Proceedings of the International Conference on Applied Mechanical Engineering Research(IC-AMER2019)
NIT Warangal, India – May 02-05, 2019
Paper No. XXX (The number assigned when the papaer is accepted)

EXPERIMENTAL INVESTIGATION ON THE MECHANICAL PROPERTIES OF AMERICAN AGAVE AND GLASS FIBER REINFORCED POLYPROPYLENE COMPOSITES

M. Indra Reddy [a,*], Vamsi Inturi[b], K. Brahma Raju[a]
[a]*Department of Mechanical Engineering, S R K R Engineering College, Bhimavaram, India*
[b]*Department of Mechanical Engineering, BITS Pilani, Hyderabad Campus, Telangana, India*

*Corresponding author Email: reddy.indra.m@gmail.com

Abstract

The utilization natural fibers have become extensive instead of conventional synthetic fibers because of the issues with greenhouse effect and consciousness towards the environment. Exploring natural fibers has several advantages such as, economically viable, availability in fibrous formreadily andease of extraction from the plant leaves. In this work, an attempt has been made to study the mechanical properties such as tensile, impact and flexural strengthof the composites made by reinforcing American Agave fibre into a polypropylene resin. In addition to that, the mechanical properties of the hybrid composites made by reinforcing American Agave and Glass fibre as 1:1 ratio into a polypropylene resin are studied. The proportion of fibre content in the composite is varied from 10 to 30 by volume percentage and the variation of mechanical properties in each case isexamined. It is observed that the American Agave and Glass fibre reinforced polypropylene hybrid composite exhibited better mechanical properties than American Agave fibre reinforced polypropylene composite.

***Keywords*:** American Agave Fibre, Polypropylene, Mechanical Properties

1. Introduction

Over the years, natural fibres are serving the mankind and find their application in various fields. Eventually, natural fibres are contending with the man-made fibres,especially, as far as sustainability, quality and economy of production are concerned [1]. Because of their biodegradable nature, the utilization of natural fibres has become expensive. Alongside, they often have low densities, lower processing costs and sustainable than the synthetic materials [2]. Conventionally, natural fibres have been used as reinforcements in polypropylene composites due to their recyclability nature [3]. The alkali and acrylic acid treatment of the banana fibres could enhance the water resistance property and improve the mechanical properties of the composites. However, the addition of compatibilizer will further intensify the above mentioned properties. It was reported that, the addition of compatibilizer improves the impact and flexural strength which further yields to alleviate the water absorption capacity [4].Zaman et al. [5] considered irradiated banana fibres and treated them with monometer (HEMA) in MeOH solution blended with 2% benzyl peroxide. The authors used thermal curing method and observed a significant improvement in the mechanical properties because of the monometer treatment.Rana et al. [6] examined the influence of compatibilizer on short jute fibre reinforced polypropylene composites. The authors observed that, there is a reduction in the water absorption capacity and a sudden increase in the mechanical properties. This can be attributed to the fact that, the addition of compatibilizer developed a linkage between the hydroxyl groups of jute and the carboxyl groups of the compatibilizer[6]. On the other hand, the properties such as modulus of composites and tensile strength are affected by composition of fibre, liquid of immersion & number of immersion cycles. In the case of kenaf fibre reinforced polypropylenecomposites, there is a reduction in the tensile strength values because of the number of immersion cycles and conditioning. However, continuous and cyclic immersion in bleach resulted to alter the tensile strength of the composites significantly. Whereas, there is a minimal variation in the values of tensile modulus after a number of immersion cycles [7].

Oksman et al.[8]examined the influence of fibre morphology of various natural fibres on the mechanical properties and on the fibre breakage of the composites due to the extrusion process. It was observed that, the sisal composites haddisplayed the favorable impact properties and the longest fibres after the extrusion among the considered natural fibres. In general, the flexural stiffness of the composites increaseswith fibre content for all types of fibres, being highest for flax composites. Perhaps, the addition of fibres has no effect on the flexural strength property because of the low compatibility[8]. Based on the exhaustive literature review, it has beenfound that the mechanical properties of American Agave polypropylene composites have not explored. The main objective of this study is to prepare the composite by incorporating the American agave and Glass fibers at various volume percentages into a polypropylene resin matrix. Finally, the composites areexamined and characterized to evaluate the tensile, impact and flexural properties.

