Study on Jute and Glass fibre reinforced polypropylene and epoxy composites

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Abstract

In this research article, natural fibre Jute & Man-made fibre glass are reinforced with polypropylene and epoxy resin for manufacturing of compression moulding composites at three different fibre volume fraction (10, 20 and 30%). The mechanical properties of both fibres composites were tested and compared. The maximum stress at break and flexural strength for glass fibre reinforced composite found high for 30% fibre volume fraction. The epoxy composite displayed higher tensile strength, flexural strength and impact strength than polypropylene composite for both jute and glass fibre reinforced polypropylene composites. Elongation at break and flexural modulus of jute and glass fibre reinforced polypropylene and epoxy composite showed low significant difference.

Key words—Composites, Natural fibers, tensile strength, maximum stress at break, flexural strength, impact strength etc.

1. Introduction

Composites were a need in the evolution of engineering materials because by a combination of materials it is possible to overcome, for instance, brittleness and poor process ability of stiff and hard polymers. The developments in composite material after meeting the challenges of aerospace sector have cascaded down for catering to domestic and industrial applications. Composites, the wonder material with light weight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, wood etc.

Composite materials have been utilized to solve technological problems for a long time but only in the 1960s did these materials start capturing the attention of industries with the introduction of polymeric-based composites. Since then, composite materials have become common engineering materials and are designed and manufactured for various applications including automotive components, sporting goods, aerospace parts, consumer goods, and in the marine and oil industries. The growth in composite usage also came about because of increased awareness regarding product performance and increased competition in the global market for light weight components. Among all materials, composite materials have the potential to replace widely used steel and aluminium, and many times with better performance. Replacing steel components with composite components can save 60 to 80% in component weight, and 20 to 50% weight by replacing aluminium parts. Today, it appears that composites are the materials of choice for many engineering applications., For the composite applications having good bonding between the fibre and the resin matrix, jute have been treated with alkali, a process known as mercerization, being commercialized for cotton fibres for superior reactivity with dyes (Ott *et al* 1954). Several authors have employed the technique on jute and the changes occurring in the fibre properties were investigated (Sarkar 1935; Mukherjee *et al* 1993). Sarkar (1935) and Samal *et al* (1995) have treated jute fibres with NaOH solution of concentration 1%, 8% for 48 h and 2% for 1 h and showed improvements in fibre properties by 130% and 13% respectively. Similar treatments were attempted by Gassan and Bledzki (1999a, b) on isometric jute yarns. They reported an improvement of 120% and 150% in the tensile strength and modulus of jute yarns respectively treated with 25% NaOH solution for 20 min and 60% improvement in the jute/epoxy composite properties reinforced with these treated yarns. The improvements have been attributed to the greater reactivity of the treated fibres with the resin administering superior bonding.

2. Experimental

2.1 Materials and Methods

The Jute fibres were collected from NIRJAFT, Kolkata, West Bengal and glass fibres were purchased from All India fibres & Polymers suppliers, Mumbai. The Polypropylene (P-445) was supplied by Pluss Polymer. The polypropylene used had high melt flow index 110 (g/ 10 min) and Epoxy was supplied by Synpol products.

2.2 Preparation of composites

Fibre configuration and volume fraction are two important factors that affect the properties of the composite. In this research work, the mould of 300 x 300 x 50 mm size is used and the randomly distributed fibres are reinforced with polypropylene and epoxy resin in three different fibre volume fractions (10 wt. %, 20 wt % and 30 wt. %) to prepare the composites. The three layers of fibres spread at random with polypropylene and epoxy resins. The material was then wrapped in an aluminium foil. It was preheated in an oven at 120^0 C for 30 mins to reduce the moisture present. The composite formation is then carried out on compression moulding machine at 180^{O} C for 10 mins at 10 bar pressure. Cooling was carried out for 5 mins. All the composites are prepared with the same process for analysis of their mechanical properties.

Fig. 1: Compression moulding machine

2.3 Mechanical testing

Tensile tests were carried out by using Instron model 4301 tensile tester with ASTM D 638-77a standards at specimen length of 100 mm and testing speed of 300 mm/min. Flexural tests were carried out on the same equipment as per the ASTM D790-71 standards. Impact tests were performed on an Instron charpy impact testing machine with impact loading of 10 J-hammer for all the samples. ASTM D256-78 standards was used for impact tests.

3. Result and Discussion

Table 1. Mechanical properties of jute fibre reinforced polypropylene composites.

Table 2. Mechanical properties of jute fibre reinforced epoxy composites.

