Effect of impact energy on hybrid woven composites

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ABSTRACT

Composite materials is of great importance, since engineers are always seeking lighter and stronger materials. Hybrid woven composites provide tremendous opportunities for tailor-ability and flexibility in composite design. This paper studied the effect of low velocity impact on the damage mechanisms in hybrid woven composites. It was found that as the impact energy increases, the damage area in the composite also increases.

INTRODUCTION

As the demand for materials with higher stiffness-to-weight and strength-to-weight ratios, tailoring flexibility, more resistant to harsh environment and damage tolerance arises; researchers and engineers seek to have more profound understanding of the behavior of different composites under various conditions. Investigations into woven composites have been extensive over recent years mainly because of their excellent impact resistance [1], dimensional stability, ease of handling etc. Some of these researches also focused on the effect of different environments, such as temperature [2] on the behavioral response of composite materials. This paper investigates the effect of impact energy on the damage of hybrid woven composites. This study mirrors the effect of tools or body of low mass dropping on a composite structure, or even a bird strike on an aircraft at low velocity.

EXPERIMENTAL PROCEDURES

Materials:

The individual constituent materials combined to form the composite material studied in this research are: IM-7 graphite (IM7-GP 6000) and S2-glass (S2-4533 6000) woven fabrics in a SC-79 toughened epoxy matrix.

For the hybrid composite, it consists of a graphite (GR) core, which is made up of 16 layers. This core is sandwiched between two outer laminates. Each outer laminate is made up of 9 layers of S2-glass fabrics and SC-79 epoxy (GL). The hybrid composite is called GL/GR/GL for short.

The composite was manufactured using the vacuum assisted resin transfer molding (VARTM) technique to stack the plain woven fabrics together. The specimens were cured at 177^0C. Fiber volume fraction for all types was 55%. The final thickness of the specimens to be tested was 6.35mm

Experimental setup

The low-velocity (drop-weight) impact study was conducted at two different temperatures: room temperature (R.T.) and 125°C. All the impact tests were performed using a drop-weight impact tester. Figure 1 shows the schematics of the experimental set-up for the low-velocity impact tests. The impact energy was 30 and 45J at each temperature. The mass of the impactor is fixed at 7.13kg, while the height above the specimen from which the impactor is dropped changes to vary the impact energy from 45 to 60J. In this study the shape of the impactor nose was hemispherical with a diameter of 16 mm. With an attached environmental chamber, an open coil heater provided the high temperature. Specimens were clamped circumferentially with a 76 mm diameter fixture, where the clamp was considered to be a fixed-fixed support. Using a data acquisition system, the time histories of impact loads were measured and recorded using a load cell located just above the impact nose. The impact velocity was also measured by a pair of photoelectric-diodes attached to the base of the test machine. With the data acquisition system, only load (the resistive force of the specimen) vs. time and the initial impact velocity (just prior to impact) can be measured directly. Using the equations of motion, energy absorbed by the specimen, velocity of impactor and deflection at the impact center were derived and recorded. A schematic of the specimen and impactor can be seen in fig.1

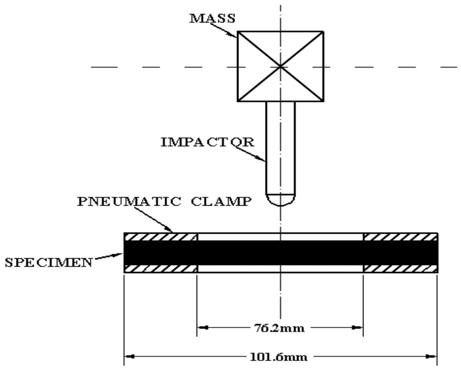

Figure 1 Schematic of the drop-weight impact test set-up

Post damage evaluation

A modular and expandable ultrasonic system was used to scan and conduct the damage evaluation for the impacted specimens. Scanning was performed using the through-transmission technique. Flat and focused 5MHz transducers (6.35mm in diameter) were used to scan these post-impacted composite specimens.

EXPERIMENTAL RESULTS

From literature review, it was found that many different factors tend to affect the damage mechanisms and damage patterns in composite materials [3-5]. Some of these factors include lay-up configuration, laminate thickness, impactor size and shape, constituent properties, temperature, impact velocity and energy, etc. To the best of authors' knowledge, no studies were done on the combined effect of temperature and energy on the impact response of thick section hybrid GL/GR/GL composite material.

While there are quite a few damage mechanisms in composite materials, the most dominant form of energy dissipation is due mainly to delamination, fiber shear out and fiber breakage.

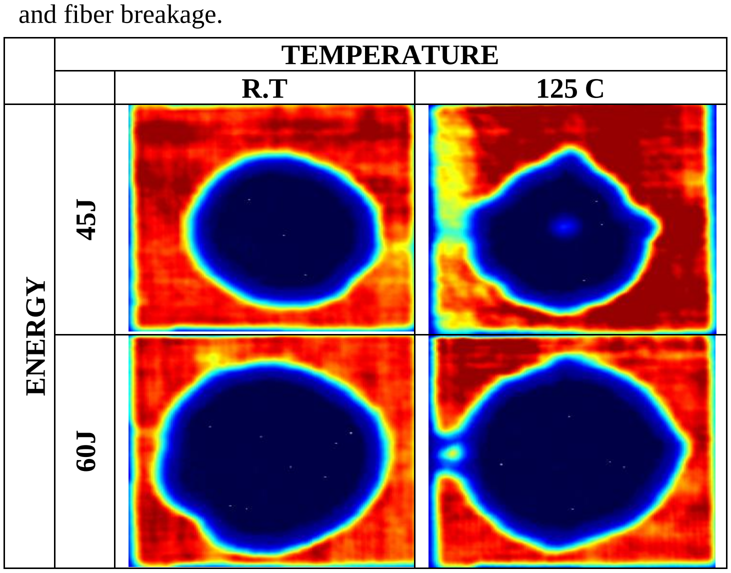

Figure 2 C-scan of hybrid GL/GR/GL composite specimens

In fig. 2 it can be seen that as the temperature increases there is a slight increase in the damage area (delamination) which is shown in blue areas. It can also be seen that as the impact energy increases, the damage area also increases. One interesting observation is that the effect of temperature is quite small, as compared to the effect of energy. It can there be said that the hybrid GL/GR/GR is more stable to a temperature change than a change in energy. The next step of this study would be to look at the impact force and fractographs. In addition, increase in impact will also be studied to have a clearer understanding of its effect.

CONLUSION

In conclusion it can be said that the effect of high temperature on the delamination area is minimal, however the effect of impact energy is more significant.

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