RESEARCH PAPER

Fabrication, Design and Analysis of Waste Chicken Feathers Fibers Composites for Automotive Indoors

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A B S T R A C T:

The rapidly increasing in pollution problems and its impact on the global climate and the need to find environmentally friendly materials to reduce this negative phenomenon, especially synthetic fiber polymer based composites that enter in automotive industry has led to attention to use natural fibers extracted from renewable sources. This work introduced a new environmentally composites for automotive indoors as the best choice than traditional polypropylene consist of waste chicken feathers fibers and epoxy resin. The concentrations of reinforcement phase are respectively 2, 4, 6, and 8 %wt. The fabrication technique of composites can be done by hand lay-up. The tensile and flexural behaviors of samples were analyzed. The experimental results indicated that there is not effect on tensile strength when added 2 wt% of chicken feathers fibers to epoxy. As weight fraction of CFF increased the tensile strength of composites increased to maximum value 25.9 MPa for 4 %wt CFF. The results also shown there is clearly effect on flexural strength when added of chicken feathers fibers to epoxy. As weight fraction of CFF increased the flexural strength of composites increased to maximum value 98.2 MPa for 4 %wt CFF.

KEY WORDS: Animal fibers, Epoxy resin, Friendly composites, Mechanical properties, Solid works software.

1. INTRODUCTION:

In the development of automotive industry, the need for synthetic fiber reinforced polymer based composites such as glass fibers, carbon fibers and polymer fibers increasing day to day for several reasons: low density and thereby further reduction in fuel consumption, production cost effective and good mechanical behaviors in comparison with traditional metallic alloys such as steel alloys and aluminium alloys (Ajai Aravind Nair et al 2017).

Due to the environmental pollution, synthetic fibers have some limitations. They are less biodegradable and non-renewable (A. Ticoalu et al 2010). Therefore, utilize friendly materials such as natural fibers may avoid the environmental problems. In current time, natural fibers are the best choice than synthetic fibers and defined as bio-based fibers extracted from vegetable and animals sources (Hoi-yan Cheung et al 2009).

Natural fibers based polymer composites can be classified according to both reinforcement and matric origins. Natural fiber/petroleum resin system and natural fiber/bio-resin system (A. O'Donnell 2004).

Animal fibers subdivided into two types. Fibers obtained from animal hair such as sheep’s wool, got hair, alpaca hair and silk. Fibers
obtained from feathers such as chicken feathers (N. Abilash 2013; Taj S. 2007). In environmental concerns, the chicken feathers fibers, CFF can be considered unfriendly material due to the disposal problems. Burning and burying are the only available methods that exist and both of them have negative effect on the environment and caused pollution (Oladele I. O. 2014; Barone J.R. 2005). To solve this environmental concerns, the best way is to use the feathers as waste in the reinforcement of composites. They are inexpensive and has the lowest density over all natural and synthetic fibers (Huda S. et al 2008). As a result they provide composites several advantages includes: light weight (high strength to weight ratio), good thermal insulation, excellent acoustic properties and excellent hydrophobic properties (Bullions T.A. et al 2006).

The overall goal of this work is to produce environmentally – friendly composite for automotive doors consist of waste chicken feathers fibers as reinforcement material and epoxy resin as matrix material instead of traditional polypropylene material.

2. MATERIALS

The materials investigated and utilized in current work are as follows:
Resin: “Duratek” epoxy resin were obtained from Gebze – Turkey. It consist of two parts DTE 1000/A resin and DTS 110/B hardener.
Waste animal fibers: Chicken feathers, CFF locally obtained from Diwaniyah city center – south of Iraq. The animal material was extracted by boiler process of chicken and then collected directly from a chicken plant. The extracted initial chicken feathers were washed and cleaned with hot water and detergent to remove the foreign materials (blood, skin, feces and flesh) and then dried under sunshine for 3 days as shown in Fig.1. After drying, the natural fibers were separated from barbs by stripping and then cutting as short form with a length about 2 mm Fig.2.

3. BIO-COMPOSITE PREPARATION

The unfilled epoxy and chicken feathers bio-composites with different fiber concentrations (2, 4, 6 and 8% wt) were prepared and fabricated by using hand lay-up moulding. The epoxy parts A and B were weighed and mixed (74:26 ratio) for 5 minutes and the poured into plastic mould. After casting, the produced materials were allowed to cure at ambient temperature for 1 day. Finally, the samples were taken out of the mould and machined into required sizes for standard tensile and flexural tests using automatic dumbbell shape sample machine LYDS250 – LARYEE as shown in Fig.3 and 4.

4. MECHANICAL PROPERTIES TESTS

Tensile testing of samples of gauge length 64 x 10 x 4 mm with cross-head speed of 1 mmm-min-1 was carried out at ambient temperature according to ISO 527 standard test, using an universal testing machine (LARYEE – Chine – University of Technology – Baghdad). Three point flexural test were performed according to ASTM D790-03 using universal testing machine (LARYEE – Chine – University of Technology – Baghdad). All the samples were cut into rectangular shapes, 160 mm by length, 13 mm by width, with the molded thickness of 4 mm. The support span was 128 mm with the cross head velocity at 1mmmin-1. As the test sample is stretched the computer generates the required data and graphs.