2. Experimental Procedures

The following section elaborates the experimental procedure carried out and the steps involved are:

1. Materials
2. Extraction of fibres
3. Fabrication of composites
4. Investigating the mechanical properties of composites

2.1 Materials

The materials used in this experimental work are:

(i). Reinforcement : American agave fibre and glass fibre
(ii).Matrix : polypropylene resin
(iii). Hardener/Catalyst: Methyl Ethyl Ketone Peroxide
(iv). Accelerator : Cobalt Naphthenate

2.2 Extraction of fibres

American agave fibre is extracted directly from the American agave plant. Initially teen aged American agave plants are taken and then the leaves are plucked. Later, the edges of the leaves are trimmed and then these edge trimmed American agave plant leaves are allowed to soak in water for about 10-15 days. After soaking for sufficient time, the residual from leaves gets deposited in the water. Remaining leaf is taken into hand and rubbed, final fibre is obtained. (these fibres appear like threads) and then dried in sunlight.For removing additional organic waste from the fibre, we go for alkali treatment. In alkali treatment we soak the fibre in 1% NaOH solution for sufficient time and later the fibers are again dried in sunlight to obtain the agave fibre.

Fig. 2.1. American Agave

2.3 Fabrication of composites

Polymer Matrix composites are prepared using epoxy resin matrix to evaluate the reinforcing ability of American Agave fibers. The accelerator (1.5% by volume) and catalyst (1.5% by volume)are added to the resin at room temperature for curing. The appropriate mixture of epoxy resin and American Agave fibers is filled up in the prepared mould and fed to injection moulding machine. In order to ensure good quality fibre reinforced composites, the fibre deformation and movement should be minimized. Hence, a compressive pressure of 0.05 MPa is applied on to the mould and the composite specimens are allowed to cure for 24 hours. In addition to the curing at room temperature, post curing at 70°C for about 2 hours is carried out onto the specimens after removing from the mould. Five composite samples are prepared with five different volume percentages of American Agave Fibers.

Fig.2.2 Fabrication of Composites

2.4Investigating the mechanical properties of composites

2.4.1 Tensile Test

In order to investigate the tensile behaviour of the American Agave and Glass fibre reinforced polypropylene composites, the specimens are prepared according to the ASTM D 638M standards (Standard, 2010). The dimensions of the composite specimens are 165 mm long, 12.7 mm wide and 3 min thick. Three identical composite specimens are tested for each percentage volume fraction of fibre. These specimens are tested at a cross-head speed of 2.5 mm/min, using a Tensile testing machine.

Fig. 2.3.Tensometer

2.4.2 Impact Test

The impact test specimens are prepared according to the standards of ASTM D256 to measure impact strength. The specimens having a length of 64 mm, width of 12.7 mm and thickness of 3 mm. To achieve the notch onto the specimen, a sharp file having an included angle of 45° is drawn across the cut at an angle of 90° to the sample axis. These specimens are fractured in a plastic Izod impact testing machine (capacity – 21.68 J). For each composition, three specimens are tested and the mean value of the absorbed energy is noted. Finally, the impact strength for a specimen is calculated by dividing the absorbed energy value with the cross-sectional area.

2.4.3 Flexural Test

In order to examine the flexural properties of the specimens, three point bend tests are performed in accordance with ASTM D 790M (Standard, 2010) test standards. Three point bend test is chosen because it gives the flexibility in determining the centre point deflections with the equipment. In addition to that, it requires less amount of material for each test cycle. The specimens are made with 125 mm length, 12.7 mm width and 3 mm thickness. During the test, the outer rollers are kept 64 mm apart and the samples are tested under the strain rate of 0.2 mm/min. Three identical specimens are tested for each composition using tensile testing machine and all the experiments are carried out at a cross-head speed of 2.5 mm/min. Flexural strength (σ) and modulus (E_f) are calculated using the following formulae:

$$\sigma = 3Pl/2bt^2$$

$$Ef = l3m/bt^3$$

Where,

σ - Bending strength (N/mm^2)
P - The maximum load (N)
L - The distance between supports (mm)
b - Width of the specimen
t - Thickness of the specimen
m - The slope of the initial straight portion of the load deflectioncurve

