SUPERSONIC FLOW SEPARATION IN FRONT OF A FORWARD-FACING STEP

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Abstract

A detailed experimental study has been done to understand the Shock Wave-Boundary Layer Interaction (SWBLI) over a Forward-Facing Step (FFS) of height (h) in a Mach 2.5 flow using Particle Image Velocimetry (PIV). In addition to PIV, unsteady wall pressure measurements, high-speed schlieren and surface oil flow visualization have been studied. Flow separation using surface oil flow visualization was observed around 4.1 step heights upstream of the step face. Shock motions extracted from the schlieren image sequence shows a peak frequency of approximately 1000 Hz, which corresponds to the dominant (low) frequency at which the shock oscillates; this being two orders in magnitude smaller than the characteristics frequency of the incoming boundary layer. Also, spectra of the unsteady wall pressure data shows that the shock oscillates with a peak frequency of approximately 1000 Hz. The effect of shock location (xs) from instantaneous velocity PIV fields in the cross-stream plane due to an upstream influence parameter (line-averaged boundary layer streamwise velocity, ul) and a downstream parameter (separation bubble or recirculation region area, A) is studied. Instantaneous cross-stream PIV measurements show significant variations of the separation shock location, incoming boundary layer velocity fluctuations and recirculation region. Besides, conditionally averaged velocity field based on incoming boundary layer streamwise velocity fluctuations and separation bubble area in the cross-stream plane shows that the shock location (xs) is correlated to the size of the separation bubble and not to boundary layer velocity fluctuations.