Mechanical Characterization of Coir Fiber Reinforced Polymer Composite Using Red Mud as Filler

[1] MR. BIREN J. SARADAVA, [2] PROF. NIKUNJ V. RACHCHH, [3]DR.R. K. MISRA, [4]DR. D. G. ROYCHOWDHARY

[1]Department of Mechanical Engineering, Marwadi Education Foundation, Rajkot, Gujarat

[2] Asso. Professor and HOD, Department of Mechanical Engineering, Marwadi Education Foundation, Rajkot, Gujarat

biren8240@gmail.com,nvrachchh@gmail.com

ABSTRACT-In the Bayer process of extraction of alumina from bauxite, the insoluble product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure is known as red mud' or bauxite residue'. Enormous quantity of red mud is generated worldwide every year posing a very serious and alarming environmental problem. With increased environmental threat it has become necessary to find out alternative uses of industrial wastes and to develop value added products using them. This work is a step in that direction. A possibility that the incorporation of both particles and fibres in polymer could provide a synergism in terms of improved properties. The present work includes the processing and evaluation of mechanical properties of red mud filled coir fiber reinforced polymer composites. The systematic experimentation leads to determination of mechanical properties at various percentage of the red mud as filler material.

Keywords: Coir fiber, bauxite residue, composite, reinforcement, mechanical properties.

I: INTRODUCTION

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, coir, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling panelling, partition boards), packaging, consumer products, etc. The objectives of the work is to Fabricate coir fibre reinforced polyester matrix composite with/without filler content and evaluation of mechanical properties (tensile strength, flexural strength, barcol hardness, density etc. Besides the above all, the objective is to develop relatively low cost composites by incorporating cheaper reinforcing phases into a polymeric resin. Also this work is expected to introduce a new class of polymer composite that might find applications in door, vibration absorber, dining table etc. coir fibre are prepared from coir plant, Polyester resins are produced by the poly condensation of saturated and unsaturated dicarboxylic acids with glycols and red mud is an industrial waste generated during the production of alumina by Bayer's process. R.K.Misra et al. [1] includes the processing and evaluation of mechanical properties of coir fiber Reinforced polyester composites. The systematic experimentation leads to determination of mechanical properties at various percentage of the coir fiber. Effect of continuous and discontinuous distribution of coir fiber in polyester resin has been studies thoroughly. Saxena et al. [2] have developed and characterized composites made from renewable resources like jute and sisal along with industrial wastes like fly ash and red mud. Their study reveals that developed composite attained far superior mechanical properties as compared to wood, medium density fiber and particle woods. S. Biswas et al. [3] developed mathematical model for estimating erosion damage caused by solid particle impact on red mud filled glass fiber reinforced epoxy matrix composites. Singh et al. [4] showed that particulate hybrid composite made from sisal fibers and industrial waste is a potential candidate to impart superior physic-mechanical properties compared with sisal-fiber-reinforced composite.

Also it can be used for making partitions, wall panels, claddings etc. Hemalata Jena et al. [5] include the fabrication of a set of glass-polyester composites using red mud an alumina plant waste product as the particulate filler. It also attempts to study the solid particle erosion wear response of these composites under multiple impact condition. The methodology based on Taguchi's experimental design approach is employed to make a parametric analysis of erosion wear process. V. Arumuga Prabu et al.[6] describes the development and characterisation of a new set of polymer composites consisting of sisal fibre reinforcement, polyester resin and red mud particulate fillers. It also evaluated tensile, flexural and impact properties of the sisal fiber reinforcement composites with and without filler content and results compared. Amiya Kumar et al. [7] developed an epoxy based hybridized composite material comprising of glass fiber, jute fiber and red mud as filler material and evaluated its mechanical properties and observed that flexural strength, tensile strength and density of the material increases with increase in number of layers of reinforcement.

II: MATERIALS AND METHODS

This chapter describes the details of processing of the composites and the Experimental procedures followed for their Mechanical properties Evaluation. The raw materials used in this work are

1. Coir fibre
2. Red mud
3. Polyester

A. Material preparation

Required materials are coir fibre, polyester resin, red mud. Coir fibre are prepared from coir plant, Polyester resins are produced by the poly condensation of saturated and unsaturated dicarboxylic acids with glycols and red mud is an industrial waste generated during the production of alumina by Bayer's process.

