5. Color Schlieren Photographs of Interaction between Oblique Shock Wave and Boundary Layer on Flat Plate with Bleeding Effect

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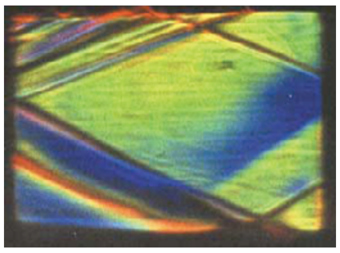
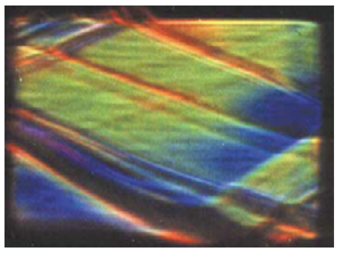


(a) Schlieren photograph (no bleed)



(b) Schlieren photograph

These figures show the CCD color schlieren photograph of interacting flow field of oblique shock wave from right middle side coming from upper two-dimensional wedge and boundary layer developed on the lower flat surface from the leading edge of rectangular intake model of 64(width)×56(height)×280(length)mm^3. The triangle section on the lower surface is the separation zone by shock/boundary layer interaction. Without bleeding of lower surface of Fig.(a), a strong oblique separation shock wave is emitted to the left upper direction and a shock wave by re-attachment of separation flow to the lower surface to the same direction is also emitted. The shock wave system is decayed and deformed if the bleed of boundary layer on flat surface is on. The two shock waves of separation and re-attachment come closer together and the strength of interacting shock waves is attenuated as shown in Fig.(b). Mach number M = 3.0, and bleeding rate is 0.1% of total intake mass flux.

6. Leading-Edge Vortices Visualized by Water Vaporization Method

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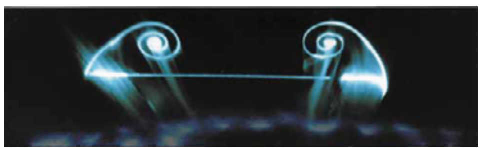
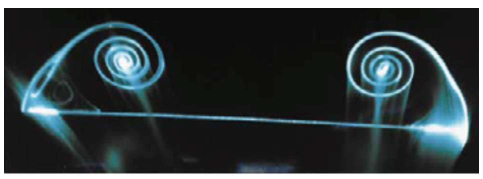
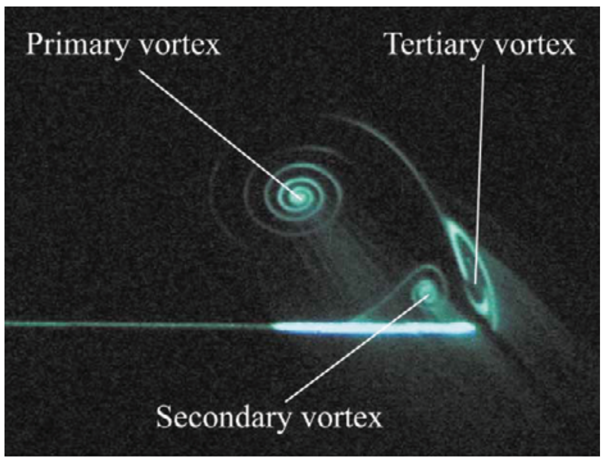


(a) Cross-sectional view of longitudinal vortices at x/c = 0.4, where x is the distance from the apex of delta wing along the centerline.



(b) x/c = 0.6



(c) Close-up view of vortices on a half side at x/c = 0.5

A pair of leading edge vortices are produced by a delta wing placed in a wind tunnel. The flow is made visible by cooling the leading edges using liquid nitrogen to condense water vapor naturally included in airflow. The delta wing model used here has a root chord length, c, of 0.25m and a sweep angle of 76 deg. Measurements were made at an airflow velocity of 2 m/s, i.e. Re = 33,000, and at an attack angle of 20 deg. Primary, secondary, and tertiary vortices are well captured as well as vortex sheets.