# Numerical Analysis of Interaction Between Supersonic Jet and Perpendicular Plate

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**Abstract**

When the under-expanded supersonic jet impinges on the perpendicular plate, it is well known that the self-induced flow oscillation occurs at the specific conditions. This phenomenon is related with the noise problems of aeronautical and other industrial engineering. But, the very complicated flow field is formed and it is difficult to clear the flow structure and the mechanism of oscillation. This paper aims to clear the characteristics of flow field and the wave pattern during the under-expanded supersonic jet impinges on the plate. The numerical calculation was carried out using the TVD numerical method. In this paper, the flow visualization, the pressure fluctuation on the surface of plate and the mechanism of oscillation are discussed.

***Keyword:*** *Compressible Flow, Supersonic Jet, Mach disk, Barrel Shock, Flow Oscillation*

## 1. Introduction

When the under-expanded supersonic jet impinges on the perpendicular plate, the self-induced flow oscillation occurs at the specific conditions. The very complicated flow field contained the several shock waves and separation bubble[1] is formed because of the interaction and it seems that it is difficult to clear the flow structure. In this paper, it aims to clear the characteristics of flow field, especially, the action of the Separation bubble, the pressure fluctuation on the surface of plate and the wave pattern during the under-expanded supersonic jet impinges on the plate using the TVD numerical method.

## 2. Results and Discussions

In this investigation, the compressible unsteady axisymmetric Euler's equation is used and solved by the TVD method[2] with the operator splitting technique[3].

Figure 1 shows the principal isopycnics at several conditions, where, the symbol $x_p$ denotes the plate position, $\phi$ denotes the pressure ratio of reservoir pressure $p_0$ and the vacuum chamber pressure $p_b$. The Mach disk, standoff shock wave and other pressure wave are clearly observed. From these figures, it is remarkable that the standoff shock wave oscillates along the flow direction and the Mach disk is a stationary.

Figure 2 shows the principal isopycnics and velocity vectors, where, the symbol $T$ denotes the periodic time. It is remarkable that velocity vectors, stagnation points are changes with time so that the structure of separation bubble changes due to occur the self-induced flow oscillation.

Figure 3 shows the relation between the time averaged pressure $p_m/p_0$ on the center of plate and pressure ratio $\phi$. The value of $p_m/p_0$ is larger than the non-dimensional vacuum chamber pressure $p_b/p_0$ and decreases with increasing of pressure ratio $\phi$. From comparison with other result, the time averaged pressure $p_m/p_0$ do not depend on the oscillation and depend on the pressure ratio and the plate position.

Figure 4 shows the relation between the maximum pressure $p_{max}/p_0$ on the plate surface and the non-dimensional position of plate $x_p/D$. The value of $p_{max}/p_0$ decreases with increasing of non-dimensional position of plate $x_p/D$ and is proportional to the pressure ratio $\phi$.

## References


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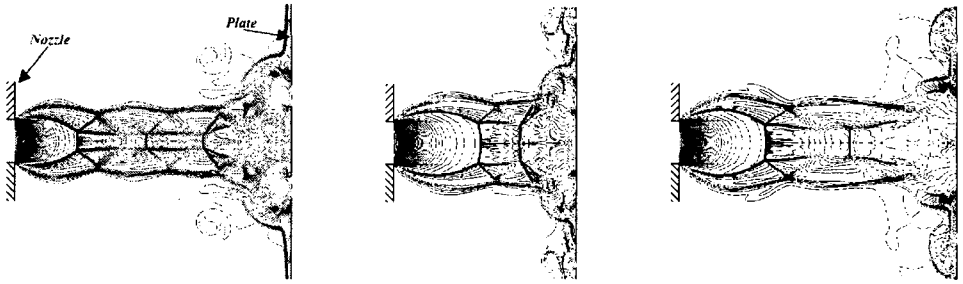
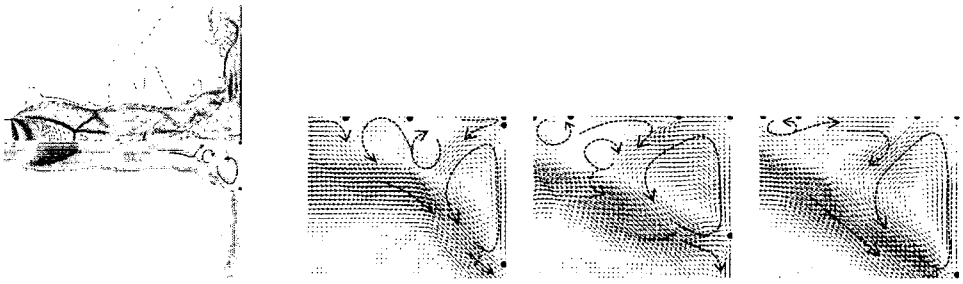



(a) $x_p/D$=6 , $\phi$=6 (b) $x_p/D$=4 , $\phi$=10 (c) $x_p/D$=6 , $\phi$=10

Fig.1. Principal isopycnics



(a) t'=T/4 (b) t'=3T/4 (c) t'=T

Fig.2. Principal isopycnics and velocity vectors

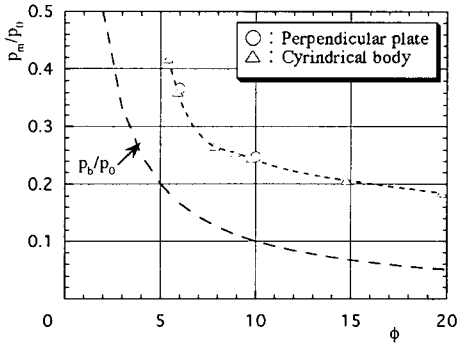



Fig.3. Relation between time averaged pressure on plate surface and pressure ratio

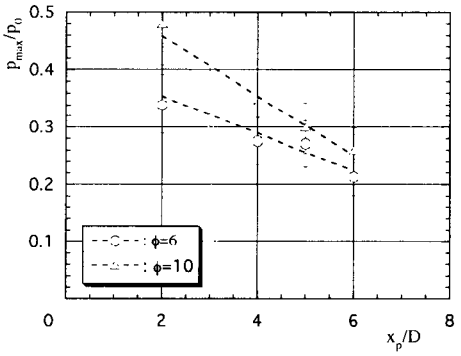



Fig.4. Relation between maximum pressure on plate and position of plate