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Shock Wave Reflections off Curved Surfaces

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Abstract

In this work two separate studies are performed on the reflections of shock waves off curved surfaces. The effect of thermal conductivity on shock wave reflection off curved surfaces and very weak shock wave reflection are investigated.

Effect of Thermal Conductivity on Shock Wave Reflection off Curved Surfaces

Previous work has shown that the properties of a shock wave reflection off a flat surface are affected by the thermal conductivity of the reflection surface. In the more complex reflection case of a curved surface, tests were done in undergraduate studies to determine whether heat transfer into the reflection surface has an effect on the shock wave reflection properties. Although the results proved promising, further testing is required to provide conclusive results.

Tests are performed on concave and convex test pieces. Test pieces of different thermal conductivities (0.19 W/mK and 401 W/mK) and hydraulically smooth surfaces are used in the experimentation. The test pieces are placed in identical positions on either side of a plane of symmetry and at the same incident angles in the shock tube. Z-configuration shadowgraph and high speed imaging is used to capture the images. Tests are performed at Mach numbers in the range of $1.26 \leq M \leq 1.5$. The images are analysed both quantitatively through reflection angle measurements and qualitatively by examining the symmetry of the reflection patterns.

Both the qualitative and quantitative analysis performed show that the thermal conductivity of the reflecting surface affects the reflection patterns off curved surfaces. The quantitative analysis showed that heat transfer into the reflecting surface affects the reflection patterns through the measurement of various reflection angles. Significant differences in the reflection angles indicate the presence of thermal conductivity effects. In the qualitative analysis asymmetry in the reflection patterns is found at all Mach numbers, supporting the findings which are found in the quantitative analysis.

Weak Shock Wave Reflection off Curved Surfaces

Little is known about the behaviour of very weak shock waves. At Mach numbers below 1.03 there is an absence of experimental data. Several attempts at achieving a Mach number below 1.03 have been unsuccessful. In a previous study, Mach numbers between 1.03 and 1.05 showed that there are variations in the accepted reflection evolution of a curved surface. The previous work indicated the existence of a regular reflection pattern in the curved shock wave reflection evolution. The aim of the current study is to perform tests at a Mach number below Mach 1.03, explore the existence of a regular reflection pattern in the reflection evolution, and investigate the evolution of very weak shock wave reflection off a curved surface.

Experimentation is performed in a large shock tube. Various diaphragm materials such as: wax paper, aluminium foil and 12μm plastic sheeting are used to obtain Mach numbers close to unity. A 520mm radius cylindrical curved test piece with zero initial ramp angle is used in the experimentation. A shadowgraph optical setup and high speed photography is used to capture the test images. The images are analysed both qualitatively and quantitatively. Novel experimental data in the form of tests at a range of $1.007 \leq M \leq 1.026$ is captured. No shear layer is present on the Mach reflection or transitioned regular reflection at Mach numbers below 1.07. A reflection pattern resembling a regular reflection exists in the evolution between the three shock reflection patterns and the transitioned regular reflection. At low Mach numbers, curved reflection waves are observed.