Numerical investigation of shock wave/vortex interaction

V. Magri\textsuperscript{a}, I. M. Kalkhoran\textsuperscript{b}

The purpose of the present study was to investigate the interaction between stream-wise vortices with oblique shock fronts of various intensities. A three-dimensional, Navier-Stokes solution of the problem with an orthogonal grid incorporating a RANS approach with a RNG $k$-$\epsilon$ turbulence model was used to simulate earlier experimental studies of the problem. The accuracy of the computational study was evaluated by comparing the results to the previous experiments of oblique shock vortex interactions using three different shock wave intensities leading to weak, moderate and strong interactions as identified in our previous experimental investigations. Similar to the experimental findings, the weak and the moderate interactions did not result in vortex breakdown as the vortex was seen to deflect in the direction of the main flow downstream of the shock with lowered intensity. Computational simulation of the strong interaction case however, confirms presence of a supersonic vortex breakdown having many of the characteristics of subsonic vortex breakdown. The flow field generated by the strong interaction is characterized by the formation of a bulged forward shock structure followed by a rapid expansion of the vortex core, formation of a stagnation point on the vortex axis and appearance of a reversed flow region (in a recirculation zone). The vortex was modeled by implementing the experimentally measured vortex properties at the inlet, namely total and static pressures, while constant total temperature was assumed to calculate the velocity, and components of the Mach number. Inlet values for turbulent kinetic energy and turbulent dissipation rate were calculated from assumed values of turbulence intensity.

\textsuperscript{a} Dep. Mechanical Engineering, Polytechnic Institute of NYU, Brooklyn, NY 11201, USA  
\textsuperscript{b} Dep. Mechanical Engineering, Polytechnic Institute of NYU, Brooklyn, NY 11201, USA  
\textsuperscript{1} M. Smart, I. M. Kalkhoran, \textit{AIAA J.} 33, 2137-2143, (1995)

\textbf{Figure 1:} (a) Experimental shadowgraph of the strong interaction\textsuperscript{1}. (b) Computational streamlines of the strong interaction.