B. Composite preparation

A wooden mold of dimension (230×230×10) mm^3 was used for casting the composite sheet. The samples were manufactured with 0, 10, 20, 30 and 40% volume fraction of red mud and coir fibre. In this present investigation 60% polyester resin is fixed. For different weight fraction of red mud, 60% polyester resin and hardener was thoroughly mixed with gentle stirring to minimize air entrapment. Then by using hand layup technique, first layer of slurry has been done. Above that chopped coir fibers are arranged and then slurry is poured and so on. This procedure has been done up to getting the required thickness. For quick and easy removal of composite sheets, a mold release spray was applied at the inner surface of the mold. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mold was allowed to cure at room temperature for 24 hrs. This procedure was adopted for preparation of 0, 10, 20, 30 and 40% weight fractions of composites. After 24 hrs the samples were taken out of the mold, cut into different sizes for further experimentation.

C. Experimental procedure

1. Sample cutting for testing

The samples were cut from the plate according to reference standard. For density measurement, samples were cut according to ASTM-792.The flexural and tensile properties samples were cut according to ASTM D-790-10 and ASTM D-638 respectively. And for barcol hardness, the samples were cut according to ASTM D-2583.

2. Procedure for density testing

In this test, samples were cut according to reference standard and then density setup was used. First, sample was put above the water then it gave a density of sample in air. It is stored in the setup. After that the samples was kept in water then measure the density of sample in water. It is also stored in the setup. Finally, it gave a combined density of sample in air and water. It was measured from the setup.

3. Procedure for flexural properties at maximum force

Flexural properties measured with the help of universal testing machine. In UTM, the samples are mounted on the flexural attachment. It is kept lower side of the UTM. Then load is applied on the sample and observed the value of flexural stress when failure has been done.

4. Procedure for tensile properties at maximum force

Tensile properties measured with the help of universal testing machine. In UTM, the samples are mounted on the tensile attachment. It is kept upper side of the UTM. Then load is applied on the sample and materials get stretched. Due to stretching, it was failed. Then observed the value of tensile stress when failure has been done.

5. Procedure for Barcol hardness testing

In this test, Barcol hardness meter is used to measure the hardness of plate. It kept on the plate then pointer was moved and took a reading in terms of BHU. It kept on the plate at different location and took five reading of the hardness.

III: RESULTS AND DISCUSSIONS

These are results developed from the experiment:

Fig.1 shows that initially, tensile stress increases and then decreases. Here, we got the best result at 20% of red mud. After that the load was not transferred from fiber to resin. Therefore, we got less result compare to 20% of red mud. The value of tensile stress is shown in Table A.

Fig.2 shows that the tensile strain is decreases initially. After that increases and then decreases. At 20% of mud, it is higher. But the value of tensile strain is higher at 30 &40% of red mud compare to 0&10 % of red mud respectively. The value of tensile strain is shown in Table A.

Table A Tensile Properties

Sr. No	Material composition	Tensile stress (Mpa)	Tensile strain	Tensile modulus
1	Resin:60%	19.52	0.244	79.988
	Coir Fiber:40%			
	RedMud:0%			
2	Resin:60%	19.44	0.32	60.756
	Coir Fiber:30%			
	Red Mud:10%			
3	Resin:60%	19.93	0.41	48.5
	Coir Fiber:20%			
	Red Mud:20%			
4	Resin:60%	12.12	0.278	43.505
	Coir Fiber:10%			
	Red Mud:30%			
5	Resin:60%	12.5	0.339	36.856
	Coir Fiber:0%			
	Red Mud:40%			

Tensile modulus is directly related the stiffness. If tensile modulus increases, then stiffness increases and tensile modulus decrease, stiffness is also decreases .Here; we got a optimum result of tensile modulus at 20% of red mud. It is shown in fig.3.The value of tensile modulus is shown in Table A. When % of coir fiber increases, the flexural modulus is also increases. It is directly proportional to the flexural stress. Therefore, flexural stress is also increases. By adding the red mud, the flexural stress will be down due to properties of the red mud. It is shown in fig.4.The value of flexural stress is shown in Table B.

