Abstract

A transonic wind tunnel was designed, constructed and calibrated in order to provide a valuable tool for the study of transonic flow phenomena. The wind tunnel makes use of flow properties surrounding the propagation of a shock wave along a tube in order to create the transonic flow. As a result, the wind tunnel is a modified shock tube, with its layout being optimised for maximum flow time. The flow times are dependent on the Mach number of the transonic flow being created, with the longest realistic flow time being approximately sixty milliseconds. The majority of the shock tube was built from commercially available steel construction tubing which was then attached to a pressure vessel of similar cross sectional dimension. A test section containing windows was constructed and placed in a position along the length of the tube to maximise the available test flow time. The position optimisation was calculated based on standard shock wave theory. The incident shock wave, as well as any resulting flow features, were visualised using schlieren photography. The test piece was designed to be set at angles of attack of up to ten degrees, both positive and negative. The main purpose of the testing carried out was to validate the functioning of the wind tunnel rather than obtaining more data on the test piece. An RAE2822 aerofoil was used as the test piece due to the large amount of aerodynamic data available on it, especially in the transonic flow region, thus making it an excellent tool for validation. In addition, the Fluent computational fluid dynamics package made use of the same aerofoil to validate their numerical results when the package was under development. This meant that for any numerical result obtained for the RAE2822 aerofoil using the Fluent package, there was a high degree of confidence. This fact provided a great tool for comparing results obtained experimentally in the wind tunnel with results obtained numerically. The short duration testing time was found to be adequate for establishing semi-steady state flow at any transonic flow Mach number. The bursting of the weak diaphragm at the end of the driven section of the shock tube resulted in the upstream propagation of a disturbance with a much lower velocity than would be seen if the incident shock wave reflected off a solid boundary and thus its arrival at the test section was delayed, resulting in a significant increase in testing time.

The results obtained experimentally compared well to results obtained numerically. Transonic shock waves that were set up on the test piece had very similar shapes, features and chord-wise positions in both experimental and numerical results, showing that the geometric layout of the test section was correct. Furthermore, it was shown that a short duration flow time wind tunnel could be constructed using a shock tube and that accurate results could be obtained through its use.