

Passive flow control of shock-wave/boundary-layer interaction using surface roughness: A numerical study

Russell Quadros

Shock-wave/boundary-layer interactions (SBLIs) are commonly observed in high speed engineering applications such as air intakes, turbo-machinery cascades, helicopter blades, supersonic nozzles, and launch vehicles. The nature of the incoming boundary layer, which interacts with the shock, has a significant impact on the flow topology and aerodynamic performance of the aerospace vehicle. It is advantageous to have a transitional boundary layer interacting with the shock as compared to a laminar or a turbulent boundary layer. A transitional interaction could bridge the gap between the large separation size obtained in a laminar interaction and the high drag associated with the turbulent interaction.

Using direct numerical simulation, we trip the incoming laminar boundary layer through hemispherical surface roughness elements, and impinge an oblique shock wave while the boundary layer is still in transition. In order to analyse the effect of shock strength on the interaction, we consider two cases of shock-generator angles (3 and 6 degrees). We compare our results with available experimental data for cases with and without the impinging shock. We observe a suppression in the mean separation region for the transitional interaction case irrespective of the shock strength. Also, lower levels of instantaneous separation are observed in the transitional interaction as compared to the turbulent interaction.