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Effect of Rice Husk Filler on Hardness and Impact Strength of Basalt Fiber Epoxy Polymer Composite

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Abstract. Natural fiber composite (NFCs) are gaining importance in various fields of engineering due to their eco-friendly nature and low cost. The aim of this present work was to evaluate the influence of basalt fiber and variation of rice husk powder (10%, 15%, and 20%) on the impact strength and hardness of basalt fiber epoxy polymer composites. By using the compression molding method the compositions were prepared by varying the proportion of rice husk powder. Filler was used to modify the epoxy composite: basalt fiber (BF), epoxy composite, and Rice Husk Particle (RHP). After the materials are subjected to hardness by Rockwell hardness method and impact strength by Charpy method. The results of the conducted research confirm that the addition of a rice husk particle to the basalt fiber reinforced with epoxy polymer composites is an effective method of improving their hardness and impact characteristics.

1. Introduction

Since the early dawn of the civilization the stiff, strong and light weight material has always fascinated mankind for typical applications. A composite material is a combination of two or more materials with different physical and chemical properties. When they are combined to create a material which is specialized to do a certain job for instance to become stronger, lighter or resistance to electricity.Among various types of composites materials available, metal matrix composites plays a vital role in terms of high strength or stiffness, low density, good corrosion as well as fatigue resistance. The purpose of the literature review is to know information about the mechanical properties of basalt fiber reinforced with epoxy composites and to study the advantages of natural fiber such as low density, low cost, environmental friendly, biodegradable and high specific mechanical performance. Arun premnath (2018) studied the mechanical properties such as tensile strength, impact strength, flexural strength and hardness for natural fiber/epoxy resin composites reinforced with sisal and jute. The composites are prepared by hand lay-up method by varying the proportion of jute fiber. One set of fiber surface is treated with NAOH solution and the impact of that particular fiber of mechanical strength was studied. Finally, from the result, it was observed that the tensile strength, flexural strength, impact strength, and hardness are increased by 20%, 25%, 27.7%, and 5% respectively.Fractured specimens were observed by scanning electron microscope. The results also indicatethat a surface-treated composite performs better, when comparing the untreated fiber composites. [01]Abdelhaleem et al (2020) examined on the tensile, flexural and impact properties of flax-basalt-glass reinforced epoxy hybrid composites. The specimens were fabricated under the process of vacuum bagging process. The author investigated the effect of reinforcement hybridization, fiber relative amount and stacking sequence of the mechanical properties. By using scanning electron microscope the morphological studies of the fabricated and fracture specimens were performed. At last the results shows that the developed hybrid composites display enhanced tensile, flexural and impact performance as compared with flax reinforced epoxy composite. The mechanical properties of hybrid laminates are proven to be highly dependent on the position of the flax layers within the hybrid composites. [02] Shandilya and Srivastava (2015) investigated the tensile, flexural and impact properties of epoxy and randomly oriented short jute fiber reinforced epoxy composite. The composite was prepared using Hand lay-up method with 30 wt. % of jute fiber in the various lengths of 5, 10, 15 and 20 mm into epoxy matrix. The results show that the tensile and flexural properties were found maximum for the composite with 15 mm length of fiber whereas the impact properties were found maximum for the composite with 20 mm length of fiber. [03]Aruna Saini et al (2019) investigated about the jute fiber and basalt fiber mats reinforced with epoxy hybrid composite material prepared by using hand lay-up technique. As per the ASTM standard the influence of the stacking sequenced on physico-mechanical properties ofhybrid composite material was experimentally studied. In general the moisture content of hybrid composite was slightly higher when compared to the simple composites (six layer of jute). Compared to the simple composite, the tensile strength of the hybrid composite was enhanced by 20%. It was observed that the hybrid composites show high strain (4.5%) and large extension (13.5 mm) in the flexural test as compared to that of simple composite. [04]Rajmohan et al (2017) examined the fabrication and Characterization of Multi-Walled Carbon Nano Tubes (MWCNT) filled hybrid natural fiber Composites. By using a single matrix, hybrid composites are fabricated by the combination of two or more fibers. In a hybrid composite the sequence of stacking fiber can be altered resulting in a varying mechanical properties. MWCNT filled banana-jute-flax fiber reinforced composites are tested for its mechanical behavior by varying the stacking sequence of the fiber layers and weight % of Multi-Walled Carbon Nano Tube. Resin was prepared by adding MWCNT in the epoxy resin using ultrasonic probe sonicator and a hybrid composite is fabricated with it by using compression molding processes. As per the ASTM standards the mechanical properties are evaluated. The incorporating of MWCNT and the stacking sequence of fiber layers shows the greater impact on the mechanical properties. By using Scanning Electron Microscope with energy dispersive x-raythe microstructure of the samples are investigated. The results indicate that increasing the weight % of MWCNT and varying the stacking sequence of fiber improves the mechanical properties of hybrid natural fiber composites. [05]Gupta et al (2015) studied the synthetic fibers are replaced by natural fibers for polymer composite due to their several benefits such as low density, environmental friendly, low cost and high specific mechanical performance. This work deals with the tensile, flexural and impact properties of the randomly oriented short sisal reinforced epoxy composite. The composites were prepared by hand lay-up method with various fiber length (5, 10, 15 and 20 mm) but constant 30 weight percent of sisal fiber content. The result offered that tensile strength