5. NUMERICAL PART

The current work investigates development of automotive indoor panels for automotive industry. The numerical analysis was achieved for a normal fracture located in the middle of the door panel. There are 2 models in this work were studied in case of stand-up including: 1 model for 8%chicken feathers fiber/92%epoxy composite system, and 1 model for traditional polypropylene car indoor penal.
In order to determine the state of stresses of the different car indoor penal materials, a numerical analysis ANSYS workbench 13 package program was used for this purpose. The scope of the analysis included determination of stresses of the natural fiber bio-composites car indoor penal and comparison their results with commercial car indoor penal (polypropylene thermoplastic material) depending on the applied load.
6. RESULTS AND DISCUSSION

Tensile Test

The typical stress–strain curves for epoxy composites reinforced with 2%, 4%, 6%, and 8% wt chicken feathers fibers are shown in Fig. 5, 6, 7 and 8 respectively. These curves show that the tensile strength increased proportionally with increasing strain until the point of ultimate load, which is the maximum load on the stress – strain curve. At this point the composite samples broke and exhibited brittle behavior with no apparent yielding.

Fig. 9 show the effect of chicken feathers fibers addition on tensile properties of epoxy based composites. The results showed that there is not effect on tensile strength when added 2 wt% of chicken feathers fibers to epoxy. As weight fraction of CFF increased the tensile strength of composites increased to maximum value 25.9 MPa for 4 %wt CFF.

Flexural Test

The typical load–extension curves for epoxy composites reinforced with 2%, 4%, 6%, and 8% wt chicken feathers fibers are shown in Fig.10, 11, 12 and 13 respectively. These curves show that the flexural load increased proportionally with increasing deflection until the point of ultimate load, which is the maximum bending load on the load – deflection curve.

Fig.14 show the effect of chicken feathers fibers addition on bending properties of epoxy based composites. The experimental results indicated that there is clearly effect on flexural strength when added of chicken feathers fibers to epoxy. As weight fraction of CFF increased the flexural strength of composites increased to maximum value 98.2 MPa for 4 %wt CFF.

The improvement in mechanical properties (tensile and flexural behaviors) of composites when animal fiber concentration increased can be explained to improve in the fiber-matrix interphase bond. This is lead that the fiber-matrix interphase bond is enough to transmit most of the applied load from epoxy matrix to chicken feathers fibers and there is no need to using chemical treatment of surface fibers for enhancement fiber–matrix interactions.

Numerical Results

The results of this analysis show that the equivalent (Von-Mises) stress of the chicken feathers fiber/epoxy composite panel is the smallest one as compared to that of polypropylene panel as shown in Figures 15 and 16 respectively. This implies that composite material has a better chose to eliminate the polypropylene material derived from petrochemicals and then the decrease in pollution by using the bio-degradation composites.

CONCLUSION

1. The work was achieved in order to utilize both waste chicken feathers fibers that are being generated everyday across the globe for the production of light, low cost and friendly composite materials for automotive doors applications.
2. Waste chicken feathers fibers improved both tensile and flexural properties of epoxy resin based composites.
3. Chicken feathers composites has a better chose to eliminate the polypropylene material derived from petrochemicals and then the decrease in pollution by using the bio-degradation composites.
4. The numerical analysis of the automotive indoor panels was performed by ANSYS Workbench 13 analysis software. Under the same applied load and boundary conditions, the smallest equivalent (Von-Mises) stress is recorded on chicken feathers composites panel as compared to the polypropylene panel.
Figure 1. Chicken feathers fibers after washing in hot water and drying.

Figure 2. Chicken feathers fibers convert into wool form and then cutting as short form to length of 2mm.

Figure 3. Samples for tensile test according to ISO 527 standard test.

Figure 4. Samples for flexural test according to ASTM 790-03 standard test.

Figure 5. Stress-strain curve for 2CFF/98 epoxy composite.

Figure 6. Stress-strain curve for 4CFF/96 epoxy composite.

Figure 7. Stress-strain curve for 6CFF/94 epoxy composite.

Figure 8. Stress-strain curve for 8CFF/92 epoxy composite.
Figure 9. The effect of CFF addition on tensile strength of epoxy based composites.

Figure 10. Load-extension curve for 2CFF/98 epoxy composite.

Figure 11. Load-extension curve for 4CFF/96 epoxy composite

Figure 12. Load-extension curve for 6CFF/94 epoxy composite.

Figure 13. Load-extension curve for 8CFF/92 epoxy bio-composite

Figure 14. The effect of CFF addition on bending strength of epoxy based composites.
Figure 15. Equivalent stress of CFF/epoxy bio-composite panel.

Figure 16. Equivalent stress of polypropylene panel.

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