Study of the Mach disk oscillations of the under expanded jets impinging upon an object

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The under expanded sonic or supersonic jet which impinges upon an obstacle has been applied to a variety field of aerospace technologies and industrial manufacturing processes and has often produced the self-induced oscillations in the flow field. This kind of flow oscillation is usually associated with the unsteady motions of the shock wave in front of the obstacle, causing a strong noise and vibration problem in the flow system.

The flow field which supersonic jet impinges on obstacle is highly complicated and fully three dimensional, almost always accompanying a considerable scale of unsteadiness in character. Much work has been carried out to understand the interaction physics between a supersonic jet and an obstacle(1-5), but the detailed mechanism of the self-induced oscillations and the fluid dynamic factors which are associated with them are not yet understood well.

Recently some work has been carried out to elucidate the flow mechanisms involved in the self-induced oscillations in the under expanded impinging sonic jets and revealed that the self-induced oscillations are mainly due to unsteady shock motions in front of the obstacle(6-8). However there are still many unsolved problems; what parameters control the shock motions in front of the obstacle, what kind of strategy should be

applied to suppress such undesirable oscillations, etc. There is, to date, no any available work to detail the shock motions occurring between the nozzle and obstacle.

The objective of the present study is to expatiate the flow characteristics involved in the self-induced oscillations of the under expanded jet impinging upon a cylindrical body, to find major factors influencing the self-induced oscillations, and thus to find a proper means to suppress the self-induced oscillations. The under expanded sonic jet is made from a nozzle and downstream of it a cylindrical body is placed to simulate the impinging jet upon an obstacle. The computational analysis using TVD scheme is applied to solve the axisymmetric, unsteady, inviscid, governing equations. An experimental work is also made to validate the computational results. A Schlieren system is employed to visualize the self-induced oscillations generated in flow field.

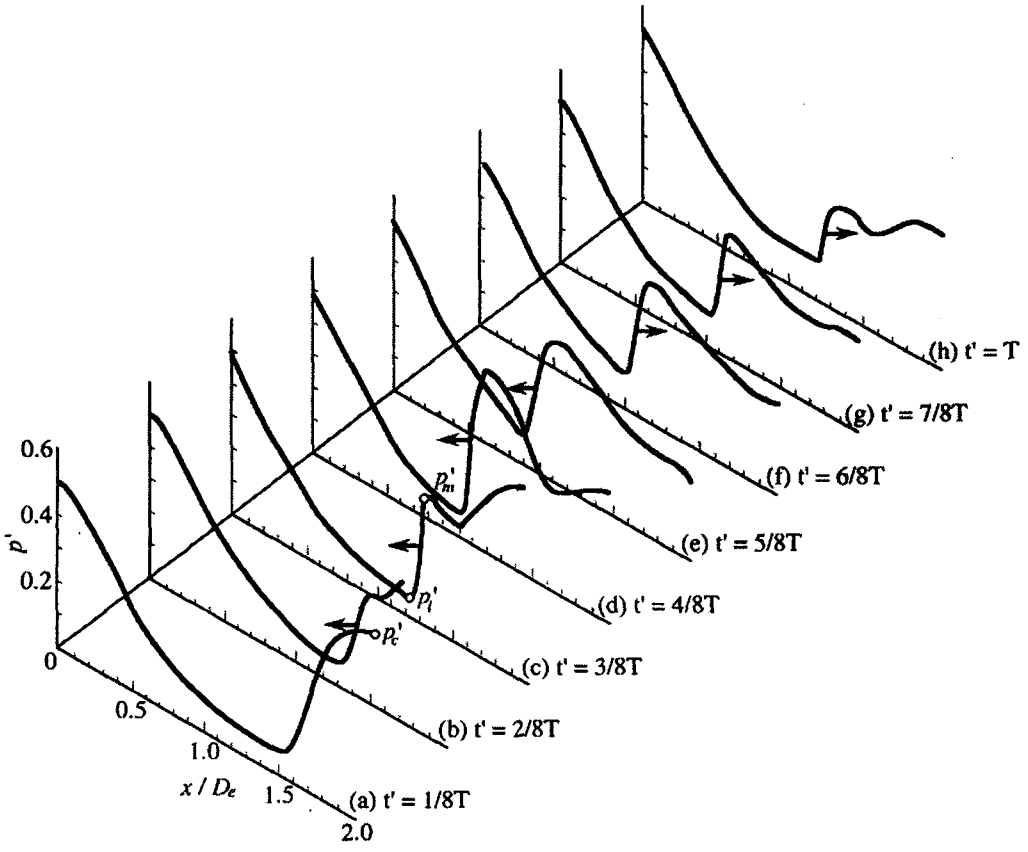

Fig.1 Pressure distributions on axis ($x_c / D_e = 2, \phi = 5.5$)

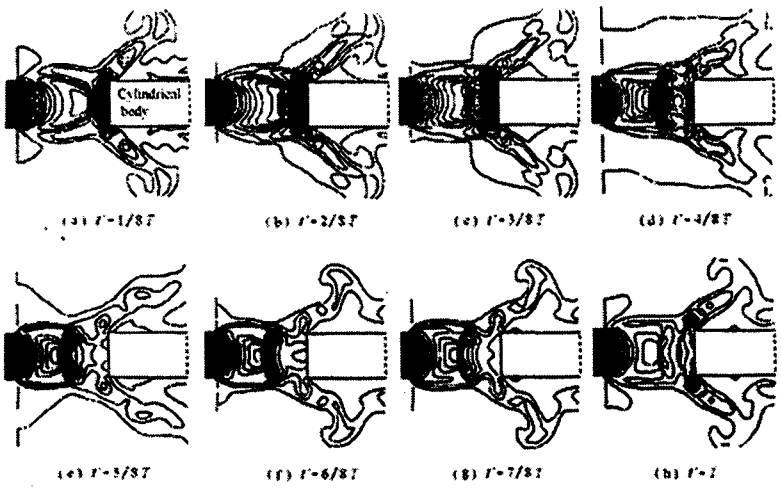

Fig.2 Density contours at several instants in a cycle of Mach disk oscillation ($x_c / D_e = 2, \phi = 5.5$)