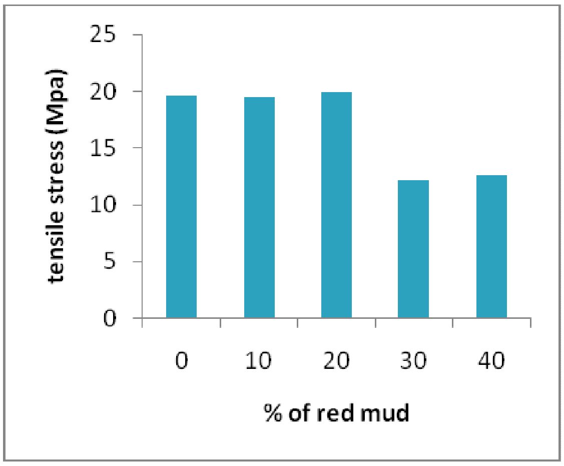

Fig.1

Table B Flexural Properties

Sr. No	Material composition	Flexural stress (Mpa)	Flexural strain	Flexural modulus
1	Resin:60%	25.4	0.0122	2082
	Coir Fiber:40%			
	RedMud:0%			
2	Resin:60%	25.84	0.0162	1595
	CoirFiber:30%			
	Red Mud:10%			
3	Resin:60%	19.87	0.0225	882.09
	Coir Fiber:20%			
	Red Mud:20%			
4	Resin:60%	7.94	0.0192	412.915
	Coir Fiber:10%			
	Red Mud:30%			
5	Resin:60%	16.39	0.0317	517.8
	Coir Fiber:0%			
	Red Mud:40%			

Fig.5 gives best flexural strain at 20% of red mud.It initially increases and then decreases. Also linearity was not satisfied due to the red mud contents. Table B represents the value of flexural strain.

When % of fiber contents increases, the flexural modulus also increases. But %of red mud increases, the flexural modulus is decreases. It is shown in fig.6 and value of flexural modulus is shown in Table B.

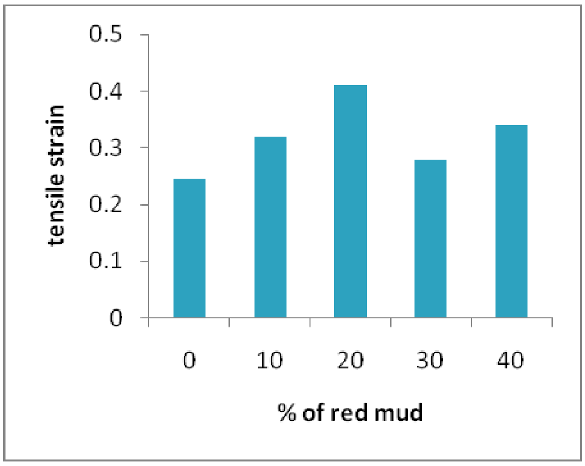

Fig.2

Table C Barcol Hardness and Density

Sr. No	Material composition	Barcol Hardness	Density
1	Resin:60%	32	1.1578
	Coir Fiber:40%		
	Red Mud:0%		
2	Resin:60%	39	1.08
	Coir Fiber:30%		
	Red Mud:10%		
3	Resin:60%	45.6	1.2015
	Coir Fiber:20%		
	Red Mud:20%		
4	Resin:60%	37.4	1.3709
	Coir Fiber:10%		
	Red Mud:30%		
5	Resin:60%	32	1.3531
	Coir Fiber:0%		
	Red Mud:40%		

If % of red mud contents increases, the barcol hardness also increases. Here got best result at 20% of red mud. After 20% of red mud, debonding can occur. Therefore, barcol hardness decreases due to increases the % of red mud. It is shown in fig.7.The value of barcol hardness is represented in Table C.

Density is directly related to the mass of the plate. If mass of the plate is increases, density increases. Therefore, % of red mud increases, density increases. It is shown in fig.8.The value of density represented in Table C.

