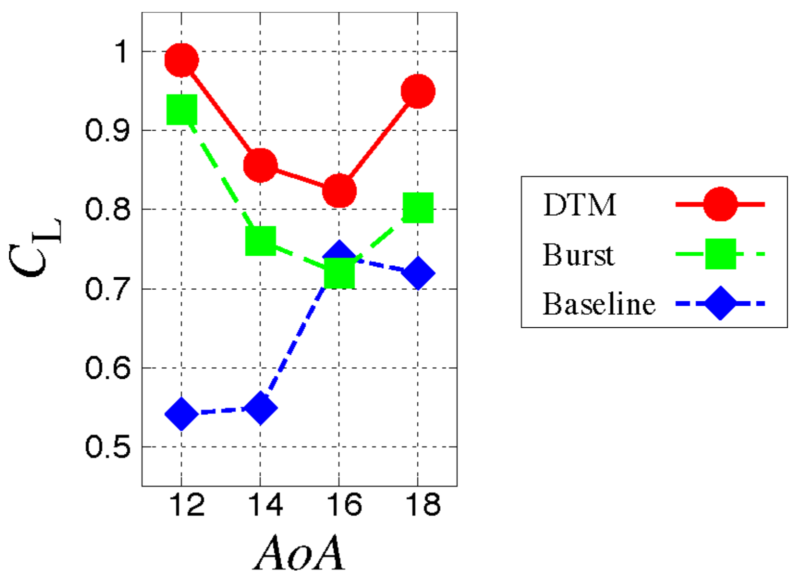

Fig. 2: Lift coefficient (CL) at each angle of attack.

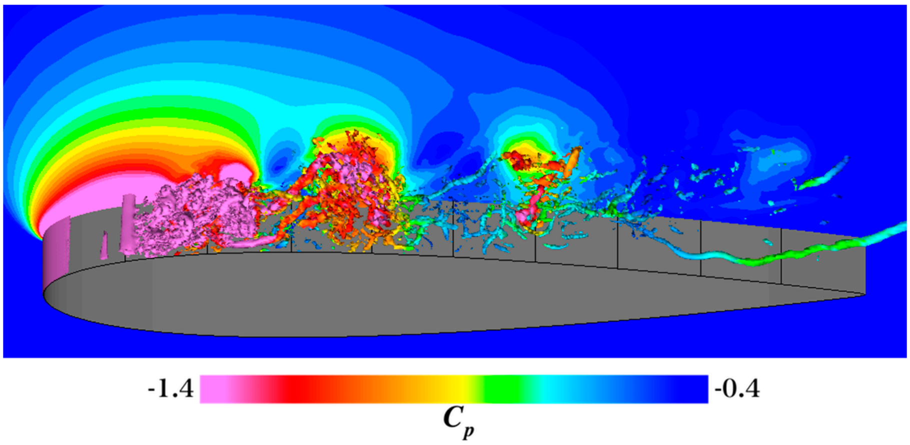

Fig. 3: Instantaneous flow field at AoA=14 deg.

Publications

- Non peer-reviewed papers

Ogawa, T., Asada, K., Sekimoto, S., Tatsukawa, T., and Fujii, K., "Feed-back Control of Stall Separation with DBD Plasma Actuator by Detecting Vortex Passing over an Airfoil," AIAA Scitech 2018, Kissimmee, Florida, 2018. AIAA 2018-1059.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	79 - 84
Elapsed Time per Case	30 Hour (s)

- **Resources Used**

Fraction of Usage in Total Resources*1 (%): 0.28

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	2,516,926.95	0.31
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	52.45	0.05
/data	20,197.92	0.36
/ltmp	2,929.69	0.25

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*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.