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Experimental Research of High Pressure Jet Interaction with Supersonic Crossflow

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Abstract : An experimental study of cold-jet (nitrogen) reaction control jet system has been carried out to investigate the flow control efficiency for low to moderate jet pressure ratios (total jet pressure p0jet over free stream static pressure in the wind tunnel p∞) and different angles of attack for infinite Mach number equal to 2. An investigation of jet influence was conducted on a flat plate geometry placed in the test section of intermittent supersonic wind tunnel of Department of Aerodynamics, WUT. Various convergent jet nozzle geometries to obtain different jet momentum ratios were tested on the same test model geometry. Surface static pressure measurements, Schlieren flow visualizations (using continuous and photoflash light source), load cell measurements gave insight into the supersonic crossflow interaction for different jet pressure and jet momentum ratios and their influence on the efficiency of side jet control as described by the amplification factor (actual to theoretical net force generated by the control nozzle). Moreover, the quasi-steady numerical simulations of flow through the same wind tunnel geometry (convergent-divergent nozzle plus test section) were performed using ANSYS Fluent basing on Reynolds-Averaged Navier-Stokes (RANS) solver incorporated with k-ω Shear Stress Transport (SST) turbulence model to assess the possible spurious influence of test section walls over the jet exit near field area of interest. The strong bow shock, barrel shock, and Mach disk as well as lambda separation region in front of nozzle were observed as images taken by high-speed camera examine the interaction of the jet and the free stream. In addition, the development of large-scale vortex structures (counter-rotating vortex pair) was detected. The history of complex static pressure pattern on the plate was recorded and compared to the force measurement data as well as numerical simulation data. The analysis of the obtained results, especially in the wake of the jet showed important features of the interaction mechanisms between the lateral jet and the flow field.

Keywords : flow visualization techniques, pressure measurements, reaction control jet, supersonic cross flow
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