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Charpy impact response of oil palm empty fruit brunch fiber reinforced metal laminate system

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ABSTRACT – The low velocity impact response of novel oil palm empty fruit brunch fiber reinforced metal laminates system has been investigated. The specimens were tested using a pendulum impact tester according to ASTM E-23 in a flatwise direction. Impact resistances of the fiber metal laminates were benchmarked with monolithic aluminum. The main failure mechanism after impact had been investigated with detailed microscopic observation. Finally, it was found that energy absorption of aluminum is higher than fiber metal laminates.

1. INTRODUCTION

In order to improve the properties of existing composites, new research had led to the development of fiber metal laminate (FML). FML is a sandwich structure consisting of layers of fiber reinforced composite material and metal sheets. Farsani *et al*. [1] conducted a charpy impact experiment on basalt fiber reinforced epoxy composite (BFRE) and FML made of BFRE composite with aluminum and steel layers. ASTM D6110 standard was used for flatwise and edgewise specimens to investigate the Charpy impact response. It was found that the damage tolerance of FMLs is superior compared to the plain BFRE composite for both flatwise and edgewise impact loads. Steel layered FML has higher energy absorption levels compared to aluminum layers. Low velocity impact tests were undertaken by Carrillo and Cantwell [2] to highlight the impact energy absorption characteristics of thermoplastic matrix FML based on a self-reinforced polypropylene composite and a 2024-0 aluminum layer. They found that impacted plates exhibit a high level of energy absorption, with damages in the form of thinning in the aluminum plies and fractures in the composite layers. Gin Bo Chai and Periyasamy [3] stated that the response of FML to low velocity impacts is affected by many parameters, e.g: Type of metal, fiber, matrix, stacking sequence, metal volume fraction, impactor geometry, target shape, post-stretch percentage and others in their review. This huge interdependency results in the difficulty to attain the optimum FML. For laminated test pieces, tests may be performed both flatwise and edgewise, and for each of these, there exists the possibility of having the laminations put parallel or normal to the direction of blow [5]. The aim of this study is to investigate the Charpy impact response on a novel oil palm empty fruit brunch fiber reinforced composite with an Al 6061-O metal layer or in other words, oil palm composite fiber metal laminates (OPC FML). To obtain a better understanding of the behavioral impact of OPC FML, the monolithic aluminum was tested under charpy flatwise impact loads at room temperature and the results were compared with OPC FML. It means that the effect of different material properties and structures on behavioral impact is studied. All specimens are studied using microscopic observation in order to examine its' failure mechanisms.

2. METHODOLOGY

2.1 FML fabrication

The oil palm fiber reinforced polypropylene composite panel (OPC) with a thickness of 1.0mm was produced using 30wt%granulated empty fruit bunch palm fiber as reinforcement and 67wt%polypropylene (PP) as matrix with 3wt% Maleic anhydride grafted Polypropylene (MaPP) as its coupling agent. The composition was heated at 185°C for 8 minutes followed by fast cooling to room temperature in a picture frame mold. The FMLs were manufactured by stacking two 0.5 mm thick aluminum sheets 6061-O for the skin and one 1.0 mm thick oil palm fiber reinforced polypropylene composite as the laminate. The laminate was glued together using modified polypropylene film adhesive at the bi-layer surface of the material. The stack was heated to 155°C under a pressure of 1kg/cm² in a motorized hydraulic mold test press machine for 5 minutes before being left to cool slowly to room temperature. The dimensions of the OPC FML panel produced were 200 x 200x2 mm.

2.2 Impact test on FML specimen

Generally the charpy test piece is supported by a horizontal beam and is broken by a single swing of a pendulum. In this work, impact specimens with dimensions of 55x10x2mm were cut from the OPC FML panels using a water jet cutting machine. Low velocity impact tests were carried out using a pendulum impact tester (Instron CEAST 9050) with a hammer capacity of 50J according to ASTM E-23. Figure 1 shows the schematic diagram of flatwise charpy impact

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test. Three samples were tested for each material, and the average absorbed energy was recorded.

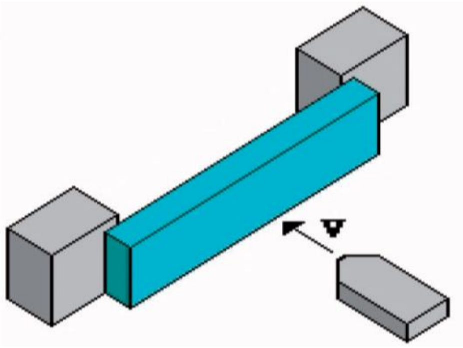

Figure 1 Schematic diagram of flatwise impact

3. RESULTS AND DISCUSSION

Figure 2 shows the average energy absorption for OPCFML and aluminum impacted in a flatwise direction at room temperature. In this experiment, aluminum is generally able to absorb higher energies compared to OPC FML material. The low energy absorption of FML can be contributed to weak bonding between the aluminum and composite laminates.

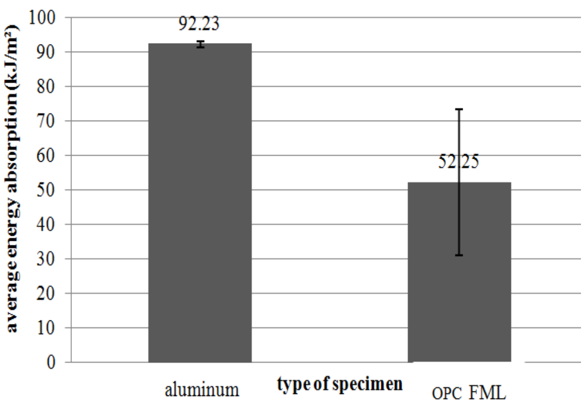

Figure 2 Energy absorption for each material

Figures 3 and 4 show the specimens after impact for both materials. The main failure mechanisms are different. Figure 3 shows the main failure mechanism on the aluminum material was damaged at the region of the line of impact.

Figure 3 Failure mechanism of aluminum

As can be seen in figure 4, plastic deformation of the aluminum layer and delamination are observed at the location of impact and are is detected as the failure mechanism. No aluminum tearing was observed. Due to the high rate strain at the impact location, the sequence of the failure mechanisms is difficult to recognize, but the initial failure is due to delamination, then fiber breakage and metal failure [1].

Figure 4 Failure mechanism of OPC FML

4. CONCLUSIONS

A new type of FML based oil palm empty fruit brunch fiber, OPC FML is studied using the Charpy impact for the first time. Aluminum and OPC FML specimens were studied for flatwise impact behavior. By comparing and studying the achieved experimental results, we can conclude that the impact energy of aluminum has more strength compared to OPC FML. Many parameters can influence the energy absorption for FML such as the type of metal, fiber, matrix, stacking sequence, bonding and others.

5. ACKNOWLEDGEMENTS

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