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MANUFACTURE AND BALLISTIC TESTING OF SHEARED PLATES MADE FROM DYENEEMA® HB26

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ABSTRACT

This work aims to investigate the effect of pre-existing in-plane shear on the ballistic performance of plates made from Dyneema® HB26. This contribution focuses on experimental characterisation. Specific parameters that are investigated include the degree of shear and fibre orientation, representing the location of impact on a formed hemispherical surface. Details of the manufacturing process of these plates are presented here.

INTRODUCTION

Studies on the failure mechanisms of Dyneema® materials have been performed in a continuous effort to enhance the ballistic performance of composite body and vehicle armour (Van der Werff, 2016). DSM is the inventor and manufacturer of Dyneema®, DSM's premium brand for UHMwPE. Most studies are however limited to flat laminates. Deep-drawing of Dyneema® UD cross-plies into spherical geometries adds curvature and in-plane shear to the laminate, each affecting the impact performance of the laminate in its own way (Cherouat, 2001). This study focuses on the effects of in-plane shear on the deformation of plates made from Dyneema® under ballistic impact.

Nazarian and Zok (Nazarian, 2014) developed analytical and numerical models that incorporate in-plane shear deformations. These deformations are accompanied by large fibre rotations, the effects of which not accounted for by the Cunniff parameter. Dangora et al. (Dangora, 2015) have characterised the in-plane shear stiffness of Dyneema® HB26, and the factors affecting it, forming the basis of the methodology used in this investigation.

In this study, a picture frame rig is built to accommodate 200 mm x 200 mm $[0/90]_2$ samples of Dyneema® grade HB26. The rig is mounted on a mechanical test machine and a displacement is applied to extend the samples in the ±45° direction until the desired shear angles, 30° and 60°, are reached. Factors investigated during the shearing process include displacement rate, 60 and 10 mm/min, frame clamping pressure, 0.1 MPa and 0.5 MPa, and temperature, 21°C and 80°C, as applied by a thermal chamber. The load is recorded against global displacement, with local strain values recorded using a video gauge system. The sheared HB26 is hot pressed to form 7-9 mm thick plates and tested under ballistic impact to determine the effect of the degree of shear on the ballistic response of the plates.

RESULTS AND CONCLUSIONS

In Fig. 1 (a) the values for the force are normalised with the sample area, representing the stress on the samples, while the shear force in (b) is normalised to the lengths of the frame and the samples, as performed in previous studies (Cao, 2008). Due to the low friction

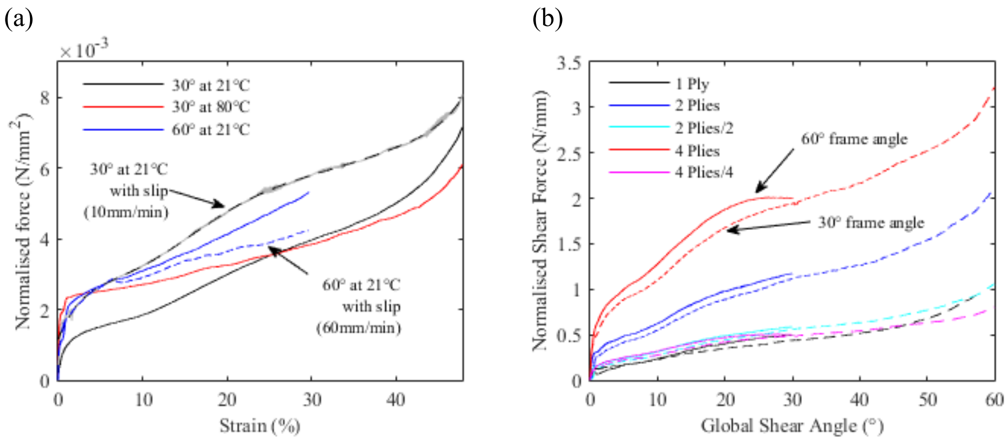

Fig.1 (a) Normalised global force-strain curves at 21°C and 80°C, (b) Normalised global shear force-global shear angle curves for single and multiple plies sheared at 21°C.

coefficient exhibited by Dyneema®, slipping was a common occurrence, which had to be inhibited through higher gripping pressure. This was therefore increased from 0.1 MPa to 0.5 MPa, without affecting the load-displacement measurements. The curves demonstrate the rapid hardening that occurs with an increasing shear angle. This is due to increasing fibre rotations as they rotate from their original 0°/90° formation towards gradually aligning with the ±45° loading direction (Nazarian, 2014). Unlike the findings of Dangora et al. (Dangora, 2015), elevated temperatures did not significantly reduce the applied load, while displacement rates of higher than 10mm/min contributed to the slippage of samples. From Figure 1(b) it can be seen that it is possible to accelerate the shearing process by shearing multiple plies (up to 4 plies of HB26), without affecting the load-displacement curve per ply.

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