IMPACT AND POST-IMPACT PROPERTIES OF CARBON FIBRE NON CRIMP FABRIC COMPOSITES

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INTRODUCTION

As composite materials have a high in-plane stiffness and strength-to-weight ratio, they are attractive materials for use in for example cars or airplanes. The use of non crimp fabrics as a reinforcement for composites has made it possible to combine the good properties of UD prepreg composites with the ease of handling of woven fabrics. However, during the lifetime of a composite part, it is not unlikely that it will undergo an unforeseen out-of-plane force, like for example an impact from a dropped tool, hail or a stone. Even if the visible damage is very small, such an event can lead to a significant reduction of the composite properties. Therefore, it is important to know how the composite behaves under impact, and what the post-impact residual properties are. In this paper, the impact behaviour of a carbon fibre non crimp fabric composite is determined and compared to the behaviour of a woven fabric composite. Also the post-impact tensile properties, both static and dynamic, have been investigated.

MATERIALS AND PRODUCTION

For this study, a ±45° carbon fibre non crimp fabric (NCF), prelaminated with epoxy resin, and a carbon fibre twill weave/epoxy prepreg were used. NCF composite plates were made with the following lay-up: [-45,+45]₂s. Five layers of the woven prepreg were used to produce the woven fabric composite plates. In the NCF composite (NCFC), the testing directions used for this work are the cross direction (CD) and one of the fibre directions (BD⁺). BD⁺ is oriented so that the fibres in the outer layer of the sample lie parallel to the loading direction (i.e. the -45° direction). In the woven fabric composite (WFC), tests are done in one of the two fibre directions (FD), and in one of the two bias directions (BD). The average fibre volume fraction of both types of composite plates is 58%. 300 x 50 x 2 mm³ samples were cut in the different materials and directions.

EXPERIMENTS AND DISCUSSION

Samples were subjected to an impact of 3.5 or 7J. No penetration of the samples occurred during these tests. After the impact tests, the projected impact damage area was determined using ultrasonic C-scanning. Post-impact static tests and tensile-tensile fatigue tests were done and the results were compared to the results without impact damage, to reveal the influence of the impact on the residual properties.

Fig. 1 shows that the damage area for the NCFC is significantly higher than that for the WFC for both impact energies. This implies that the resistance of the NCFC to impact damage is
lower than that of the WFC. The difference between the FD and BD in the WFC and between the CD and the BD+ in the NCFC is due to the geometry of the test set up.

The results for the post-impact strength are shown in fig. 2. The strength of all 4 types of samples decreases with increasing impact energy, but the effect is most pronounced for the NCFC in the fibre direction, where an impact of 7 J results in more than 20% loss in strength.

Post-impact fatigue tests were done on the impacted samples, up to a maximum stress level corresponding to a fatigue life of about 1 000 000 cycles for the intact material. Fig. 3 shows the average fatigue life curve for the intact NCFC and WFC in the matrix dominated directions (CD and BD), and the results of the fatigue tests after an impact of 3.5 and 7 J. For both materials, there is a decrease in fatigue life after an impact. For the NCFC CD samples, an impact of 7 J leads to a shorter fatigue life than one of 3.5 J. For the WFC BD however, no significant difference between 3.5 and 7 J was found, although both fatigue lifes are shorter than the expected lifetime for the intact material. Also in the fibre directions a significant influence of the impact damage on the fatigue life was found.

CONCLUSIONS

In this paper, the impact and post-impact static and dynamic properties of a carbon fibre/epoxy NCFC and a carbon fibre/epoxy WFC were determined and compared. The projected impact damage area for the NCFC was larger than that for the WFC for both impact energies used.

It was found that already a relatively low energy impact has a significant negative influence on the residual properties in both static and dynamic tests, both in the fibre direction as in the matrix dominated direction. For most cases, an impact of 7 J leads to a larger reduction in properties than an impact of 3.5 J, although in some cases, no significant difference between these samples was found.