Influence of Recycled Rubber And Alumina Powder Filler on Mechanical Behaviour of Woven Glass Fiber Reinforced Epoxy Composites

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Abstract- *In this work a hybrid composite material was prepared using recycled rubber and alumina powder as filler, epoxy resin as matrix with woven glass fiber as reinforcement. The present work is to determine the influences of different volume percentage such as (0%, 3%, 6% and 9%) of the filler on the mechanical properties such as tensile, flexural and impact as per the ASTM standards and sem images analysis is done for the best component.*

Keywords- Glass fiber, Recycled rubber, Alumina powder, Flexural test, tensile test, epoxy.

I. INTRODUCTION

In this modern era, road transportation is highly increased, which in turn increased the utilization of tires in the vehicles. After a certain period, these tires will be worn out and it can't be used. The disposal of waste rubber from the tires is a big problem in most of the developed and developing countries [1]. The present work is one such attempt to reuse the rubber for some special purpose applications. Rubber filled concrete is used in highway medians, sound barriers and other transportation structures where high strength is required [2]. The manufacturing methods and experimental results concerning to the mechanical behavior in case of the composite materials filled with wood flour obtained by recycling of the wood wastes is shown in the works [3,4]. The recycled materials from vegetable waste in a matrix based on polymer-modified cement were used in the civil engineering field [5]. C. Cerbu presented a research paper in The World Congress on Engineering on thermo-mechanical recycling of post-consumed plastic bottles, and its use as composite materials for engineering applications. The particles obtained from recycling of CDs DVDs were used to make composite materials. Density of aluminum is less than other metals so it can be used as filler material in hybrid composite[8].Thomas u from Australian institute of geoscientists showed that adding rubber particles as aggregates in cement mixture gave good result in terms of compressive and to tensile strengths. It also induced a significant decrease of the modulus of elasticity [10].

II. MATERIALS AND METHODS USED

The main materials used are, 1) Epoxy resin (araldite GY250), 2) Woven glass fiber, 3) Recycled rubber and alumina powder.

Epoxy is the cured end product of epoxy resins, as well as a colloquial name for the epoxide functional group. Glass fiber is a material consisting of numerous extremely fine fibers of glass. It is most commonly used as reinforcement material because of is exceptional properties. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle. Recycled rubber powder which passing through 600 micron mesh sieve and alumina powder 45 micron is used as filler materials for making samples.

Figure 1: Milled Recycle rubber

Figure 2: Alumina powder

Figure 3: Die arrangement

As per the calculations 8 layers of 250x250 sized glass fiber was cut. The required amount of epoxy resin was weighed. Calculated amount of recycled rubber and alumina powder filler were added after that hardener was mixed and thoroughly stirred. Then by using Hand layup technique the glass fiber along with resin was compressed and cured in the die for 24hours. Same procedure is repeated by varying filler percentage i.e. 3%,6% and 9%.

Figure 4: cured sample

The specimens needed for different tests (tensile test, flexural test and impact test) were marked in the top of the fabricated laminate using a marker according to ASTM standards. The fabricated laminate composites were cut in to necessary sizes with the help of a jig saw cutting machine.

Figure 5: Universal testing machine

III. RESULT AND DISCUSSIONS

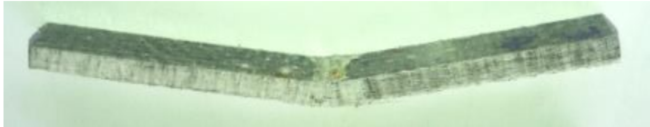


Figure 6: specimen after flexural test

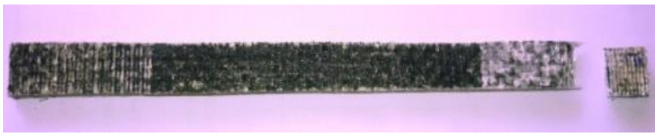


Figure 7: Specimen after tensile test

Figure 8: Specimen after impact test

The variations in tensile strength, Flexural strength and impact strength are shown in Figure. 9, 10 and 11

Table 1: Ultimate tensile strength (UTS)

Percentage of filler	Ultimate tensile strength (MPa)
0%	234.66
3%	276.27
6%	337.75
9%	279.58

