Flow Circulation and Ozone Concentration Generated by Plasma Actuator in a Closed Circuit Pipe

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This experimental research includes the characteristics of the flow generated by dielectric barrier discharge (DBD) plasma actuators installed on the wall inside a circular pipe as a closed circuit. We compare and discuss with the flow velocities and their distributions in the closed-loop tunnel at the various excitation voltages and frequencies applied to the actuators. We also observed the variation of the ozone concentrations with various conditions supplied to the actuators. The velocity magnitude of the air in the closed pipe decreases as the ozone concentration rapidly increases at first short time. Higher voltage excited to the plasma actuator makes its increasing rate grow steeper. However as time goes, the ozone concentration is saturated in a closed pipe and consequently it is independent on the electrode excitation voltage of the plasma actuator.

Abstract

Flow phenomena such as a separation on the surface wall or the leakage flow on the gas turbine blade tips normally cause flow losses. Therefore in order to increase some efficiencies related on the aerodynamic flow, they are needed to be depressed by the flow control. Plasma actuator can be used as one effective choice of the methods for active flow control, which has many advantages such as simple structure without moving parts and so on [1]. DBD plasma actuator induces parallel flow on the wall surface of the actuator by the interaction between plasma and neutral air particles.

As shown in Fig. 1, an experimental setup was arranged with single and multiple DBD actuators installed on a circular tube wall. The electrode is connected to high-voltage power amplifier (TREK 20/20C) excited by a function generator generating sine waves. The voltage and frequency ranges are 10~16 kV and 0.5~1.0 kHz respectively. Ozone concentrations were measured by USB New iStar ICCD Camera (Andor Technology) and analyzed by S/W, Andor Solis. Flow velocities were also measured at several radial positions inside the pipe by hotwire anemometry.

Ozone concentrations were measured for 20 minutes in a closed circular pipe under the operation of the plasma actuator as shown in Fig. 2. Firstly they dramatically increase for a short time, 300 seconds. Subsequently they gradually decrease to be saturated conditions. Higher excitation voltage applied to the actuators generates higher growing rate of them. The velocity magnitude in the pipe steeply decreases as the ozone concentration rapidly increases.

References

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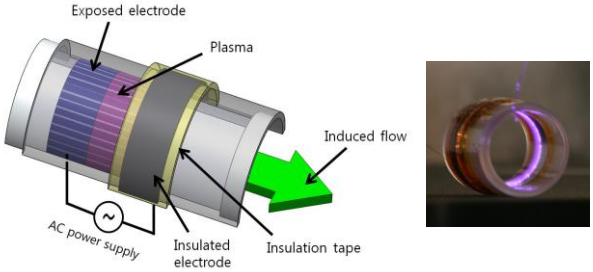

Figure 1 Schematic half view of a DBD plasma actuator on inner wall of a circular pipe

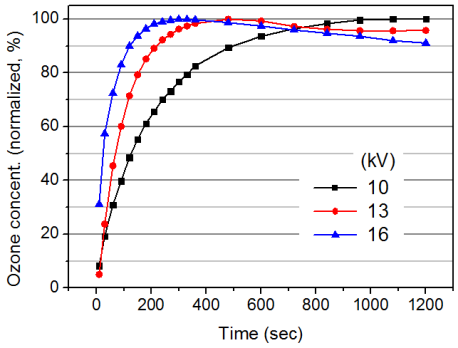

Figure 2 Ozone concentrations with different electrode voltages of DBD plasma actuators (1 kHz)