Sr. No.	Fibre Vol. fraction	Max. stress MPa	Elong. At Break %	Flexural Strength MPa	Flexural Modulus MPa	Impact Strength
1	10:90	29.06	3.91	36.21	4211	7.98
2	20:80	36.11	4.03	43.21	3862	9.25
3	30:70	45.63	2.707	44.67	4025	9.90

Sr. No.	Fiber Vol. fraction	Max. stress MPa	Elong. At Break %	Flexural Strength MPa	Flexural Modulus MPa	Impact Strength
1	10:90	22.11	3.908	25.13	1825.4	7.21
2	20:80	31.17	3.6	23.46	1803.7	8.89
3	30:70	39.67	3.51	32.17	1920.2	9.63

Table 3. Mechanical properties of Glass fibre reinforced polypropylene composites.

Sr. No.	Fibre Vol. fraction	Max. stress MPa	Elong. At Break %	Flexural Strength MPa	Flexural Modulus MPa	Impact Strength
1	10:90	29.62	4.84	29.01	2107	7.92
2	20:80	37.33	3.6	25.87	1975	9.36
3	30:70	41.96	3.27	42.18	2236	9.97

Table 4. Mechanical properties of Glass fibre reinforced epoxy composites.

Sr. No.	Fibre Vol. fraction	Max. stress MPa	Elong. At Break %	Flexural Strength MPa	Flexural Modulus MPa	Impact Strength
1	10:90	33.64	4.27	36.42	3629	7.90
2	20:80	37.58	4.64	44,39	3725	9.79
3	30:70	49.64	3.96	49.21	3974	9.92

3.1 Tensile strength (Maximum Stress at break)

Fig. 2. Showed the maximum stress at break of jute and glass fibre reinforced polypropylene composites. Glass fibre PP composite showed the highest (41.96 MPa) Maximum stress at break for 30 % Volume fraction of fibre in comparison with 10 & 20% volume fraction of glass fibre PP composite, while jute fibre PP composite also showed highest (39.67 MPa) maximum stress at break.

It is discussed that maximum stress at break of any composite depends on several factors, majorly the properties of reinforcement, compatibility of fibre with resin and fibre volume fraction. The effect of the fibre volume fraction on the tensile strength of composite can be seen in Table 1, 2, 3 and 4. The increased tensile strength observed with increase in fibre volume fraction for both the jute and glass fibre polypropylene and epoxy composites. The higher tensile strength observed for epoxy composite than polypropylene composite both for jute and glass fibre reinforced.

Fig. 2. Maximum stress at break of jute and glass fibre reinforced polypropylene composites.

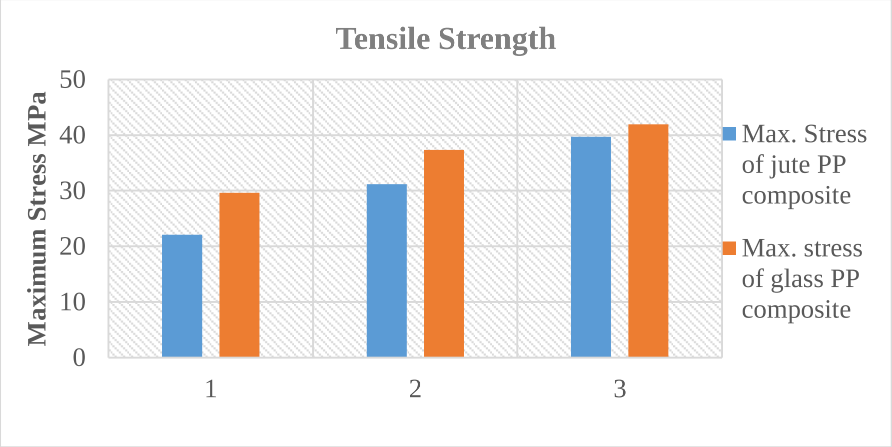
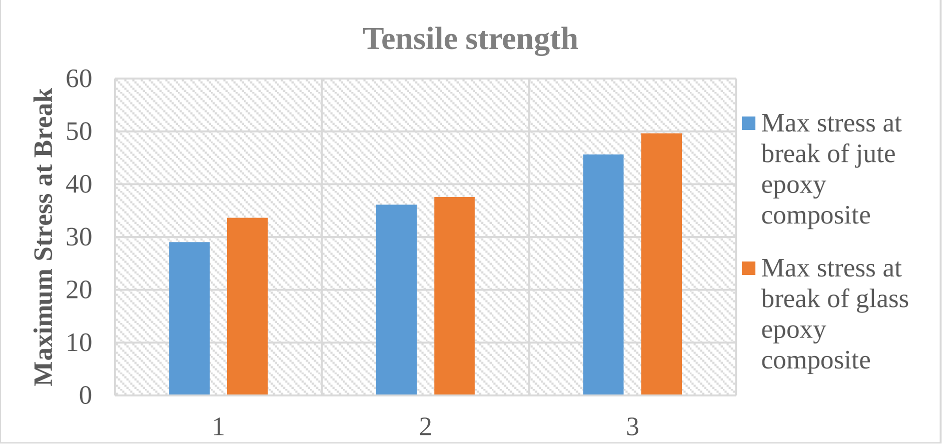


Fig. 3. Maximum stress at break of jute and glass fibre reinforced epoxy composites.



