Investigation on Mode I Interlaminar Fracture Toughness of Chemically Treated / Untreated Saw Dust Powder Based Jute Fabric Reinforced Epoxy Composite Structure

R. Suthan*, V. Jayakumarb, S. Madhuc

*Department of Mechanical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai – 602 105, Tamil Nadu, India.

bDepartment of Mechanical Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Chennai Campus, Chennai – 601 103, Tamil Nadu, India.

cDepartment of Automobile Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai – 602 105, Tamil Nadu, India.

Corresponding Author: itsmesuthan@gmail.com

Abstract. Nowadays polymer matrix composites are widely used in the areas of automotive, medical, aircraft and aerospace industries. Since, chemically surface modified saw dust with jute fiber reinforced composites play vital role in developing lightweight structural materials in many engineering industries. This study focuses on utilizing chemically surface modified saw dust with jute fibers reinforcement filler loading malic acid treated and un treated (10%, 20% and 30%) and fiber loading (3-layer jute fiber) in epoxy resin. This composite was fabricated using hand lay-up process. The influence of filler volume fraction and fiber weight fraction on the fracture toughness properties of treated / untreated modified saw dust with jute fiber/filler was studied initially. Test results revealed that the composite 20-volume fraction malic acid treated saw dust with 3-layer jute fiber composite has better fracture properties as compared with other specimens.

Key words: Epoxy, chemically surface modified saw dust with jute fiber, fracture properties.

1. Introduction

Kokta et al. (1989) studied the mechanical behaviour of wood flour - added polypropylene composite and found the addition of filler material in the polypropylene matrix increases the mechanical properties of the composite material. Sarki et al (2011) have used coconut shell powder as filler material in epoxy composite and it was found that incorporation of coconut shell powder increased the tensile strength and modulus with a slight decrease in impact strength. Mohamad Hana...
et al (2017) investigated the coconutshell powder with PVC composite for automobile application. This research revealed that tensile, flexural and impact strength as well as it modulus of elasticity is improved by 42%, 25% and 23% respectively when compared to the pure resin. Chun et al (2013) used coconut shell powder as filler in recycled polypropylene, and sodium dedecyl sulfate (SDS) as coupling agent. It revealed that the addition of filler provide dan increase intesnile properties, thermal stability, and crystalinity and lower the water absorption compared to unmodified composites. Kuburi et al (2017) investigated the coconut shell powder filled composite prepared from recycled low density polyurethane polymer matrix contain upt 15wt% of coconut shell powder as filler the effect of coir fiber loading and the process of the composite was investigated. The result reveals that both mechanical properties and waster absorption properties are improved. Siro(2010) prepared a completely bio composite based on Poly Lactic Acid(PLA) and olivepit powder and it was reported that addition of filler resulted in increase tensile modulus and decrease inflexural strength. Muthukumar et al(2006) investigate about developing the polymer matrix composite using coconut shell powder and groundnut shell powder in different volume fraction the evaluation showed that the tensile strength, impact strength and flexural property and hydrophilic behaviour has increased. The material properties are greatly influenced by the coconutshell powder and groundnut shell powder volume fraction. Udhaya Sankar et al. (2015) researched the coconut shell powder reinforced polymer composite. Results revealed that the filler addition improves the mechanical properties like tensile strength and impact strength. Chandramohan et al(2017) studied the bio particle composite from coconut shell powder, walnutshell and rishehuskin epoxy matrix. The result revealed that 20vol% of filler provides better mechanical property and modulus due to uniform dispersion of filler and matrix. Onuegbuetal(2011) studied polypropylene based composites with groundnut husk powder at varies particle size. The polypropylene composites were prepared in an extrusion moulding machine and the resulting composites were extruded as sheets. ThePresence of pulverized ground nut husk improved the tensile strength, modulus, flexural strength and impact strength of the composites and these properties are increased with increase in filler contents and decreases with filler particle size. Raju et al.(2012) investigated the groundnut shell powder reinforced polymer composite the composites were prepared with different weight% of particles in polymer matrix. From the experimental results. It has been observed that the sample with 20wt% of reinforcement, has maximum MOR (modulus of Rupture) of 40.57MPa and 60wt% reinforcement has maximum MOE(Modulus of Elasticity) of 8.204GPa. The impact test study showed increase in impact strength upto 50wt% of filler addition.
2. Materials and Method

In this current research work Epoxy resin (LY-556) was used as matrix material. HY951 was used as hardener for the preparation of composite. Chemically surface modified saw dust with jute fiber was used as reinforcement. Silicon spray was act as mould releasing agent.

