Application of distributed micro plasma actuators

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Abstract

Plasma actuators (PAs) are flow control devices that use discharged plasma to generate wall jets from smooth surfaces. In recent years, a method of generating a distribution of body force on a surface by using a large number of small-scale PAs has been proposed by the applicants. The objective of this study is to obtain knowledge about the application method of plasma actuator and its optimization method for arbitrary control of the velocity profile of a three-dimensional boundary layer, keeping in mind the boundary layer control of high-speed flows.

Reasons and benefits of using JAXA Supercomputer System

In order to perform large-scale 3D flow analysis and aerodynamic optimization with high computational costs, a supercomputer is required. The JAXA supercomputer, which provides an environment for the use of computational tools, is the most suitable environment for this study.

Achievements of the Year

The focus of this year's research was on the application and validation of the optimal design method.

In the application of the optimal design method, numerical and aerodynamic analyses were performed by RANS for two-dimensional asymmetric arbitrary shapes, and multi-objective optimization problems were solved by using the optimal design tool. FaSTAR, developed by JAXA, was used for the numerical calculations. For grid generation, HexaGrid, an automatic grid generation software also developed by JAXA, was used. The computational grid is as small as 100,000 points. For the optimal design, a spline function was used to define the shape of the grid from a large number of design points, which was then changed in various ways to automatically generate the grid while analyzing several hundred samples to search for solutions.

Figure 2 presents the sample distribution of the design exploration and shows that most of the additional samples are clustered in the upper left optimal direction compared to the initial sample, indicating that the solution search

is being performed appropriately. The design points were reduced using the variable reduction method developed in this study (shown in Fig. 1), and the optimal direction aimed to minimize Cd and maximize Cl. The samples are concentrated near the front edge of the Pareto surface, indicating that the search for a non-inferior solution is proceeding efficiently. The shape and Mach number distribution of the solution samples on the Pareto surface are shown in Figure 3, where Sample B has the largest L/D among the samples. It illustrates that a shape similar to a general cambered airfoil shape can be obtained with a limited number of sample points due to variable contraction and that the required specifications can be met.

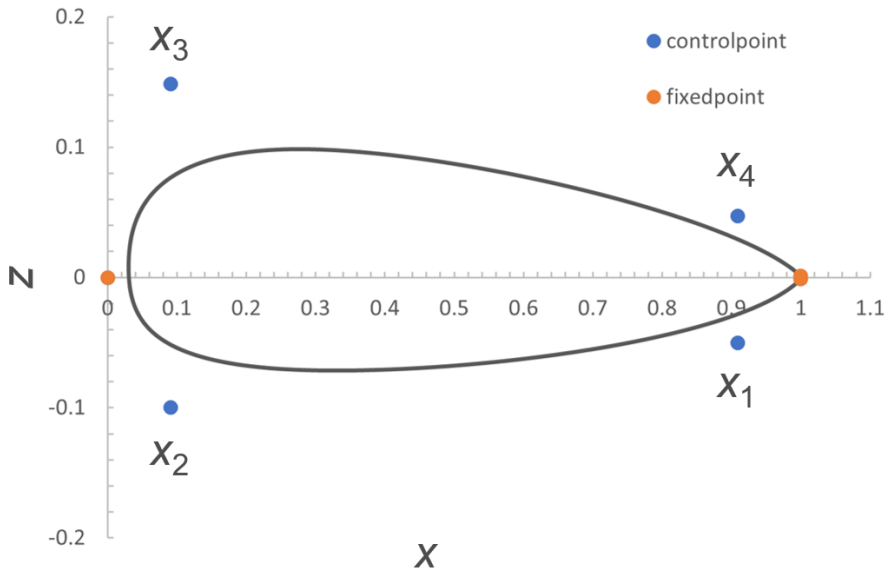

Fig. 1: Locations of the design variables selected by the current variable reduction method