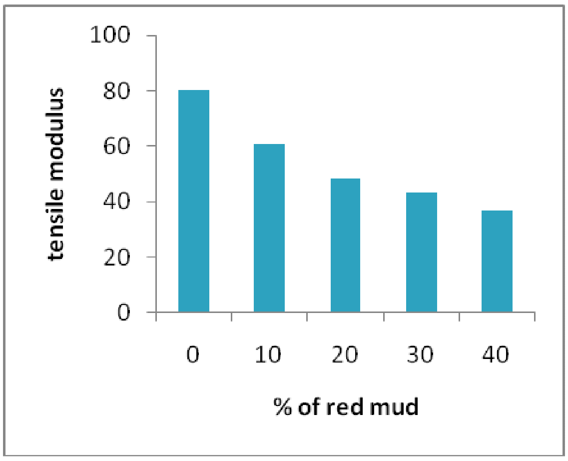

Fig.3

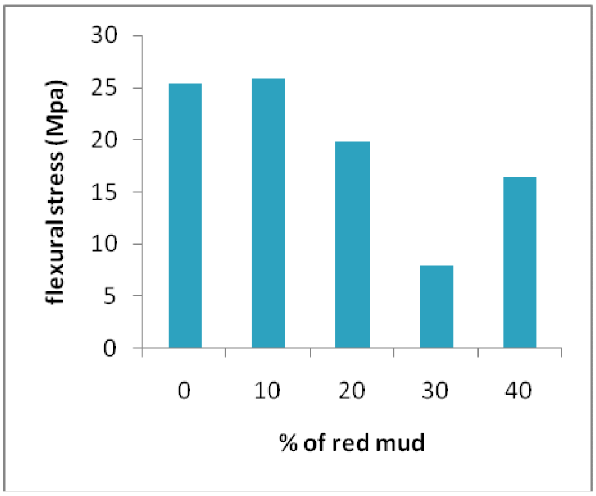

Fig.4

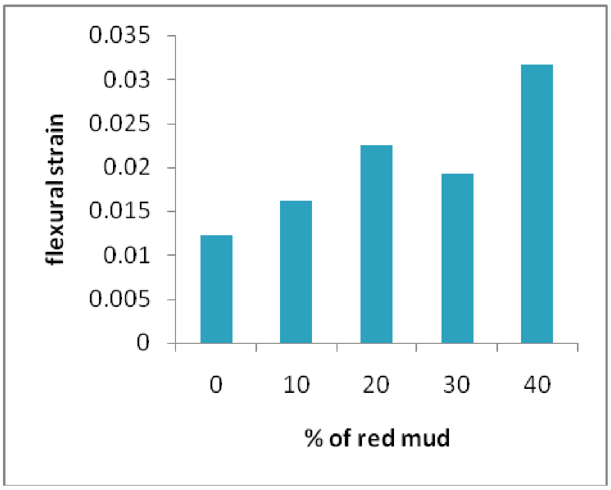

Fig.5

IV: CONCLUSION

This experiment investigation of red mud filled coir-polyester polymer composites leads to following conclusions:

