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Chirewa, B.T.

2024
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Blast Wave Generation and interactions

B.T. Chirewa

A dissertation submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, April 2022

Abstract

The purpose of this study was to produce blast waves and study the flow properties behind the blast wave wherre the blast wave Mach number ranges from 1.11 to 1.44. Previous studies on blast waves only focused on the positive phase of the pressure decay profile. The negative phase is usually ignored. The negative phase was given more attention in this study. A blast tube that was designed in a previous study was used in the experiments to generate the blast waves. A numerical study was performed using Ansys CFD software alongside the experimental study to have a validation for the blast tube design. Both the experimental and the numerical pressure decay profiles showed strong correlation with the Friedlander pressure decay profile. The decay profiles were further validated by calculating the positive impulse. This was calculated as the area under the positive phase of the decay profiles. The experimental positive impulse was 1.08% higher than the positive impulse of the Friedlander profile and the numerical positive impulse was 1.32% higher than the positive impulse of the Friedlander profile. These were insignificant differences which showed that the blast tube was producing blast waves of good quality. The secondary shock was observed in the pressure traces as a sharp increase in pressure in the negative phase followed by a gradual decrease. It was noted that the secondary shock wave remained in the negative phase. The flow velocity in the negative phase was observed to be high enough to pick debris caused by the incident shock wave which can result in further structural damage. As the Mach number increases, the incident shock wave and the secondary shock wave become further apart. This is because the speed of the incident shock wave increases at a faster rate with increasing Mach number than the speed of the secondary shock wave. The experimental diffraction was studied on a 90° corner using a schlieren optics setup connected to a high-speed camera set to capture 65000 frames per second. The observed diffraction patterns in the perturbed region were similar to those observed in the diffraction of weak shock waves. This region was characterised by a diffracted shock wave, a reflected expansion wave, a vortex, a slipstream and a viscous vortex. The slipstream angle was noted to decrease during the blast wave diffraction, contrary to shock wave diffraction where the flow is pseudo-stationary. The contact surface that is seen in the diffraction of weak shock waves was observed being entrained into the vortex but not visible near the incident shock wave. The reflected expansion wave that is circular in

the diffraction of weak shock waves was seen to be distorted in the blast waves case. The distortion happened as soon as it encountered the variable velocity and sound speed behind the incident shock wave. A comparison of the ratio of the distance moved by the expansion wave to the distance moved by the incident shock wave during diffraction was made between normal shock waves and the blast waves. It was observed that the ratio was higher for blast waves than for shock waves. This is because the flow velocity trailing a blast wave decreases at a faster rate than the decrease in sound speed. This causes the reflected expansion wave to propagate further upstream in blast wave diffraction than in shock wave diffraction. The difference between the ratios was observed to become smaller as the Mach number approaches unity. This was because flow velocity tends to zero at Mach 1 and the propagation of the reflected expansion wave will only be determined by the sound speed which will be similar for both the blast wave diffraction and the shock wave diffraction. A higher resolution camera should be used to allow for accurate measurement of distances and a wider range of Mach numbers should be used to confirm the trend. A numerical study with better flow visualisation resources is recommended for future studies. Future studies are also recommended on the vortex behaviour in blast wave diffraction, which was established to be much more complex than in shock wave diffraction.