# Influence of nozzle exit velocity distribution on flame stability using a coaxial DBD plasma actuator

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## 1. INTRODUCTION

In the control of a current jet flow, various researches on the control that have been used many control methods; sound wave, flap type actuator, controlled coaxial flow, MEMS actuator etc. Recently, dielectric barrier discharge plasma actuator (DBD-PA) [1] has been applied to flow control. DBD-PA has been investigated as a device for separation control on wings by many investigators [2]. And also it was applied to the jet diffusion control [3]. On the other hand, control of the jet is that the performance of controlling the mixing of combustible gas and airs in the burner combustion efficiency, small size can be such, for industrial application range is wide, an important field of research. In this study, coaxial DBD-PA is applied to control the flame shape, the control to maintain excellent flame stability was attempted.

## 2. DBD-PA AND EXPERIMENT

Figure 1(a) shows a cross section of the coaxial DBD-PA set up at the round nozzle exit, the main jet, and the overall view of the induced flow due to DBD-PA. It consists of an exposed electrode, an insulated electrode, and a dielectric layer. In a convergent round nozzle having an exit inner diameter of $d$ = 6 mm, the electrode was arranged coaxially with the nozzle. Plasma was generated by adding the alternating high voltage from the power supply. Fig. 1(b) shows the example of velocity distribution chart for the case in which a plasma at $x/d$ = 1 is not generated and the velocity distribution chart for frequencies from 4 kHz to 14 kHz. Here, $U_0$ is the center velocity of $x/d$ = 1 when DBD PA is not generated. The velocity distribution in the free boundary layer is maximal at approximately $y/d = \pm 0.4$, and at the center decreases as the frequency increases. This is because the flow in the vicinity of approximately y/d = ±0.4 is accelerated by the induced flow generated by the DBD-PA. DBD-PA is applied to the control of the flame stability on condition equivalence ratio: $\phi$ = 0.85, 1.00, 1.14. Premixed gas of air and propane was used for fuel. Voltage is applied to the coaxial DBD-PA after ignition, to generate an induced flow by plasma. The applied voltage is 5 kV to 8 kV and OFF, and frequency is 8 kHz constant. Flame stability limit is taken with a high speed camera.

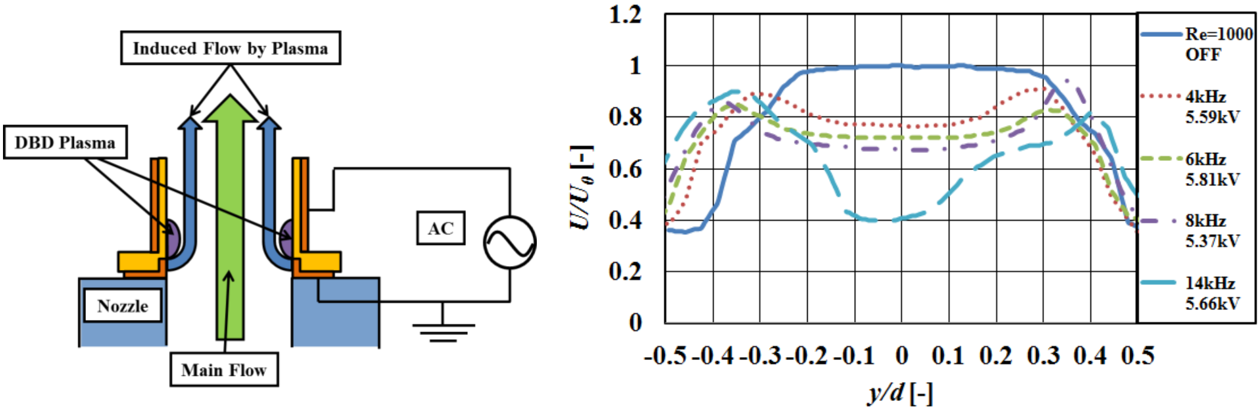


Figure 1(a): Cross section of the DBD-PA; (b): Velocity distribution around the nozzle at x/d = 1 (Re = 1.0×103).

