A Comprehensive Study of CNC Waste Reinforced Epoxy Composites

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Abstract. To reduce the carbon foot prints of recycling, reuse of the waste of the CNC industries is the focus of attention. The present research intends to use CNC waste in the polymer composite which reduces the waste in the landfill encourages to the sustainability of the environment. In the present work CNC waste varied from 0-20g and developed CNC waste filler composites. The specimens will be taken from the laminates as per ASTM standards and evaluated mechanical properties and inter facial bonding between the CNC waste filler and matrix was analysed through the scanning electron microscopic (SEM) analysis

Keywords: CNC waste; Epoxy; SEM.

1 Introduction

The current environmental policies invokes that to decrease the carbon emissions due to this manufacturing industries are looking for the innovative, carbon free, natural resource and high strength material which can replace the carbon, glass and many more material. From the last decade, the usage of natural fibre reinforced (NFR) and filler reinforced(FR) composite material were alternative for the synthetic material in the polymer composite sector. The advantages natural fibre and filler reinforced composites have light in weight, high strength, low density, low corrosion, cheaper cost of manufacturing, and many more.[1].These properties of the NFR and FR composites material attracted in many engineering application like construction, automotive, house hold, structural and so on[2].alkali treatments of the fibre enhances the bond between the fibre and matrix, improves the mechanical properties of the natural fibre composites, bio fibres can reduces the pollution and ecofriendly in nature[3,4,5]. The properties are depends on the fibre loading and filler content was used in the composite [6].Fillers can reduce the voids within the composite and also enhancing the mechanical and electrical properties of the filler reinforced composites revealed by various authors [7,8]. fibre and filler reinforced hybrid composites will have better prop-

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erties, good fastening between the fibre/filler and matrix [9,10].li et al.,[11] studied the inorganic and bio filler reinforced sisal fibre composites and observed that with the accumulation filler content the properties were superior than other composites. Inorganic and bio-filler reinforced composites will have similar properties and degradation behaviour was more for natural and bio-filler reinforced composites. natrayan et al.,[12] observed the mechanical properties of TiO2-bamboo reinforced polyester composites , by the accumulation of filler content then the properties of the fibre/filler composites and interfacial bonding between the fibre and matrix were enhanced. Chaudary et al.,[13] developed jute, jute/hemp, and hemp hybrid reinforced composites. The authors revealed hybrid jute/hemp composites have superior properties than individual fibre reinforced composites. Ramaswamy et al., [14] investigated Calotropis gigantea Bast natural Fiber for the replacement of synthetic fibre and alkali treated fibre has better mechanical properties over raw fibre. Jawaid et al.,[15]prepared oil-palm/jute fibre reinforced hybrid composites and they observed with the inclusion of the jute fibre in the oil palm composites the mechanical (tensile, impact and flexural) properties were enhanced and its impact strength declined. Poulose et al.,[16] explored mechanical and electrical possessions of bio char reinforced polypropylene composites and they revealed with the enhance of bio char content the mechanical and electrical properties were enhanced. Reddy et al.,[17] worked on the alkali treatment of the tapsi fibre reinforced epoxy composites. The alkali treatment enhances the mechanical properties and the good bonding between fibre and matrix. Naveen et al.,[18] observed mechanical and moisture properties of the Kevlar/cocos nucifera reinforced hybrid composites. Hybrid composites exhibit improved properties than pure fibre reinforced composites and these composites are suitable for the defence application. Ramesh et al.,[19] reviewed the inclusion of the filler on the composites. With the inclusion of the filler the mechanical properties were enhanced, through SEM analysis voids and the bond region between the reinforcement and matrix were observed. The objectives of current study computer numerical controlled (CNC) machine waste considered as the reinforcement and prepared composites and evaluated the mechanical (tensile, impact and flexural) properties were evaluated, bonding region between the CNC waste and matrix observed through SEM analysis.

2 Material and methods

CNC waste was collected from the Pulla reddy engineering college and converted in to the fine chips and used. Epoxy ly951 and hardener grade were purchased from M S Industries, Kakinada and used in the preparation of the composites. Different wt% of CNC waste reinforced epoxy composites were fabricated using hand layup technique. in the hand layup technique glass mould is prepared with the size of 150 X 150 X 3 mm^3.Epoxy-hardener are mixed in the ratio of 10:1 to get the gel type structure. Different weight proportions of CNC waste was mixed with the epoxy -hardener mixture; poured into the glass mould, place the emery paper, roll it evenly and apply a load to get the smooth surface over the laminate, after 24 hours the laminate was taken out from the glass mould and specimens were cut as per the ASTM standard. ASTM3039 specimen size was considered for tensile strength, ASTM-07 specimen size was considered for flexural strength, and ASTM 256 specimen was considered for impact strength. Characterizations of the fabricated composites were also studied. SEM analysis carried at yogi Vemana University. The specimen size 1 X 1 X 0.3 cm^3 taken and gold sputtered for the better visualization of the objects in the specimen. Thermal degradation behaviour of the composites were analysed through the TGA analysis. Functional compounds present in the specimen carried through the FT-IR spectroscopy.

