Abstract

Curved shock waves, particularly converging shock waves, have applications in a wide variety of fields, yet they are severely under-represented in the literature. Shock reflection is typically categorised in terms of the shock Mach number and incident angle, but these parameters both vary with time for a curved shock wave.

A facility capable of producing shock waves with an arbitrary two-dimensional profile was designed and manufactured. A planar shock from the end of a conventional shock tube is passed through a narrow slit and turned through a 90° bend, generating a shock with an initial shape matching the profile of the slit.

The facility was first used to study the propagation of shock waves of arbitrary shape. This included a brief computational fluid dynamics (CFD) study of the interaction between straight and concave segments on a shock front, followed by CFD and experimental studies into the propagation of shock waves consisting of both concave and convex segments, with initially sharp and rounded profiles. Shocks with Mach numbers between 1.2 and 1.45 were generated, and the behaviour of the shock waves produced by the experimental facility agreed favourably with the CFD simulations, particularly for the higher Mach numbers.

A detailed study into the reflection of converging cylindrical shock wave segments was then carried out. CFD simulations for Mach numbers at the apex of the wedge varying from 1.2 to 2.1, for wedge angles between 15° and 60°, and experiments with apex Mach numbers between 1.5 and 2.1 and wedge angles between 15° and 50° were carried out. The sonic condition usually used for predicting the planar shock reflection configuration was successful at predicting the initial reflection configuration. If the initial reflection was regular, then the shock was cleanly reflected off the surface, with no discontinuities in the reflected shock front. However, if the initial reflection was a Mach reflection, this would inevitably transition into a transitioned regular reflection, with the residual Mach stem and shear layer still present behind the reflection point. Collision of the Mach stem with the corner at the end of the wedge generated a small region of very high pressure, which lasted for several microseconds.

A simple theoretical model was developed for estimating the Mach stem height and transition point for a converging cylindrical shock segment encountering a straight wedge. The model gives reasonable predictions for shocks of moderate strength and wedge angles below 40°, but deviates from experimental results for wedges at 40° and above.