Fig. 2.4.Flexural Testing Machine

3. Results and Discussions

3.1 Tensile Strength

The variation of mean tensile strength and tensile modulus of composite with varying fibre content is illustrated in Fig. 3.1 and Fig.3.2. It can be observed that, the tensile strength is increasing with the increase in the fibre content of the Polypropylene matrix. This can be attributed to the fact that, as the polypropylene resin disseminates it dispenses the applied stress to the American agave fibers which further resulted to higher strength value. The tensile strength of the composite with maximum fibre content (30% volume of the fibre) is found to be 27.03MPa. The tensile strength and the tensile modulus of American glass fibre reinforced polypropylene composite considered in this study is far better than that of American agave fibre reinforced polypropylene composites.From the tensile test, we obtained Load vs. Displacement graphs at 30% volume of fibre, which are shown in the Fig.3.3.

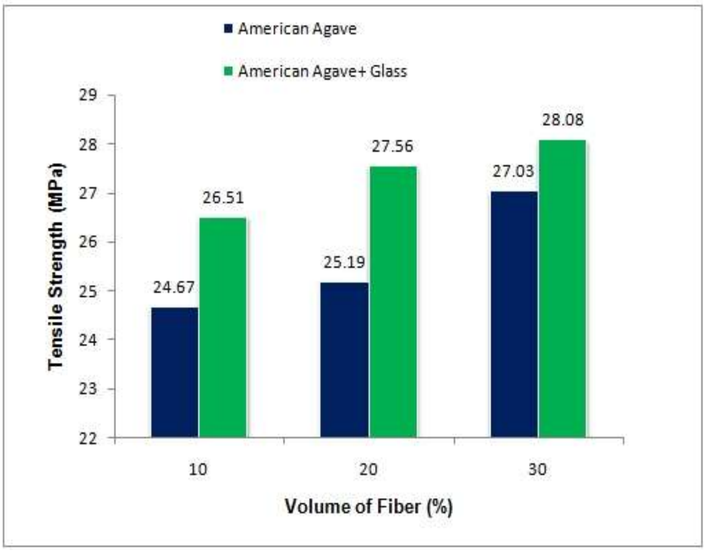

Fig. 3.1 Variation of Tensile Strength of composites with volume of fiber

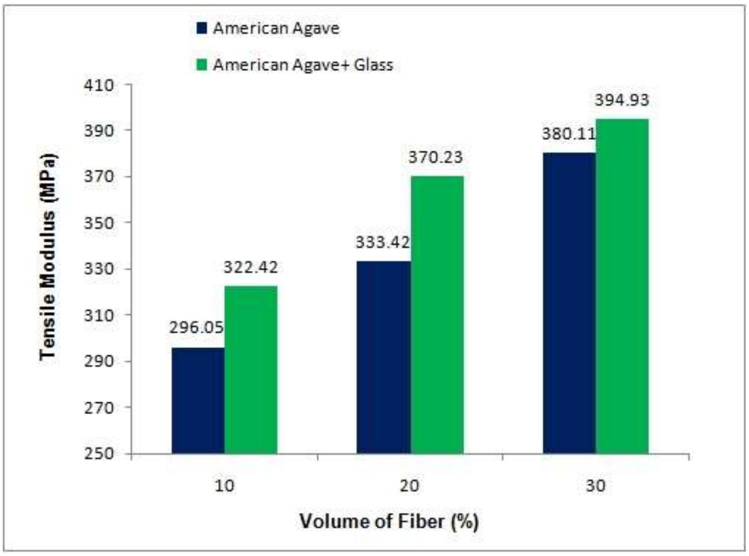

Fig.3.2 Variation of Tensile Modulus of composites with volume of fiber

