Abstract

In traditional two-dimensional shock wave theory the reflection of a shock wave off a surface is treated as an adiabatic process and that the reflection surface is perfectly rigid and smooth with an inviscid flow of the fluid. In reality it has been found that these assumptions are not entirely accurate, and that although they are a good indication in the regular and irregular reflection domains of shock waves over the surface, viscous and thermal effects are present within the flow field. It has been experimentally shown that the transition of regular reflection to irregular reflection exceeds the theoretical limit, which is known as the von Neumann paradox. This paradox has largely been accounted for in the formation of a viscous boundary layer behind the reflected shock wave, based on numerous experimental and computational studies. However, the thermal effects in the reflection process have largely been neglected as the assumption of heat transfer between the post-shock wave gas and the reflection surfaces is assumed to be invalid.

These thermal effects were investigated by testing materials with a varying range of thermal conductivities (1.13 to 401 W/mK) and similar surface roughness's below the suggested limit for hydraulic smoothness. Each experiment placed two test pieces at the same incidence angle, symmetrically in the shock tube. This allowed flow properties to be exactly the same for the two materials being tested with a single plane shock wave. Test Mach numbers ranged from 1.2790 to 1.3986, with tests conducted at shock wave incidence angles of 36°, 40°, 60° and 70°. This allowed both the regular and irregular reflection domains to be tested. Shadowgraph images were created using a z-configuration optical set up. These shadowgraph images were analysed quantitatively based on the angles measured as well as qualitatively based on flow features and symmetry.

Both the quantitative and qualitative tests indicated that there was a difference in the angles between the reflected shock waves and surfaces based on the material thermal conductivity. In the quantitative tests the value of this angle was larger for materials with a lower thermal conductivity, and smaller for ones with a higher thermal conductivity for the regular reflection cases. In the irregular reflection cases the angle between the reflected and incident shock waves was larger for materials with a higher thermal conductivity. The materials with midrange thermal conductivities had reflection angles that lay within the

bounds of the glass and copper angle values. The qualitative images supported these findings showing asymmetry in materials with different thermal conductivities with the intersection of reflected shock waves lying closer to the material with a higher thermal conductivity. Control experiments using test pieces made from an identical material showed no bias due to the location of the test piece in the shock tube.