3 Results and discussion

3.1 Tensile behaviour of the CNC waste reinforced composite

The specimen of the size 150 X 15 X 3 mm^3 was taken from the laminates and conducted tensile test on UTM machine with the crosshead speed of 5mm/min. From the figure it can be observed that CNC waste content was increased from 5-20 g and the 15g CNC waste reinforced composite have better tensile than other CNC waste reinforced composites.15g CNC waste reinforced composites have 45MPa and the 20g CNC waste reinforced composite have 42MPa (approximately) which is lower tensile strength than 15g CNC reinforced composites due to the voids and other parameter influences on the strength of the reinforced composite.

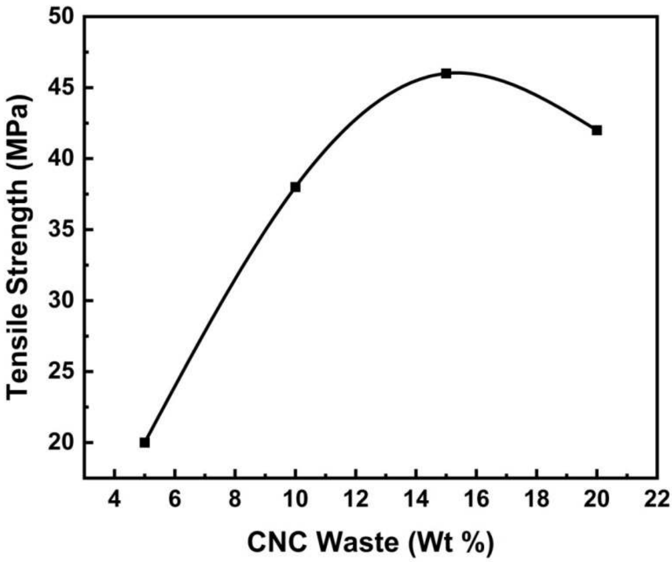

Fig. 1. Tensile behaviour of CNC waste filled reinforced composites

3.2 Flexural behaviour of the CNC waste reinforced composites

The specimens were taken as per ASTM 07 size of 15 X 1.27 X 0.3 cm^3 from the laminate and used for flexural test on UT machine with crosshead maintained at a speed of 5 mm/min. from the figure it can be noted that 15 % of the CNC reinforced composite will have higher flexural strength which is 95MPa than other CNC reinforced epoxy composites. fabricated and evaluated the mechanical properties Various $CaCO_3$ (0-60phr) filler reinforced rubber composites and observed that 20phr $CaCO_3$ rubber composites will have better properties than other $CaCO_3$ reinforced rubber composites studied by Longkaew et al. 20 g CNC waste filled reinforced composites have 90MPa flexural strength which is lower than 15 g CNC waste filled reinforced composites. Krishnudu et. al. developed $CaCO_3$ filler reinforced composites through injection moulding technique and observed 15 g $CaCO_3$ filled reinforced composites have higher mechanical properties than other $CaCO_3$ filled reinforced composites.

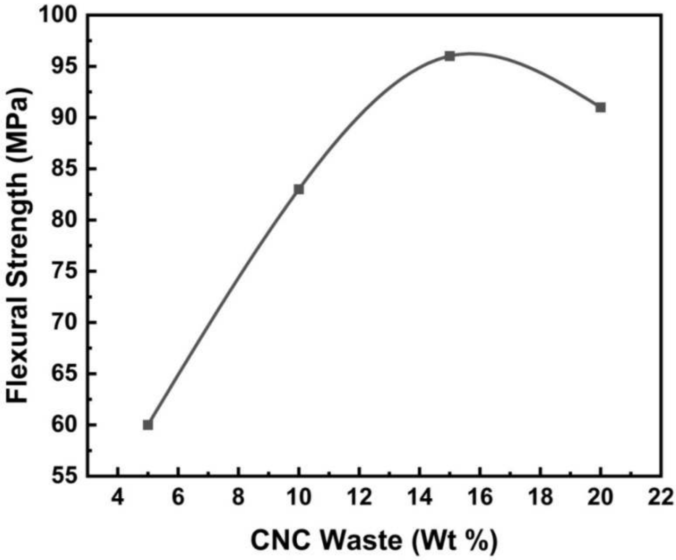

Fig. 2. Flexural behaviour of CNC waste filled reinforced composites

3.3 Impact behaviour of CNC waste reinforced composites

The capability of polymer/metal matrix material to absorb and more energy without cracking or breaking is termed as impact strength. The amount of impact energy of the CNC waste composites is primarily lying on the adhesion region between the CNC filler and matrix. Pendulum method is used to determine the impact strength of CNC waste reinforced composites. From the figure it was observed that 15 g CNC filler reinforced composite have highest impact energy (28J/m) than other CNC filler reinforced composites which indicated it can withstand for heavy load applications. Similar trends were observed by krishnudu et al. The energy lost by the pendulum is measured as the impact strength of the CNC waste reinforced composite specimen.

