THE HIGH VELOCITY IMPACT RESISTANCE OF FIBRE METAL LAMINATES

J. Zhou[1], C.Kaboglu[2], I. Mohagheghian[2], Z. Guan[1], J. P. Dear[2] and W.J. Cantwell[3],

[1] School of Engineering, University of Liverpool, Liverpool, L69 3GH. United Kingdom,
Email: jinzhou@liv.ac.uk
[2]Department of Mechanical Engineering, Imperial College London, SW7 2BX , United Kingdom.
Email: c.kaboglu13@imperial.ac.uk
[3]Aerospace Research and Innovation Center, Khalifa University of Science Technology and Research,
127788 Abu Dhabi, United Arab Emirates.
Email:cantwell@liv.ac.uk

Keywords: High velocity impact, Fibre metal laminates, Digital Image Correlation, Hashin 3-D Criteria, Finite Element.

ABSTRACT

The high velocity impact resistance of fibre metal laminates (FMLs) based on combinations of three different aluminium alloys (6161-O, 6061-T6, 7075-T6) and a glass fibre reinforced epoxy resin have been investigated both experimentally and numerically. A series of perforation tests on multilayer configurations, ranging from a simple 2/1 lay-up to a seven ply 4/3 laminate. High velocity impact was conducted using a projectile gas-gun launcher, operating in the velocity range between 119 m/s and 252 m/s.[1] 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 deformations and strain for FMLs which providing the full field strain history and 3D measurements up to sample perforation. The perforation resistance of the panels was predicted using the finite element analysis package Abaqus/Explicit. A vectorized user-defined material subroutine (VUMAT) was employed to define Hashin's 3D rate-dependant damage criteria for the composite layers. The subroutine was implemented into the commercial finite element software ABAQUS/Explicit to simulate the deformation and failure of FMLs. Agreement between the predictions of the finite element models and the experimental data was good across the range of configurations. Ballistic limit of those FMLs was obtained from both the experimental tests and numerical approaches.

A series of the impact velocities both above and below that required for full perforation were applied to investigate the ballistic limit curve of the sample. The range of the applied impact velocity was between 115 m/s and 252 m/s. Figure 1(a) shows the residual velocity versus initial velocity to find out the ballistic limit and the ballistic curve of the each sample. The increasing ratio of the residual velocity is lower than the increasing ratio of initial velocity. Seven samples were perforated with increasing impact velocity of 116 m/s and 252 m/s. The Figure 1(b) shows top view and cross sections. All damage localised under the point of impact and tensile fracture was observed on the distal surface of the sample [2-3]. The tensile fracture ended up with cross shape failure was determined up to impact velocity of 172 m/s, after then the failure on the distal surface of the sample became more circular. The matrix and fibre cracking was observed as a first failure through the whole sample on the GFRP laminates; cracking on metal laminate at the distal face of the sample and delamination between metal and GFRP laminates which are closest to the distal surface of the sample followed respectively. [4] The DIC measured displacement shown in the Figure 1 (c). The experimental data is used for FE validation.

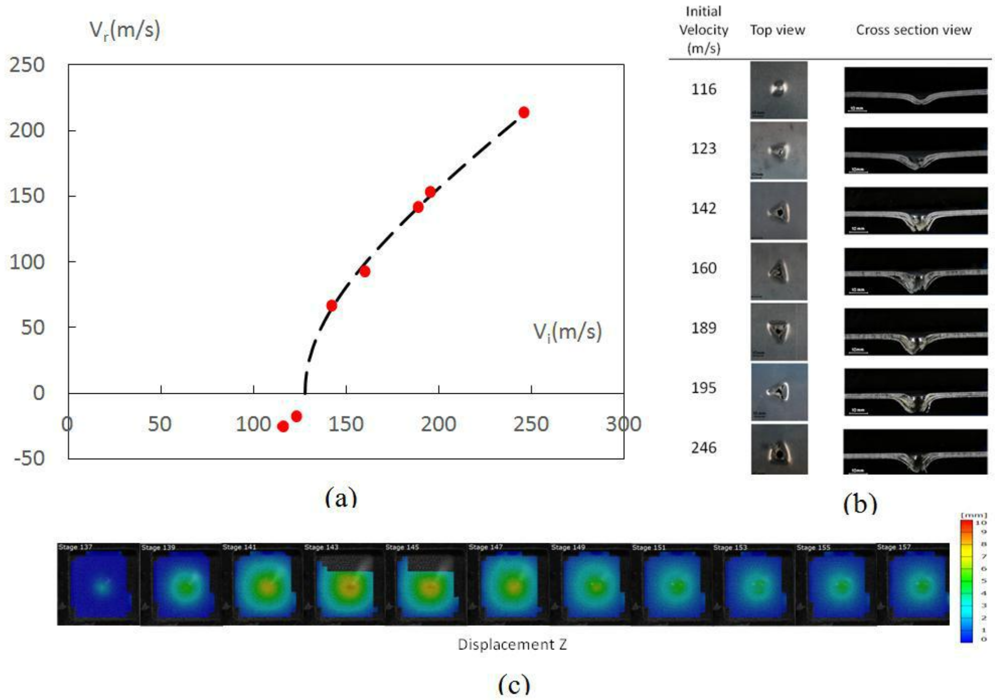

Figure 1 High velocity impact tests on 7075-T6 based FMLs (a) Impact velocities (b) Impact surface and cross sections, (c) DIC measured displacement of first specimen with 116 m/s impact velocity.

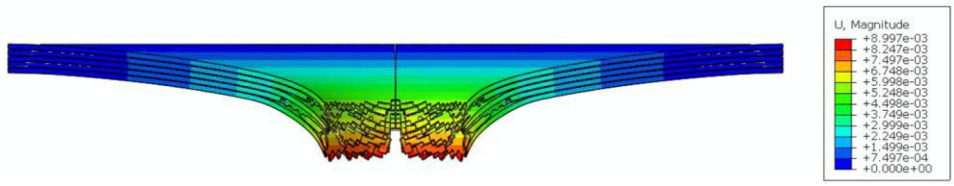

Figure 2 Finite element simulation of perforation

High velocity impact tests were carried out to investigate impact behavior of the FMLs subject to high impact velocity between 100 m/s to 250 m/s. The perforation energies of a range of FMLs have been investigated though a series of high velocity perforation tests. Initial attention focused on perforation energies on a series of perforation tests on multilayer configurations, ranging from a simple 2/1 lay-up to a seven ply 4/3 laminate and followed by impact test with increasing velocity on 3/2 configuration. It has been shown that both the individual composite and the aluminum substrates exhibit a low degree of energy absorption, the perforation energy increasing slightly with increasing of impact velocity. An examination of the cross-sections of the failed laminates indicated that the failure process were similar. Here, similar levels of plastic deformation, fiber fracture and delamination were observed. Finally, it has been shown that the validated FE model be able to simulate the perforation and parametric studies.

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