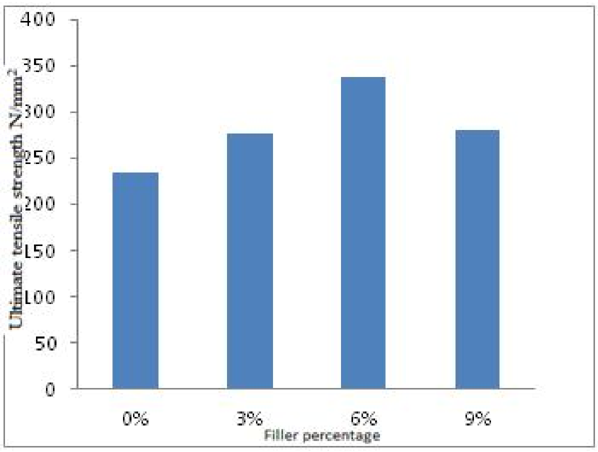


Figure 9: Ultimate tensile strength v/s filler percentage

Table 2 : Flexural strength of composite laminate

Percentage of filler	Flexural strength (MPa)
0%	164.33
3%	374.06
6%	502.66
9%	415.13

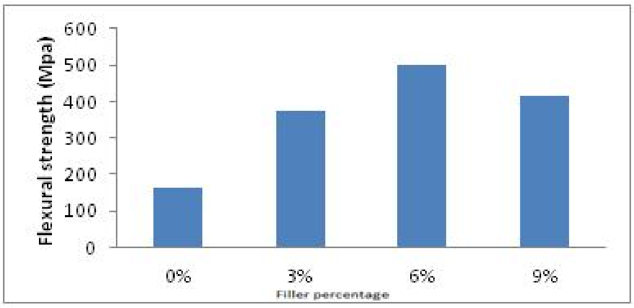


Figure 10: The flexural strength v/s filler percentage

Table 3: Impact strength

Specimen	Impact strength (J/mm)
0%	0.0790
3%	0.0826
6%	0.0925
9%	0.0905

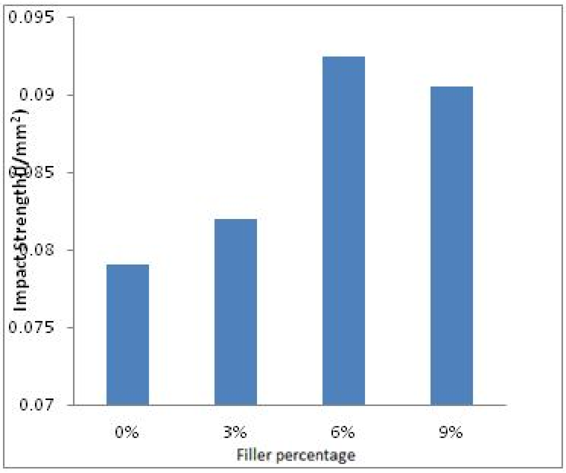
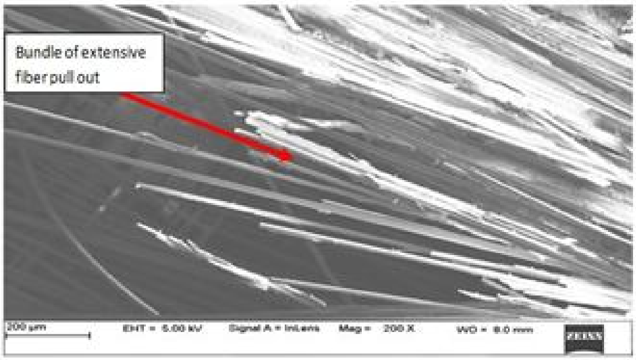


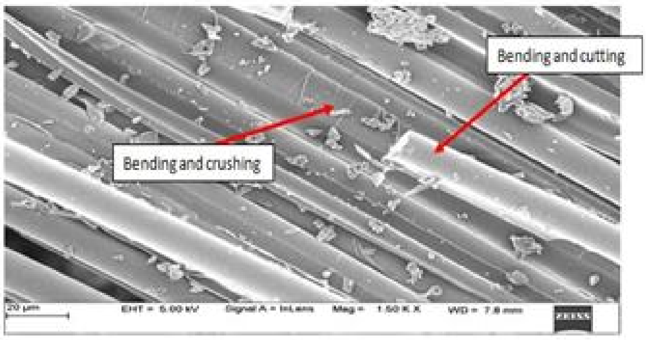
Figure 11: Impact energy v/s filler percentage