![Saw dust powder and Fabricated composite](image)

Figure 1 Fabricated saw dust reinforced jute fabric composite

Hand layup process was used for fabricating the composite with the dimension of (300 × 300 × 3 mm) as per the Table 1. Figure 1 (a) shows the saw dust powder used for this investigation. Figure 1 (b) shows the fabricated saw dust reinforced jute fabric composite.

| Material code          | Filler (wt %) | Jute (wt %) | Epoxy (wt %) |
|------------------------|--------------|-------------|--------------|
| Saw dust 10 jute       | 10           | 40          | 50           |
| Saw dust 20 jute       | 20           | 40          | 40           |
| Saw dust 30 jute       | 30           | 40          | 30           |

Table 1 Designation and composition of developed composites

3. Fracture Test (CT) Specimen Preparation

The fracture toughness was determined using Instron type universal testing machine as per ASTM D5045 standard. The crack will begin on the point of the notch and extend through the sample. CT specimens are used extensively used in the area of testing, in order to establish fracture toughness values for a material. CT specimens are used for experiments where there is a shortage of material
available due to their compact design. Figure 1 shows test specimen used for this investigation. Stress intensity factor K can be considered as an estimate of fracture toughness. It depends on the applied load, flow depth and geometry of the specimen. Critical stress intensity factor for mode 1 can be determined from the following equation 1.

\[ K_c = \frac{P}{B \sqrt{W}} \left\{ F \left( \frac{A}{W} \right) \right\} \quad \text{--------- Eq. 1} \]

Where ‘P’ is the load at which crack propagate. ‘B’ denotes the thickness of the test specimen and ‘w’ is the length of the specimen. Crack length is ‘a’.

\[ F \left( \frac{A}{W} \right) \text{- Geometry factor} \]

\[ \left\{ F \left( \frac{A}{W} \right) \right\} = \frac{2 + \left( \frac{A}{W} \right)}{(1 - \frac{A}{W})^2} \left( 0.866 + 4.66 \left( \frac{A}{W} \right) - 13.32 \left( \frac{A}{W} \right)^2 + 14.72 \left( \frac{A}{W} \right)^3 - 5.6 \left( \frac{A}{W} \right)^4 \right) \quad \text{--------- Eq. 2} \]

Figure: 2: Test specimen with specification

Universal testing machine is used for fracture test which is shown in Figure 2.
After finishing the fabrication of specimen, that specimen is fixed in the machine as shown in the Figure 3. The testing of the specimen is done with the help of universal testing machine. The 2 bolts are inserted in the 8mm diameter hole. The 2 bolts are fixed in the testing machine as shown in the Fig 3. Thus the specimen will be fixed in the testing machine for conducting CT test specimen. The testing machine will be connected with the computer to record the required results digitally. Fig 4. Shows the various specimens tested for this investigation.

Fig.3 Testing of specimen

Fig.4 Specimens used for Mode I fracture

4. Result and discussion

Mode I fracture toughness was investigated using UTM machine. Table 2 shows the mode I fracture toughness value obtained from the experimental results.

Table 2 Mode I fracture toughness

| Material code       | Mode I fracture toughness |
|---------------------|---------------------------|
|                     | Untreated | Treated |
| Saw dust 10 jute    | 1.2*10^-3 | 2.1*10^-3 |
| Saw dust 20 jute    | 0.8*10^-3 | 1.9*10^-3 |
| Saw dust 30 jute    | 1.8*10^-3 | 2.2*10^-3 |
5. Mode I fracture toughness

5.1 Effect of surface treated saw dust powder on mode I fracture toughness

![Graph showing effect of saw dust powder on mode I fracture toughness](image)

Figure 5 Effect of sawdust powder on mode I fracture toughness

The effect of treated and untreated sawdust powder on fabricated composite mentioned in Figure 5. From the figure it was seen that increasing the w.t% of sawdust powder from 10% to 30% will increase the fracture toughness. The uniform distribution of sawdust particles in epoxy rein decrease the stress intensity factor which in turn increasing the fracture toughness in the fabricated composite.