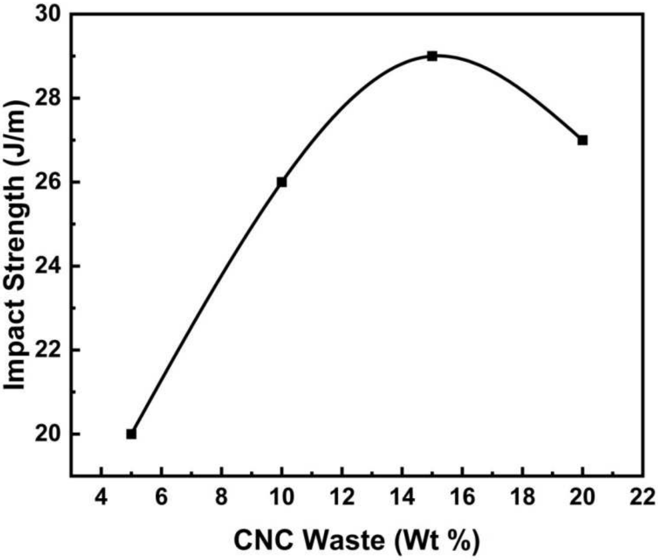

Fig. 3. Impact strength of CNC waste filled reinforced composites

3.4 SEM analysis of CNC waste reinforced composites

SEM morphology of the CNC waste reinforced epoxy composites was analysed. from the figure 4 it can be observed that the CNC waste filler was distributed evenly throughout the composite specimen.15 g of the filler reinforced composite does not contain any voids and wax content in the filler so the strength of the composites have more than other filler reinforced composites. From the figure 5 20 g of the CNC filler reinforced composites will have void and also agglomeration of the CNC waste was observed due to that the strength of the composites diminished

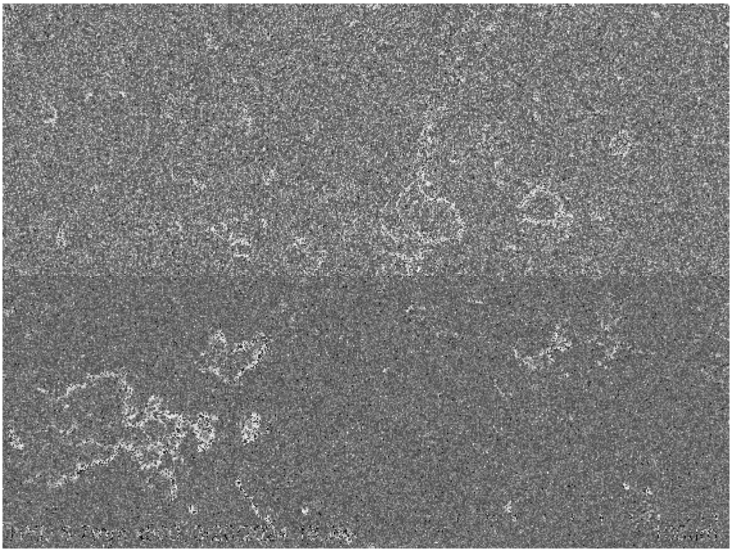

Fig. 4. SEM image of 15g CNC waste filled reinforced composites

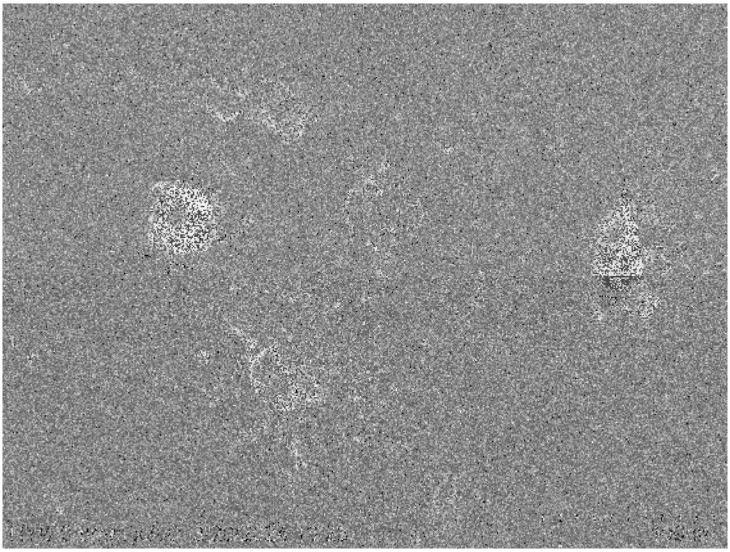

Fig. 5. SEM image of 20 g CNC waste filled reinforced composites

4 Conclusion

A comprehensive study was conducted for the CNC waste filler reinforced epoxy composites and observed the mechanical properties and the interfacial boding between the CNC waste filler and matrix was studied.15 g of the CNC waste filled reinforced composite have high tensile, flexural and impact strength than other CNC waste filled reinforced composites. From the SEM analysis it can be observed that good interfacial and there is no void for 15 g CNC waste filled reinforced composites and voids were observed for the 20 g of the CNC waste filed reinforced composites

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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