Plasma actuator array for shock wave/boundary layer interaction control

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Plasma actuator shows wide application prospect in suppressing flow separation, alleviating turbomachinery stall, and shock wave/boundary layer interaction control. Compared with dielectric barrier discharge (DBD) plasma actuator, the localized arc filament plasma actuator (LAFPA) and plasma synthetic jet actuator (PSJA) generate stronger actuation, which are more suitable for high speed flow control. However, different from the DBD, the resistance characteristic of the arc discharge channel is negative. As a result, it is difficult to generate large area arc discharge, which restricts the performance of LAFPA and PSJA.

To solve this problem, the concept of plasma actuator array is put forward and demonstrated. By adjusting the circuit impedance characteristics actively, the plasma actuator array can be driven by only one power supply. The driving circuit of plasma actuator array is shown Fig. 1. To optimize the circuit parameters, a discharge model is built. Based on this model simulation results, the discharge channel number can be increased. 31-channel arc discharge with one power supply is achieved, as shown in Fig. 2.

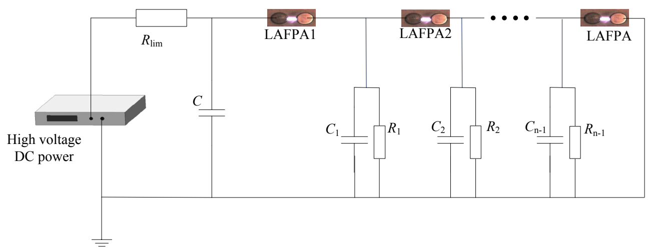

Fig.1 The schematic diagram of plasma actuator array driving circuit

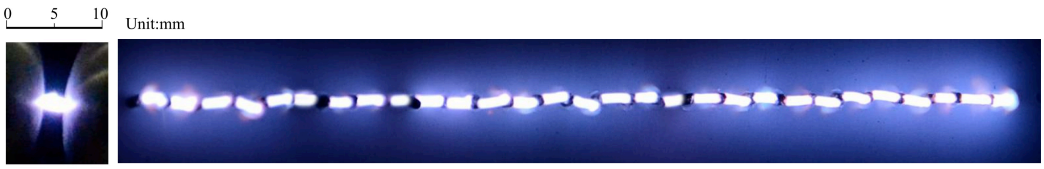

Fig.2 31-channel arc discharge

Localized arc filament plasma actuator array is used to control the shock wave/boundary layer interaction (SWBLI) at a 26° compression ramp in a Mach 2.0 flow. 16 LAFPAs are adopted to control the flow field. The plasma actuator array is installed upstream of the SWBLI and actuated at 2 kHz and 5 kHz, respectively. The shock wave is modified significantly by the hot gas produced by LAFPA. The foot portion of the separation shock wave disappears, while the oblique shock wave bifurcates when the hot gas passes through the interaction region. The surface pressure measurement reveals pressure decrease in the interaction region in the mean sense, and the joint probability density also proves decrease of instantaneous pressure. The pressure spectrum further demostrates that the low-frequency energy content in the baseline SWBLI is reduced, which is considered the result of the disruption of the original shock system.

