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Flow visualization of supersonic transverse jet over Mach 2 freestream of a sharp cone

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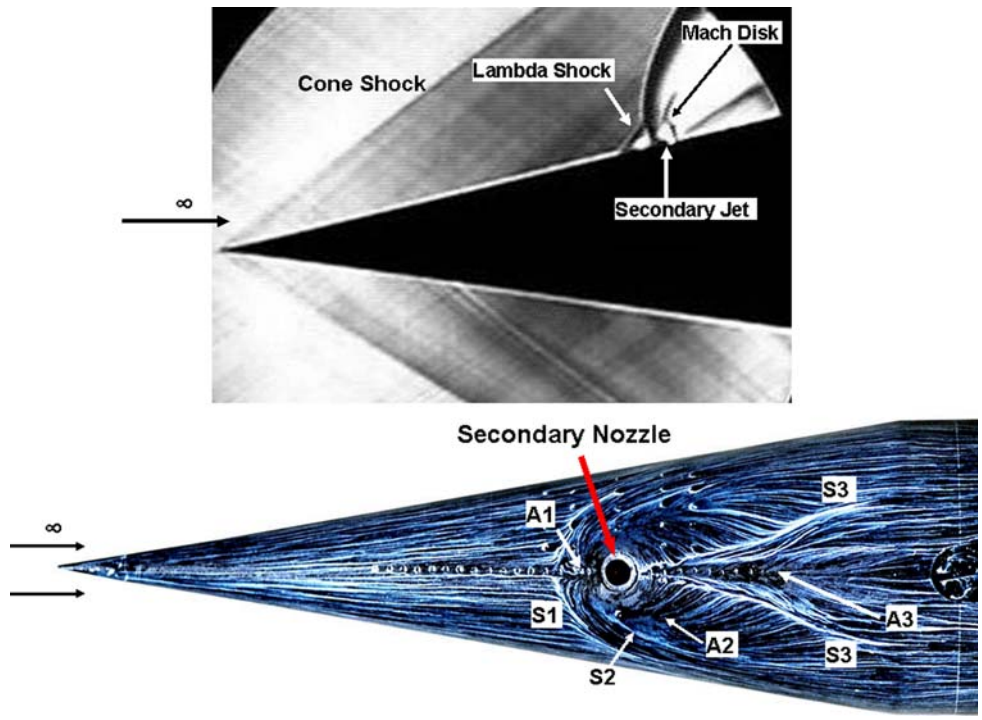

Fig. 1 Flow visualization of supersonic transverse injection ($M_{jet} = 2.5$) into supersonic flow over a cone ($M_\infty = 2$) *Top* Schlieren picture; *bottom* surface oil flow visualization

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Flow field visualization around the injection at Mach 2 freestream environment with supersonic transverse jet ($M_{jet} = 2.5$) over a sharp cone of 20° nose-angle was carried out using single pass schlieren (vertical knife edge) and oil flow techniques which were visualized in Fig. 1. The freestream Reynolds number based on the diameter of cone is 1.57 million. The total pressure of transverse jet medium of nitrogen gas is 17 bar and jet to freestream momentum flux ratio is 4.8. A mixture of titanium dioxide, 500 cP lubricant oil and oleic acid in the volumetric ratio 5:10:1 was used for oil flow visualization. After the test, the oil flow picture was recorded using still camera. Supersonic freestream flow turns by 10° over the surface of cone and forms an oblique shock attached to the cone tip. Flow after the cone shock remains at supersonic speed and this supersonic stream interacts with transverse jet. It results a bow shock upstream secondary jet. The bow shock interacting with boundary layer forms a lambda shock. A barrel shock in the secondary jet bends due to inertial loads of primary flow. These features including Mach disk are visible in Fig. 1 (top). White oil lines in Fig. 1 (bottom) indicate the flow pattern on the surface of cone. Thick oil stream marked with letter 'S' indicates location of vortex leaving the surface whereas light oil streams marked with letter 'A' indicates the location of vortex touching the surface. Three types of vortices are identified from the surface oil flow visualization. The first one is a horse-shoe vortex upstream of secondary jet, in plane of symmetry. The second vortex is in the wake, i.e., downstream of secondary jet and between pair of lines S3. The third type is either side of symmetric plane between S2 and S3.