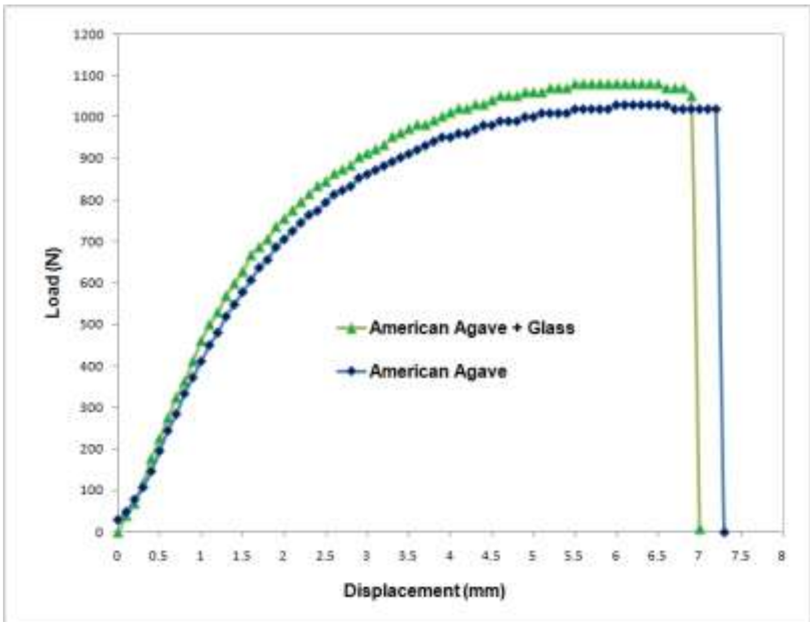

Fig.3.3 Load vs Displacement curve of composite at 30% volume of Fiber

3.2. Impact Strength

Fig. 3.7 describes the results of Izod impact test. From below figure it is evident that, as the percentage of volume increases, the value of impact strength increases. It can be noted that, the Impact strength value of the composite with maximum fibre (30% volume of the fibre) content is found to be 5.8J. The impact strength of American agave- glass fibre composite is better than American agave fibre reinforced composites.

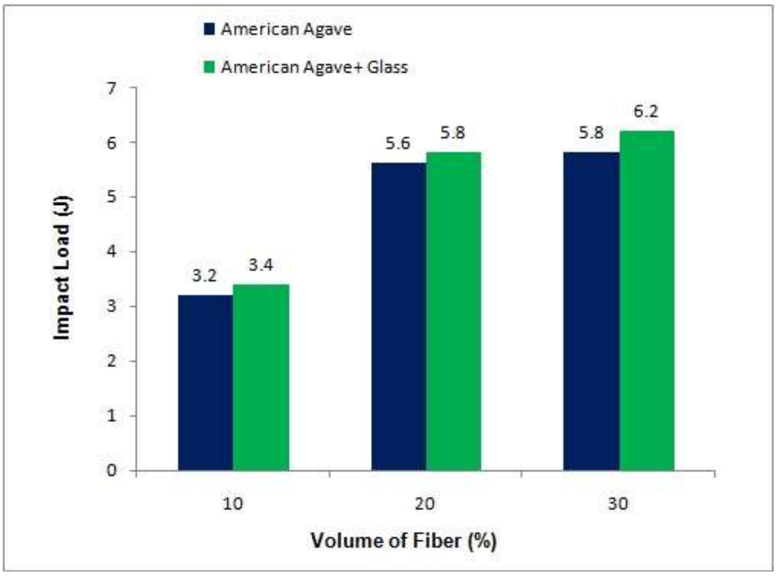

Fig. 3.4 Variation of Impact Strength of composites with volume of fiber

3.3. Flexural Strength

Figure 3.5 and 3.6 describe the flexural behaviour of American Agave fibre reinforced composites and American Agave-glass fibre reinforced composites.The trend is similar to the trend observed for the case of tensile properties with the same above mentioned conviction. The flexural strength value of the composite with maximum fibre (30% volume of the fibre) content is about 84MPa. The American agave-glass fibre reinforced composite considered in this study has shown improved flexural strength value than that of American agave fibre reinforced composites.

