The Perforation Resistance of Fibre Metal Laminates Subjected to High Velocity Oblique Impact

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Abstract. The high velocity impact resistance on 7075 series aluminium alloys and glass fibre reinforced epoxy resin based fibre metal laminates (FMLs) have been investigated experimentally. A series of oblique impact tests was conducted on typical 3/2 configurations (3 aluminium layers and 2 composite layers) fibre metal laminate using a projectile gas-gun launcher. The oblique angle was increasing up to 60 degree, The impact velocity range between 140 m/s and 160 m/s. The impact response of fibre metal laminates samples was characterised by determining the energy required to perforate the panels. A stereoscopic Digital Image Correlation (DIC) method was adopted to measure full-field 3D deformation measurements for FMLs which providing the full field strain history up to sample perforation. It has been shown that the absorbed energies increased with the oblique angles.

Introduction

Fibre metal laminates (FMLs) are very important aircraft materials in civil industries, due to its advanced performance compared to metallic alloy and conventional composites [1-2], such as specific strength and fatigue resistance. Increasing research focusing on enhancing impact resistance of such materials makes update the knowledge of damage mechanism[3], failure properties and dynamic response of FLMs [4] subjected to the high-speed impact very important[5]. The present research investigates the impact performance of two types of FMLs by conducting gas gun tests with various impact angle, initial velocities up to 160 m·s-1, employing with 3D Digital Image Correlation (DIC). The glass fibre reinforced woven plastic (GRP) and two types of 7075 series Al-ally panels are used to manufacture the FMLs with the design structure of Al/ GRP/ Al/ GRP/ Al; brass are machined as projectiles. These specimens are tested under penetrated velocities and unpenetrated velocities. Figure 1 shows the experimental set-up for the gas-gun impact tests.

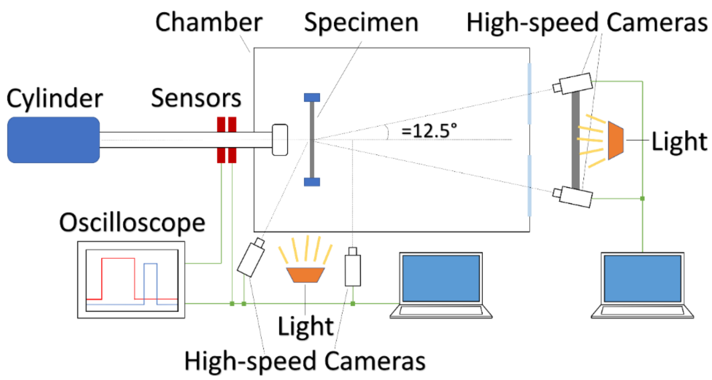

Figure 1. Schematic illustration of the experimental set-up for the gas-gun impact tests.(a) Gas gun (b) Stacking configuration of 3/2 FMLs

Experimental procedure

The FMLs investigated were manufactured from two woven glass-fibre-reinforced plastic layers and three aluminium alloy layers using a hot press. The size of square FML panels is 160 mm x 160 mm. The specimen was placed on a steel clamps with opening of 100 x 100 mm. The rotating angle of clamps allow to be rotated by 15° for angled impact.

High-velocity impact tests were conducted using the gas gun apparatus shown in Figure 1. Four high-speed cameras are introduced, two of them are placed out of the chamber and with a certain distance away from the rear of the chamber, they are used to record the history of the out-of-plane displacement. The other two are placed on the one side out of the chamber, one of them records the impact history happened the surface of the specimen, another is used to calculate the residual velocity of the projectile after penetration. When the projectile flies through, the sensors at the end of the barrel record the impact velocity of the projectile, which is shown on the screen of the oscilloscope; meanwhile, these four cameras are triggered to record. By comparing the residual velocity and out-of-displacement history generated by 3D DIC at each angle impact, the characteristics of FLMs subjected to high-speed-angle impact are summarised.

Results and discussion

The deformations of the rear surface of the FML panels are reported using the 3D DIC technique when the face of the front aluminium alloy layer of the panel is subjected to angled impact by a 10 mm diameter brass projectile. Figure 2 shows the full-field out-of-plane displacement contour maps (Fig 2) during impact of This FML type has a configuration of three aluminium alloy outer layers and two middle composite layer and was subjected to an impact velocity of 140 m s^{-1}.

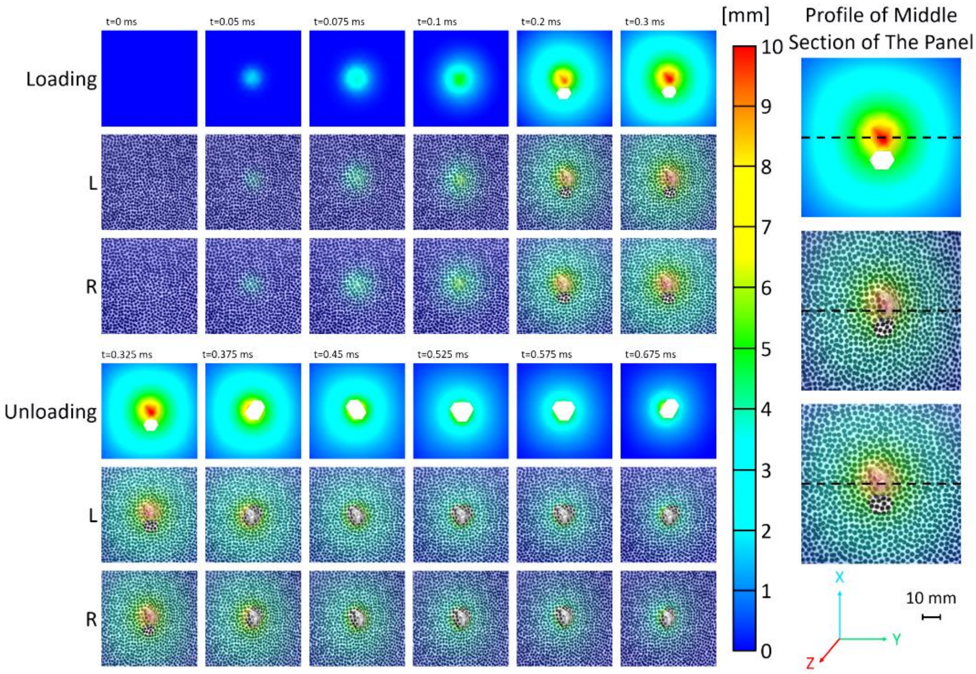

Figure 2 Measured results (obtained from 3D DIC) for the 3/2 FML panel impacted at a velocity of 140 m s^{-1}.

Conclusions

High velocity impact tests were carried out to investigate angled impact behavior of the FMLs subject to impact velocity between 130 m/s to 160 m/s. The perforation resistance of FMLs have been investigated though a series of high velocity impact tests with increasing oblique angles. An examination of the deformation of the failed laminates indicated that the failure process was various depends the oblique angels. It has been shown that the the absorbed energies increased with the oblique angles up to 45 degrees.

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