5.2. Microstructural morphology

The scanning electron microscope (SEM) was used to identify the fracture morphology of the composite samples.

The surfaces of the composite specimens are examined directly by scanning electron microscope. The composite samples are washed, cleaned thoroughly and are coated with 120 Å thick platinum in sputter ion coater and observed SEM at 40 kV. Similarly the composite samples are mounted on stubs with silver paste. To enhance the conductivity of the samples, a thin film of platinum is vacuum-evaporated onto them before the photomicrographs are taken.
The test results were found out the value mentioned above Table 2. The maximum fracture properties were observed for the composite with 20 volume % chemically surface modified saw dust with jute fiber. The Increase with the incorporation of chemically surface modified saw dust with jute fiber this due to uniform distribution of saw dust with jute fiber in the epoxy matrix and Due to uniform dispersion, stress is created because of applied load is disseminated equally it is evident from SEM images Fig 6 (a). It also indicates that bonding between treated filler/fiber and matrix is better when compared to the composite with another untreated filler/fiber material. 30 volume % of filler that reveals clustering of saw dust in the epoxy composite it is evident from SEM image Fig 6 (b) and 6 (c). This agglomeration of filler material results in amorphous nature of the composite.

6. Conclusion

The influence of different volume fraction of malic acid treated saw dust with jute fiber reinforced filler/fiber addition in the epoxy resin on the mode-1 fracture where analyzed the fractured
toughness results replaced that the treated 3-layer jute fiber with 20 % percentage filler in the epoxy matrix increase the mode-1 fractured toughness properties such as fracture of the composite material. Further additions of saw dust filler reduce the property due to the non-uniform dispersion in filler/fiber in the epoxy matrix. Comparison of the experiments results are filler/fiberadded un treated another composite. Hence saw dust/jute fiber is a one type of natural filler can also be used with epoxy resin.

REFERENCES

[1] Kokta, BV, Raj, RDaneault, C 1989, ‘Use of wood flour as filler in polypropylene: Studies on mechanical properties’, Polym. Plast. Technol. Eng.,vol.28, no. 3, pp. 247–259.
[2] Sarki, J, Hassan, SB, Aigbodion, VS, Oghenevweta, JE 2011, ‘Potential of using coconut shell particle fillers in eco-composite materials’, Journal of Alloys and Compounds, vol.509,no.5, pp. 2381-2385.
[3] Chun, KS, Husseinsyah, S, Azizi, FN 2013, ‘Characterization and properties of recycled polypropylene/coconut shell powder composites: Effect of sodium dodecyl sulfate modification’, Polym. Plast. Technol. Eng., vol. 52, no. 3, pp. 287–294.
[4] Kuburi, LS, Dauda, M, Obada, DO, Umaru, S, Dodoo-Arhin, D, Iliyasu, I & Mustapha, S 2017, ‘Effects of Coir Fiber Loading on the Physio-mechanical and Morphological Properties of Coconut Shell Powder Filled Low Density Polyethylene Composites’, Procedia Manufacturing, vol. 7, pp. 138-144.
[5] Siró, I &Plackett, D 2010, ‘Microfibrillated cellulose and new nanocomposite materials: a review’, Cellulose, vol. 17, no. 3, pp. 459-494.
[6] Muthukumar, S &Lingadurai, K, ‘Global Journal of Engineering Science and Researches’.
[7] Udhayasankar, R &Karthikeyan, B 2015, ‘A Review on Coconut Shell Reinforced Composites’, International Journal of Chem Tech Research., vol. 8, no. 11, pp. 624-637.
[8] Chandramohan, D & Kumar, AJP 2017, ‘Experimental data on the properties of natural fiber particle reinforced polymer composite material’, Data in brief, vol. 13, pp. 460-468.
[9] Onuegbu, GC &Igwe, IO 2011, ‘The effects of filler contents and particle sizes on the mechanical and end-use properties of snail shell powder filled polypropylene’, Materials Sciences and Applications, vol. 2, no. 07, p. 810.
[10] Raju, GU &Kumarappa, S 2011, ‘Experimental study on mechanical properties of groundnut shell particle-reinforced epoxy composites’, J. Reinf. Plast. Compos. vol. 30, no. 12, pp. 1029–1037.