# Abstract

Higher wave drag is a common problem for an object flying in the supersonic or hypersonic flow regime. Hence, the present investigations use computational fluid dynamics as a tool to study the dynamics of flow field to mitigate the adverse effects in such a complex environment. For this, a finite volume-based two dimensional axisymmetric compressible reacting flow solver is developed which is comprised of five species and eleven chemical elementary reactions. Initial investigations on blunt object show that downstream movement of the bow shock and shock stand-off distance lead to increases in the surface pressure and thus drag force. Shock reconstruction for the spiked object leads to the downstream movement of the conical shock which leads to the lesser size of recirculation zones. Hence, higher pressure and drag is obtained for every shapes of spike (Conical, spherical and flat) length at higher stagnation enthalpy cases. Integration of two drag reduction methods, spike and counter flow jet, is also proved a better drag reduction device. Further, studies are carried out to understand the Shock-Shock (S-S) interactions for a spherical object in the presence of a forward-facing stagnation spike. The shock stand-off spike (L=0.125D) witnesses initiation of the S-S interaction and seeding of a recirculation zone. This is the spike case at which frictional drag is higher than the wave drag. Further longer spikes alter the recirculation bubble size and S-S interaction type. Stronger interaction and undeveloped recirculation, for spike length of 0.25D, lead to maximum drag enhancement for the object. Higher exergy destruction is also observed for the same spike length. Further increment in spike length produces weaker interaction as well as larger recirculation zone which improves drag reduction for the same object. Combination arrangement of spike (L=0.25D) and counter-flow jet is also investigated to prove that at least two recirculation zones and weak S-S interaction are mandatory for the realization of drag reduction using a stagnation spike. Unsteady single pulse energy deposition at higher freestream enthalpy show increase in pressure and decrease in density in the deposited energy pulse. Moreover, the size of the blast wave increases for elevated enthalpy cases. This alteration in energy pulse leads to the formation of a stronger vortex in the stagnation region and witnesses generation of an extra valley in the drag signal. Hence, power effectiveness for the energy pulse increases at higher enthalpy conditions and it is in consistent with all upstream deposition locations. Further, steady energy deposition is marked with higher drag and lesser power effectiveness at higher stagnation enthalpy conditions. Hence, the unsteady energy deposition is found to be better for drag reduction over the steady energy deposition at higher enthalpy cases. Performance of unsteady energy deposition has shown further improvement when multiple pulses are deposited in a certain frequency at a given upstream location.