MODE II INTERLAMINAR FRACTURE TOUGHNESS OF FLAX AND GLASS EPOXY HYBRID COMPOSITES

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ABSTRACT

The propensity of composite materials to delaminate during service is of significant concern and the presence of delamination crack is severe. It prevents the distribution of load between laminas reducing the strength of the material, which could result in a cascading effect of failure. Here, the mode II interlaminar fracture toughness (G_{IIc}) of three flax and glass hybrids are characterized applying ASTM standard D7905 [1], then 3D models of the hybrid materials are investigated applying the Hashin criteria and the Virtual Crack Closure technique in Ansys simulation software to assess the damage in the flax epoxy plies. Applying Finite element Analysis to investigate the failure in the hybrid laminate overcomes the expensive cost of using x-rays, gamma rays, Ultrasonic testing and other Non-Destructive Examination techniques (NDE). The characterization of the mode II fracture toughness and failure analysis using Ansys are outlined and discussed.

Keywords: composite materials, interlaminar fracture, delamination, FEA, VCCT, Ansys.

INTRODUCTION

Composite materials are susceptible to delamination during their service life. Detection of this damage modes requires sophisticated non-destructive methods, therefore it is important to improve the understanding of the delamination resistance of composite materials to reduce over design of composite parts [2,3], which will enable the full weight saving opportunities that lies in the application of composite material achievable [4]. Interlaminar fracture or delamination between composite plies is among the most common damage mechanism of composite materials. The growth of Finite Element Analysis (FEA) has made it possible to assess the failures in the plies of composite materials during delamination. In the paper presented, the mode II interlaminar fracture toughness, the flexural modulus of three hybrids of glass and flax is investigated by experiments and the failure in the flax epoxy plies is assessed using the Hashin criteria in ANSYS Simulation software.

RESULTS AND CONCLUSIONS

The three hybrids laminate evaluated are hybrid one (H1) [0_{G}/0_{F}] 8S, hybrid two (H2) [0{4G}/0{4F}] S, and hybrid three (H3) [0{4C}/(90/0)_{2F}] S, where subscripts F and G denote flax and glass epoxy plies respectively. Forty-five experiments and data reduction to obtain the mode II fracture toughness and flexural modulus were carried out according to the ASTM standard [1]. Figures 1 and 2 show the End Notch Flexural (ENF) test setup and the 3D ENF model setup with boundary conditions in Ansys simulation software.
The compliance calibration method is the data reduction method that is applied to obtain the mode II interlaminar fracture toughness. The candidate fracture toughness is obtained using (1):

\[ G_Q = \frac{3mF_{max}^2}{2B} \]  

(1)

The Flexural modulus is obtained using the equation (2):

\[ E_{1f} = \frac{1}{4ABh^3} \]  

(2)

where \( A \) and \( m \) are the calibration compliance coefficients obtained from the linear least square regression analysis of the three compliance \( C \) versus the crack length cubed \( (a^3) \).

The Mode II fracture toughness of hybrid 1, 2, and 3 are 1.484 kJ/m\(^2\), 1.339 kJ/m\(^2\), and 1.333 kJ/m\(^2\), respectively. The flexural modulus of hybrid 1, 2, and 3 are 40.63 GPa, 42.07 GPa, and 41.96 GPa.

The results from the finite element analysis were in strong agreement with experimental results. Hybrid one has a higher mode II fracture toughness compared to hybrid 2 and 3, and it also has a better fracture toughness than glass epoxy laminate.

Applying the Hashin criteria to examine the flax epoxy plies at the point of delamination, showed the influence of the layup sequence on the flexural strength and fracture toughness of the composite material.

REFERENCES