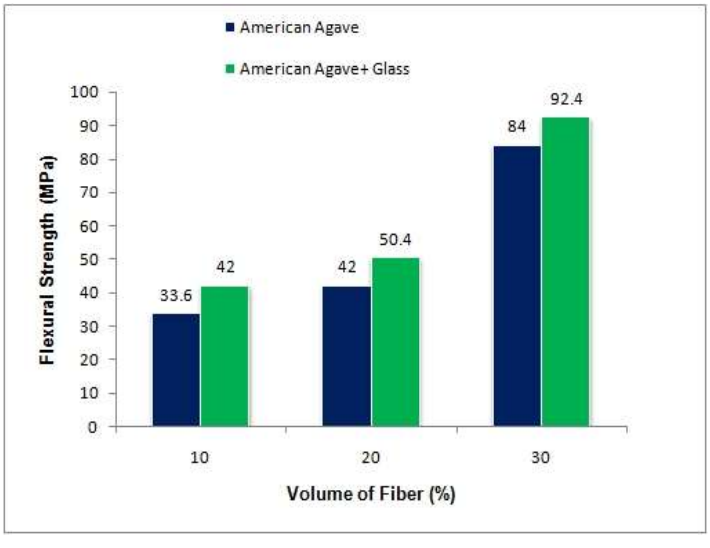

Fig. 3.5 Variation of Flexural Strength of composites with volume of fiber

Fig.3.6 Variation of Flexural Modulus of composites with volume of fiber

4. Conclusions

In this study, American agave fibre reinforced polypropylene composite and American Agave-glass fibre reinforced polypropylene hybrid composites are prepared with different volume of fibers and the mechanical properties namely, Tensile, Impact and Flexural properties are examined. After investigating the obtained experimental results, the following conclusions are made:

- The tensile strength and tensile modulus of the American Agave and Agave-Glass fibre reinforced polypropylene composite increases with increase in volume of fibre.
- The flexural strength and flexural modulus of the American Agave and Agave-Glass fibre reinforced polypropylene composites increases with the increase in volume of fibre.
- The impact strength of the American Agave and Agave-Glass fibre reinforced polypropylene composites increases with increase in volume of fibre.
- American Agave and glass reinforced polypropylene composites shows better mechanical properties than American Agave fibre reinforced polypropylene composites.

References

1. Kozłowski, Ryszard M., ed. Handbook of natural fibres: Types, properties and factors affecting breeding and cultivation. Elsevier, 2012.
2. Heng, Jerry YY, Duncan F. Pearse, Frank Thielmann, Thomas Lampke, and Alexander Bismarck. "Methods to determine surface energies of natural fibres: a review." *Composite Interfaces* 14, no. 7-9 (2007): 581-604.
3. Joshi, Satish V., L. T. Drzal, A. K. Mohanty, and S. Arora. "Are natural fiber composites environmentally superior to glass fiber reinforced composites?." *Composites Part A: Applied science and manufacturing* 35, no. 3 (2004): 371-376.
4. Prasad, Nirupama, Vijay Kumar Agarwal, and Shishir Sinha. "Banana fiber reinforced low-density polyethylene composites: effect of chemical treatment and compatibilizer addition." *Iranian Polymer Journal* 25, no. 3 (2016): 229-241.
5. Zaman, Haydar U., Mubarak A. Khan, and Ruhul A. Khan. "Banana fiber-reinforced polypropylene composites: A study of the physico-mechanical properties." *Fibers and Polymers* 14, no. 1 (2013): 121-126.
6. Rana, A. K., A. Mandal, B. C. Mitra, R. Jacobson, R. Rowell, and A. N. Banerjee. "Short jute fiber-reinforced polypropylene composites: Effect of compatibilizer." *Journal of Applied Polymer Science* 69, no. 2 (1998): 329-338.
7. Haniffah, W. H., S. M. Sapuan, K. Abdan, M. Khalid, M. Hasan, and M. Enamul Hoque. "Kenaf fibre reinforced polypropylene composites: effect of cyclic immersion on tensile properties." *International Journal of Polymer Science*2015 (2015).
8. Oksman, Kristiina, Aji P. Mathew, Runar Långström, Birgitha Nyström, and Kuruvilla Joseph. "The influence of fibre microstructure on fibre breakage and mechanical properties of natural fibre reinforced polypropylene." *Composites Science and Technology* 69, no. 11-12 (2009): 1847-1853.