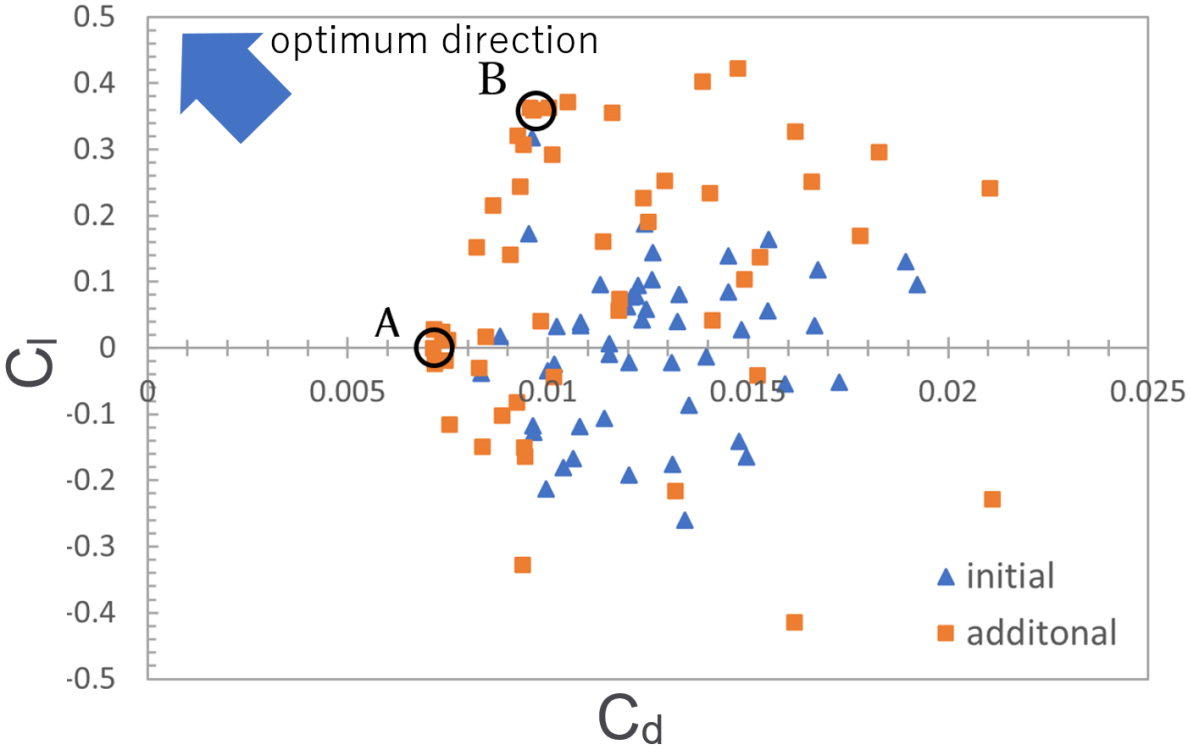

Fig. 2: Sample distribution of the design exploration

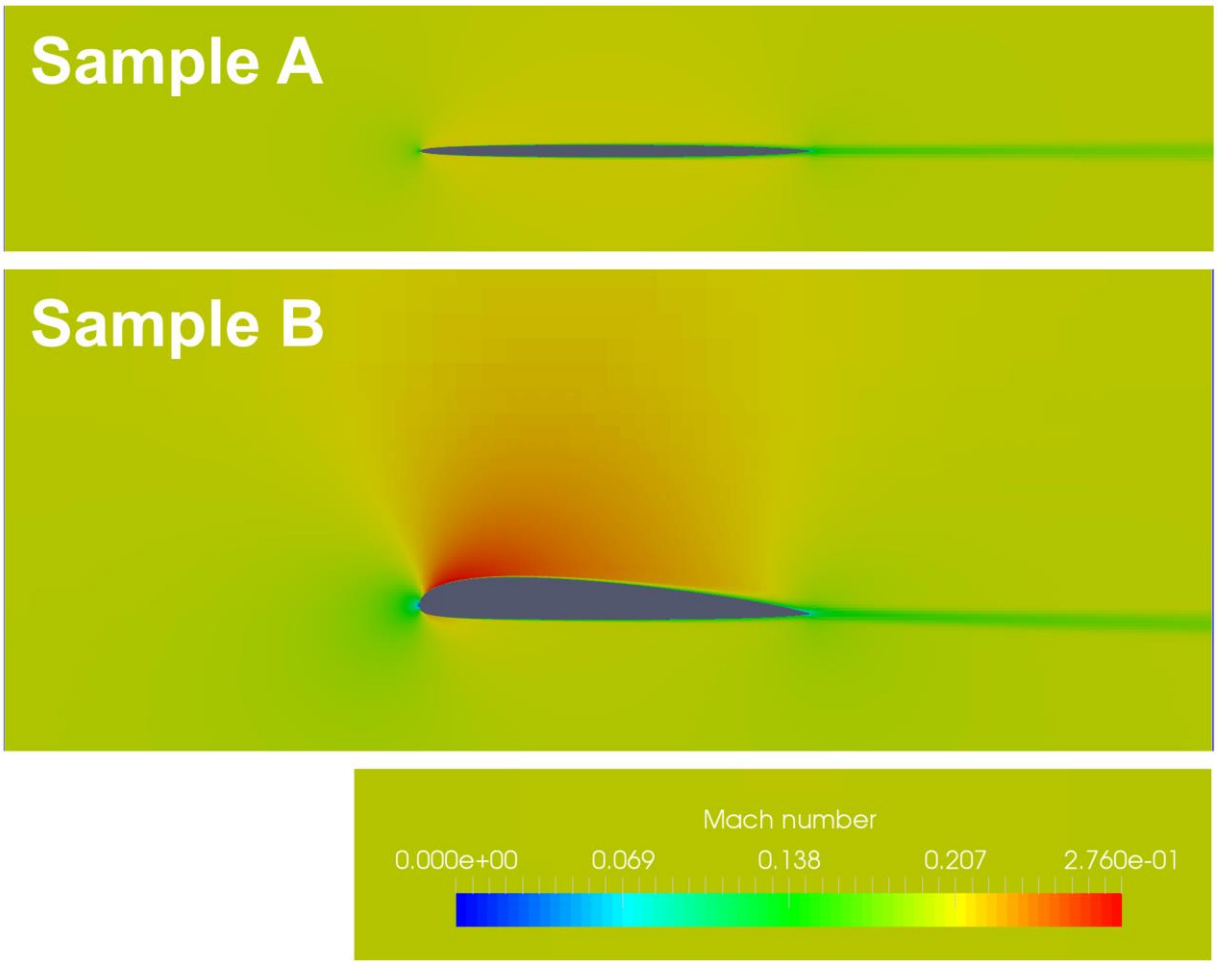

Fig. 3: Shape and Mach number distribution of the solution samples on the Pareto surface

- **Publications**

  N/A

- **Usage of JSS**

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	12 - 1000
Elapsed Time per Case	12 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.24

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	6,148,046.82	0.27
TOKI-ST	91,629.18	0.09
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	4,610.88	0.31
TOKI-TST	0.30	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	463.33	0.42
/data and /data2	17,853.67	0.14
/ssd	386.67	0.05

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	2.02	0.01

[*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)	467.55	0.33

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.