3.2 Flexural strength

Table 2 & 4. Showed the flexural strength of jute and glass fibre reinforced epoxy composites. The increase in flexural strength observed for increase in fibre volume fraction for both jute and glass fibre composite. Highest (49.21 MPa) flexural strength noticed for 30 % Volume fraction of glass fibre in comparison with 10 & 20% volume fraction of glass fibre epoxy composite.

The effect of the fibre volume fraction on the flexural strength of composite can be seen in Fig.4 and 5. The increased flexural strength observed with increase in fibre volume fraction for both the jute and glass fibre polypropylene and epoxy composites. The higher flexural strength of jute and glass fibre reinforced epoxy composite observed than polypropylene composite.

Fig. 4. Flexural strength of jute and glass fibre reinforced polypropylene composites.

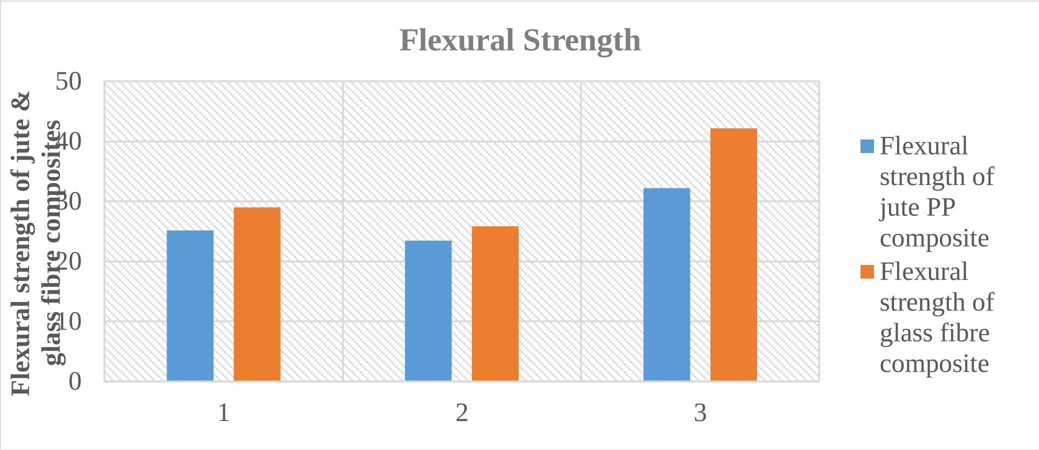
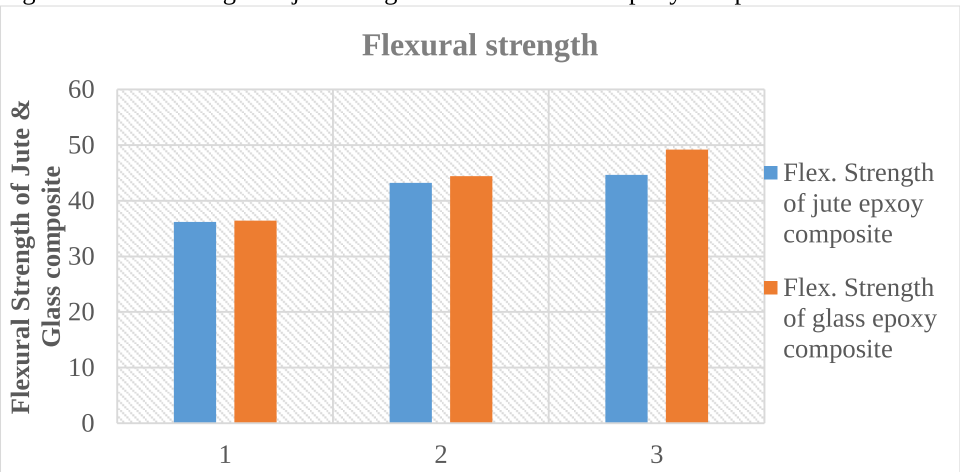


Fig. 5. Flexural strength of jute and glass fibre reinforced epoxy composites.



