EXPERIMENTAL STUDIES ON COMPOSITES AND FOAMS UNDER INTENSE LOADING USING SHOCK TUBE

C. Jayarami Reddy, V.Madhu

Armour Design and Development Division, Defence Metallurgical Research Laboratory, Kanchanbagh PO, Hyderabad-500 058, INDIA.

ABSTRACT

Fibre reinforced composite materials and aluminium foams are being widely used as blast mitigation materials, due to their light weight and good energy absorption properties. The explosive blast on materials involves the generation of shock wave and its intense loading on materials. The understanding of shock loading on materials and their corresponding failure mechanisms is very important to design materials for blast mitigation. Conventionally, the shock interaction or shock loading studies are carried out using high explosives at different stand-off distances. However, these studies are very unsafe, expensive, time consuming and also requires large samples and test fields. Alternatively, these shock interaction studies can be performed using shock tube at lab scale.

In the present study, the behaviour of E-glass/epoxy composites and aluminium foams under intense shock loading was studied using gas driven and piston driven shock tubes. Reflected shock pressures ranging from 10-50bars and 50-200bars were generated using gas driven and piston driven shock tubes, respectively. The real time pressure measurements were recorded using piezoelectric pressure sensors. Higher shock pressures in piston driven shock tube were achieved by changing the initial driven gas pressures. The failure mechanisms of the composites and aluminium foams were monitored by transmitted pressures and post-test sample analysis. The effect of the temperature of the shock wave and the thickness of the composite sample on failure patterns was also studied. The transmitted pressures were increased with increase in incident and reflected shock pressures. No failure of E-glass/epoxy composites was observed when interacted or loaded with shock wave pressures up to 50bar. 3mm thick E-glass/epoxy composites exhibited a shear cap type of failure, fibre breakage and delamination on the back side of sample when subjected to shock pressures ranging from 70-150bar and completely perforated at 200 bar. No failure was observed on the front side of 5mm thick sample up to 200bar. However, internal delamination was observed on the back side of the 5mm E-glass/epoxy composites at all the shock pressures ranging from 70-200bar. The delamination area on the back side increased with increased shock pressures. The main damage mechanisms of fibre composites under shock loading are observed to be fibre breakage and delamination. 10mm and 20mm thick Aluminium (Al) foams were perforated at approximately 60bar pressure, thereby transmitting the shock pressure. The failure mechanisms of foams at higher shock pressures were observed to be core crushing and core fracture.