## 3. FLAME STABILITY CHANGE

In Figures 2(a) and 2(b), with the flow rate set at Q=3.31 L/min, the photographs show laminar flow flames recorded when chemical changes were made by varying the voltage. It blew on the way and, in the case of plasma off, the flame of $\phi = 0.85$ of Fig. 2(a) shows blowoff. However, the flame was stable when a voltage was applied, and this is thought to due to the production of ozone by plasma product, which leads to enhanced combustion. Because a sufficient amount of fuel was provided, the flames of Fig. 2(b) remain for stoichiometric mixture $\phi = 1$, and thus continue burning with or without the plasma actuator. However, the inner flame decreases in size and the shape of the outer flame changes when the plasma actuator is used. In addition, larger changes are found for the 8 kV flame. Specifically, the center becomes hollow and the inner flame assumes a crown shape. It is thought that this is due to a change in velocity in the free boundary layer due to the DBD induced flow. The hollow core is thought to be formed because while the mean mass flow rate of pre-mixture gas was constant and the velocity of the boundary layer increased. It is considered that when central velocity of the pre-mixture jet decreases and occurred by an inner flame having become low by induced flow of DBD-PA.

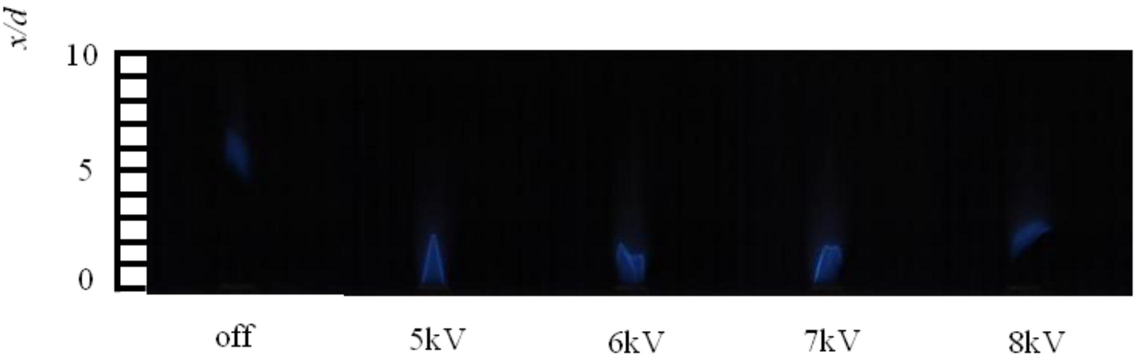


Fig. 2(a) Images of inner flame shape (Q = 3.31 L/min, $\phi$ = 0.85, 8 kHz)

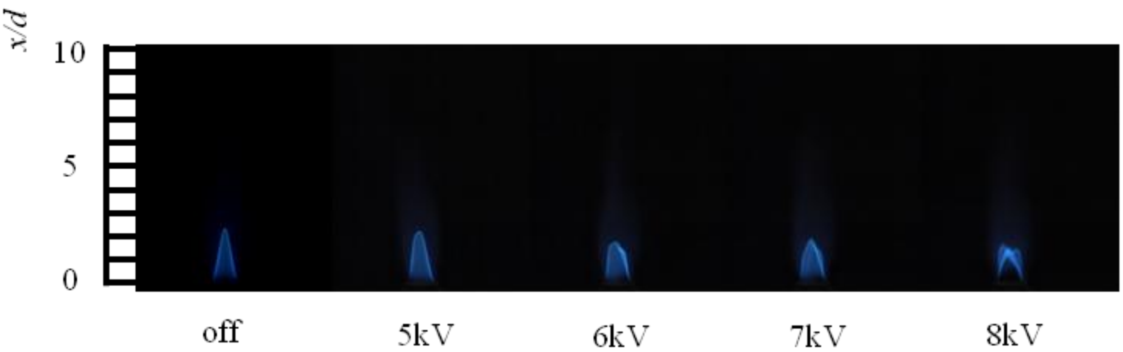


Fig. 2(b) Images of inner flame shape (Q = 3.31 L/min, $\phi$ = 1.00, 8 kHz)

## 4. ACKNOWLEGEMENT

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## REFERENCES

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## KEYWORDS

Jet, flow control, DBD plasma actuator, instability, free shear layer, flame.