3.3 Impact Strength

Fig 6 and 7 represents the impact strength (energy observed per cross sectional area) results of the jute and glass fibre reinforced composites. The jute fibre reinforced composite showed low impact strength compared to glass fibre reinforced composite for both polypropylene and epoxy resins. It is known that the impact strength of fibre composites is more practically affected by the interfacial bond strength, the matrix media and the fibre properties. Impact energy is dissipated by debonding, the fibre and / or matrix fracture and fibre pull out. Fibre fracture dissipates less energy compared to fibre pull out. The former is common in composites with strong interfacial bond, while the occurrence of later is the sign of weak bond.

The effect of fibre volume fraction on the impact strength is shown in table 1, 2, 3 and 4. An increase in impact strength observed with increase in fibre volume fraction for both jute and glass fibre reinforced composites. The 30 % volume fraction showed highest impact strength for both jute and glass fibre composites.

Fig. 6. Impact strength of jute and glass fibre reinforced Polypropylene composites.

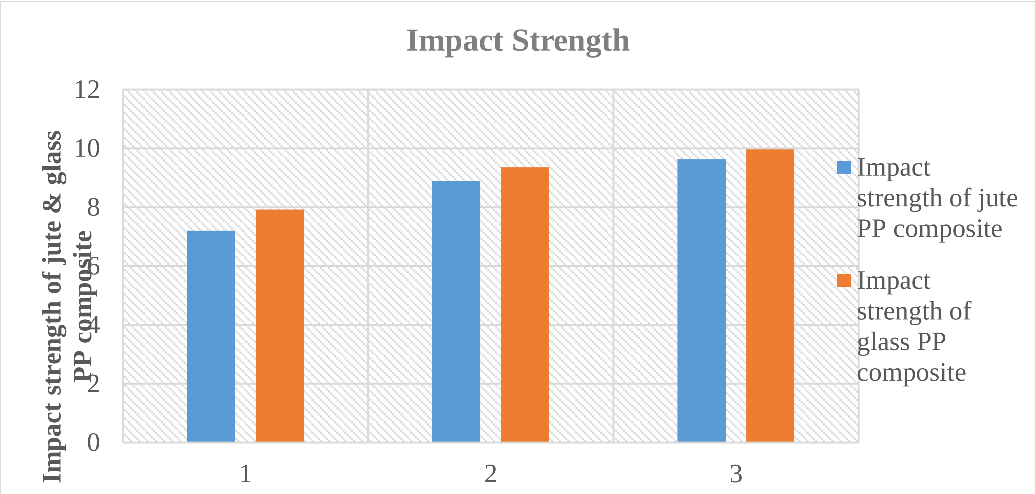
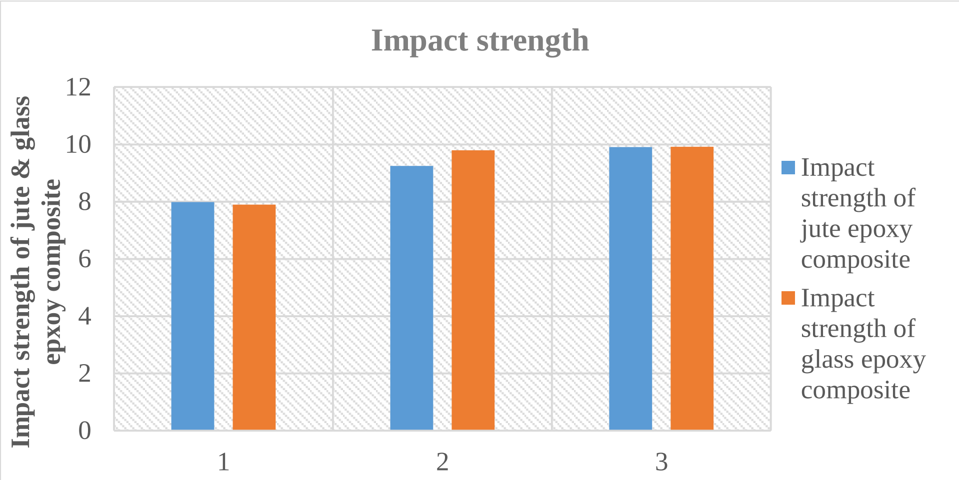


Fig. 7. Impact strength of jute and glass fibre reinforced epoxy composites.



4. Conclusion

The mechanical properties of jute and glass reinforced polypropylene and epoxy composites have been investigated. The maximum stress at break and flexural strength increases with increase in fibre volume fraction. Glass fibre composite showed highest mechanical properties than jute fibre reinforced polypropylene and epoxy composites. Comparable difference was not observed for elongation at break and flexural modulus for both jute and glass fibre reinforced polypropylene and epoxy composites. The epoxy composites registered higher mechanical properties than polypropylene for jute and glass fibre reinforced composites.

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