was not increased by reinforcing sisal but flexural strength was improved 25% by 15 mm sisal fiber and large improvement was observed in impact properties by 20 mm sisal fiber. [06] Potter et al (2011) investigated the experimental fabrication and characterization of out-of-plane fiber waviness in continuous fiber-reinforced composites. The development of fabrication techniques and experimental measurements of out-of-plane fiber waviness in a continuous fiber-reinforced polymer composite. Three fabrication methods were developed such as transverse-strip method, ply-drop method, and constant-thickness ply-drop method. Experimental characterization demonstrated that specimens with a range of waviness parameters can be easily manufactured. The most important features of the techniques are no difficulty of fabrication and simplicity of experimental setup. An industrial part was characterized optically to validate the techniques. [07] Mehmatbulut et al (2015) investigates the tensile and damping behavior of Kevlar/glass/epoxy hybrid laminates. Hybrid kevlar/glass with epoxy resin composites is fabricated considering different fiber volume fractions to show the influence of hybridization. Mechanical properties were studied by an instrumented tensile test machine. Vibration tests were conducted to determine dynamic characteristics of the samples. Damping properties are calculated from logarithmic decrement method by using vibration response envelope curve. In addition to that the effects of fiber angle on natural frequencies were tested using ANSYS. At last the results show that the hybridization of relatively brittle material S-glass fibers with tough and high performance Kevlar fibers has showed to be highly effective in improving damping capacity of S-glass fiber composite laminates. [08] Z.Sucharda et al (2009) discussed the mechanical Properties of basalt fiber reinforced composite prepared by partial pyrolysis of a polymer precursor. The flexural strength of the unidirectional composites ranges from 620 to 820 Mpa or from 405 to 510 Mpa for composites pyrolyzed to 650 or 750°C, respectively. The Young's modulus and tensile modulus from the resonant frequencies range from 50 to 80 Gpa, shear modulus from 10 to 22 Gpa. The shear modulus values increase after pyrolysis to 750°C, which expresses the increasing integrity and stiffness of the material. At last after the exposition to hot air (at 650 or 750°C) the strength fell further and the failure mode became brittle. [09]Yang zhiming et al (2017) investigated on mechanical properties and failure mechanisms of basalt fiber reinforced aluminum matrix composites under different loading conditions. The composites are prepared by hot press sintering with different fiber content. Microstructure analysis indicates that basalt fibers are uniformly distributed in 10% basalt fiber reinforced aluminum matrix composite. There is no interface reaction between basalt fiber and aluminum matrix and the interfacial bonding between basalt fiber and aluminum matrix is good. Quasi-static tensile, quasi-static compression and dynamic compression properties of basalt fiber reinforced aluminum composites were studied, and the influences of basalt fiber content on mechanical properties also discussed. Meanwhile, the failure mechanisms of basalt fiber reinforced aluminum matrix composites with different fiber content were analyzed. [10]**A.V** Soukhanav et al (2009) explained the modern basalt fibrous material and basalt fiber based polymeric composites. The data presented characterize modern continuous basalt rovings as a novel type of silicate fiber having improved acid and alkali resistance, the strength level close to the well-known E-fibers, and improved elasticity modulus typical of high-modulus and high-strength magnesium aluminosilicate S-fibers. Mechanical properties of epoxy basalt plastics are similar to the properties of S-glass fiber-reinforced plastics and greater than those of E-glass fiber-reinforced plastics. The alkali resistance and heat/humidity resistance of epoxy basaltoplastics are much greater than those of epoxy composites derived from E- and S-glass fibers, which is associated with the specificity of adhesive properties .[11**]**Zhinsenwu etal (2018) investigated the tensile strength, melting properties, and fiber-forming properties of natural continuous basalt fibers, such as andesite, andesite basalt, and tholeiitic basalt, are studied as a function of their chemical and mineral compositions. The results were indicates that when the basalt glass melts are homogeneous, the tensile strength is mainly determined by the chemical composition as well as the mineral components, which will affect the melting properties and fiber-forming properties. By optimizing the melting properties and fiber-forming properties, a high filament tensile strength of 3390Mrpa was achieved for the basalt andesite with region of tholeiitic basalt with SiO_2 weight percentage of 49% to 57%.[12]Naveen krishna et al (2021) explained the tensile, flexural and impact properties of hybrid sun hemp-flax fiber based thermosetting composites. It has been used in a lot of real-life applications. In this paper, sun-hemp and flax natural fibers were selected for making the new hybrid natural composite material. The mechanical properties of hybrid composites were studied by experimental approach. The hybrid composite plates were made with the blending of sun-hemp and flax fibers using polyester resin as a matrix material. The sun-hemp-flax reinforced polyester composite plates were made by various fiber lengths such as 15 mm, 30 mm, and 50 mm respectively. Similarly, composite plates were made with different orientations angles like 0°, 45°, and 90° respectively. The mechanical test has been conducted for different orientations such as unidirectional, biaxial, triaxial, and random. It was found that the triaxial-oriented fiber exhibited better results in tensile strength, flexural strength and impact strength are (86.3 MPa), (117.1 MPa), and(153.8 kJ/m^2) respectively.[14]Tumadhiret al(2019)explained the thermal and mechanical properties of basalt fiber reinforced concrete. The volume of basalt fiber of (0.1, 0.2, 0.3, and 0.5% by total mix volume) was used. Properties such as heat transfer, compressive and splitting tensile strengths were tested. Results indicated that the strength increases with increase the fiber content till 0.3%. Then there is a slight reduction when 0.5% fiber used. Heat conducted through the thickness of concrete specimens is lesser in amount than the conventional concrete was recorded. [15]