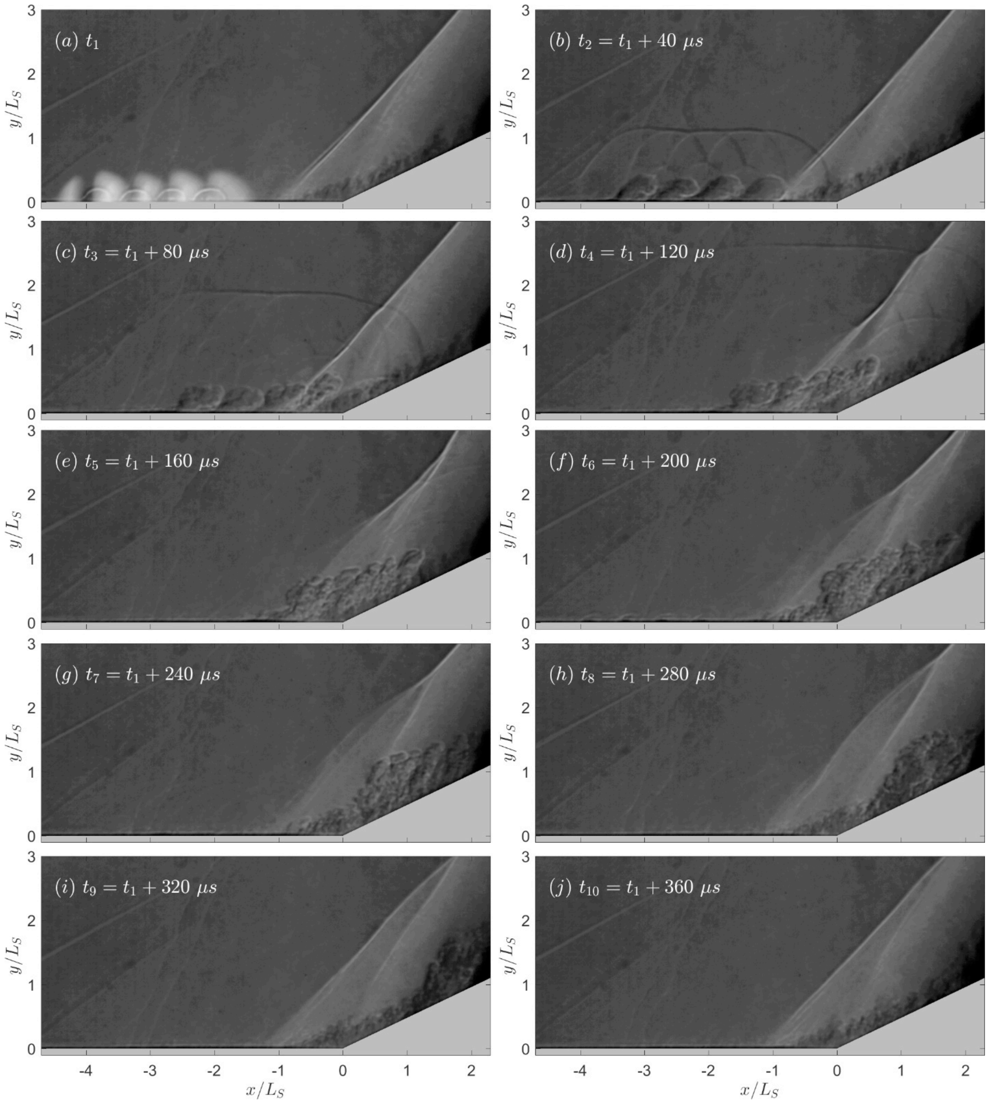

Fig.3 Time-resolved schlieren visualization of SWBLI control process with 2 kHz LAFPA array

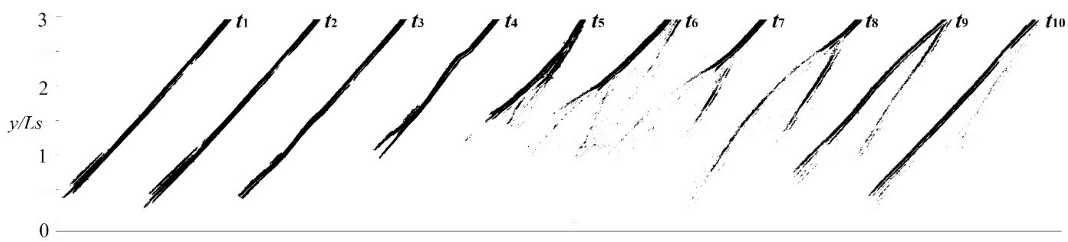

Fig.4 Evolution of the shock wave system with LAFPA array

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