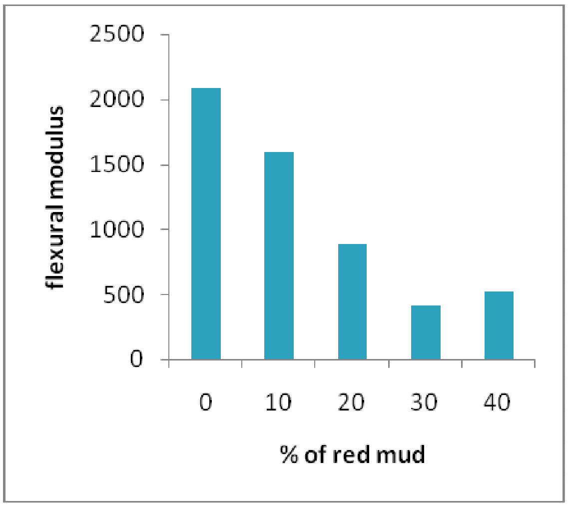

Fig.6

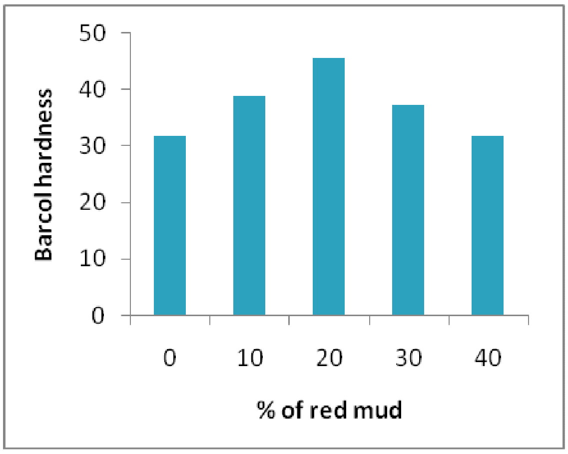

Fig.7

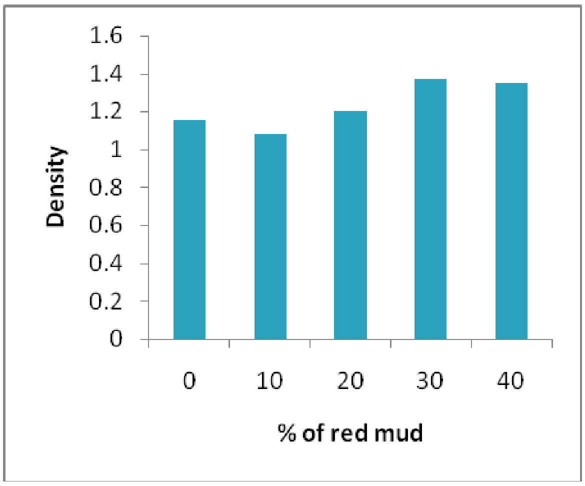

Fig.8

The tensile strength of the coir-polyester composites almost remains constant by adding the red mud initially and then decreases. Here, we will get best tensile strength at 20% of red mud. Adding more red mud leads to decrement in tensile strength as load cannot be transferred from fiber to resin effectively. The flexural strength of the coir-polyester composites increases by adding the % of the red mud upto a certain limit and then decreases.. Barcol hardness of the coir-polyester composites increases by adding the % of the red mud because metal particles are presents in the red mud and we will get the optimum hardness at 20% of the red mud. And density also increases by increasing the % of red mud content because metal contents are presents in the red mud and it is heavy in nature. By utilizing the red mud waste, we can improve the mechanical properties of coir polyester polymer composites.

REFERENCES

[1] R.K. Misra and N.V. Rachchh," *Mechanical Performance of Coir Fibre Reinforced Polyester Composite*", International Journal of Advanced Materials Science Volume 1, Number 1 (2011), pp. 19–28.

[2] M. Saxena, R.K.Morchhale, P.Asokan and B. K. Prasad, "*Plant Fiber – Industrial Waste Reinforced Polymer Composites as a Potential Wood Substitute Material*", Journal of composite Materials, Vol. 42, pp 367-384, 2008.

[3] Sandhyarani Biswas, Alok Satapathy, "*Tribo-Performance analysis of red mud filled glass epoxy composites using Taguchi experimental design*", Material And Design, vol.30, pp 2841-2853, 2009.

[4] B.Singh, Manorama Gupta, Anchal Verma, "*Mechanical Behaviour of particulate hybrid composite laminates as potential building materials*", Construction and Building Materials, Vol.9, pp. 39-44, 1995.

[5] Hemalata Jena, Alok Ku. Satapathy," *Fabrication, Mechanical Characterization and Wear Response of Hybrid Composites Filled with Red Mud: an Alumina Plant Waste*", Proc. of Int. Conf. on Advances in Mechanical Engineering 2011.

[6]V.Arumuga Prabu, S.Kalirasu, M.Utha Yakumar and V.Manikandan," *Processing and Characterization of Red mud Filled Sisal Fibre Reinforced Polymer Composite*", IEEE International Conference On Advances In Engineering, Science And Management (ICAESM -2012) March 30, 31, 2012. 136

[7] Amiya Kumar Dash, D.N.Thatoi and M.K.Sarangi,"*Analysis of the mechanical characteristics of red mud filled hybridized composite*", Frontiers in Automobile and Mechanical Engineering, pp: 8-11, 2010.