From Figure 9 it is clear that the tensile strength goes on increasing as the percentage of filler increased up to 6% and at 9% tensile strength of material decreased. From Table 1 we can observe that for 6% filler filled composite there is 44% raise in tensile strength when compared to unfilled composite. This means that the elasticity of the material goes on increasing as we increase the filler percentage up to 6%. It is clearly seen in Figure 10 that flexural strength is high at 6% filler filled composite and in Table 2 we can observe 206% increase in flexural strength as compared to unfilled composite. This may be due to the better uniform distribution of the filler and good interfacial bonding between the matrix, filler material and fiber. In Figure 11 it is clear that the impact strength of the material goes on increase as the percentage of filler increased up to 6% at 9% impact strength of material decreased. From Table 3 we can observe that for 6% filler filled composite there is 17% raise in impact strength as compared to unfilled composite.

IV. SEM ANALYSIS



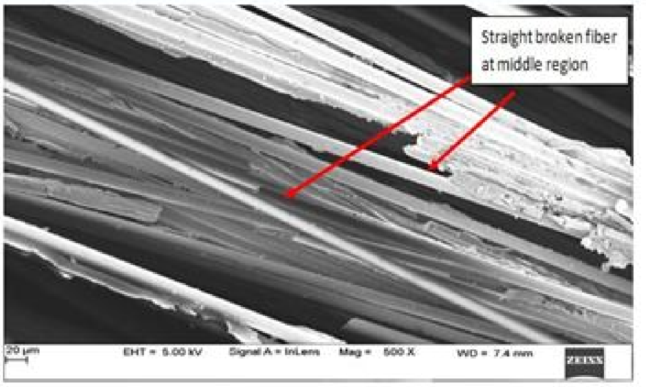
(a)



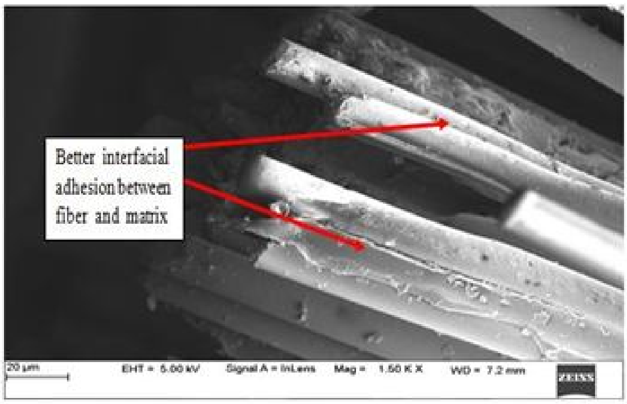
(b)

Figure 12: Sem images of flexural fractured surface of unfilled glass fiber epoxy composite after flexural failure at (a) 200x (b) 1500x magnification.

The SEM images of Figure 12 and 13 show the fractured surfaces (obtained by three point bending test) of the unfilled and 6% recycled rubber/alumina particulate filled composite systems, respectively. Figure 12 (a) and (b) revealed the brittle type of fracture along with instant multiple fractures. This is due to de-lamination between fiber and matrix. The main de-lamination was due to inter-laminar stresses and failure was observed at middle of the specimen. It is very clear from this SEM images that de-bonding and breaking of fibers are essentially localized in the area where the compressive stresses and tensile stresses were higher. In 0% filler glass fiber epoxy composite the bonding between fiber and matrix was weak. Also extensive fibers pull out, fiber breakage, and band formation in the fiber was identified. This is due to higher tensile stress at the bottom region.



(a)



(b)

Figure 13: Sem images of flexural fractured surface of 6% filler filled glass fiber epoxy composite after flexural failure at (a) 500x and (b) 1500x magnification respectively.

SEM images of the fractured surface of 6% recycled rubber/ alumina filled glass fiber/epoxy composite show very different fracture morphologies than that of unfilled glass fiber/epoxy composite. The recycled rubber/alumina filled glass fiber/epoxy composite revealed the simultaneous breakage of fibers and matrix, less de-lamination and less fiber breakage. These have led to increase in flexural strength and better interfacial adhesion between fiber and matrix. This is shown in Figure 13.The recycled rubber powder particles in the matrix were attributed to the improvement in bending strength.

V. CONCLUSIONS

From the tensile test, flexural test, impact test results it is observed that the strength of the material is increased with the addition of recycled rubber till 6%. The maximum tensile, flexural and impact strength is observed at 6% filler filled composite at 9% strength of the material decreased. This indicates that addition of filler above 6% affect on bonding strength between matrix and reinforcement.

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