From the literature it is found that, many research works was done on basalt fiber composite material alone. But, the influence of rice husk particles on mechanical properties was explored in the present study.

TABLE 1. Various Mechanical Properties from the Literature

COMPOSITION	TREATMENT	FILLERS	RESIN	PROCESS	YEAR
Basalt fiber	_	Rice husk powder	Epoxy	Compression molding.	Present work
Basalt fiber skin /pine	_	Agro waste	PALF/Epoxy	Hand layup	2021
apple leaf fiber					
Basalt and aramid	_	_	Ultra high molecular	Hot compression	2021
Weight poly ethylene				molding	
Flax-basalt-glass fiber	_	_	Epoxy	Vacuum bagging	2020
Jute-kelvar hybrid	treated with	Nano filler (fumed silica)	Epoxy	Hand layup	2020
	Alkali				
Jute and glass	_	Aluminium	Epoxy	Hand layup	2020
Jute and basalt fiber	_	_	Epoxy	Hand layup	2019
Sisal and jute	treated with	_	Epoxy	Hand layup	2018
	NAOH solution				
Basalt fiber	_	Aluminium	_	Hot press sintering	2017
Jute fiber	_	_	Epoxy	Hand layup	2015
Jute and glass	_	_	Epoxy	Hand layup	2015

2. Experimental Procedure

Materials: In the present study, epoxy is used as a matrix material was procured from the Roto polymers and chemical, India. Various proportion of rice husk powder and basalt fiber is used as the reinforcement. Fabrication of composites: The composites are prepared by compression molding method as shown in fig 1. The steps used for the composites preparation are given below. The first step is to spray the release gel to prevent the sticking of fiber. An epoxy polymer in liquid form is mixed thoroughly in the required weight percentage of RHP and poured onto the surface of basalt fiber. A roller is used for even the distribution of the epoxy polymer. Then the basalt fiber laminate is placed and the process is repeated again and again till it reaches the required layer of composite. The composition of fabricated material is shown in Table 3. Lastly, the composite specimen was pressed using a hydraulic press to ensure that the epoxy polymer has penetrated the porosity of the mat at room temperature. Thus, the three different composite specimens are made using this process. The fabricated specimens are kept at curing temperature for 24-48 hrs for strengthening of matrix and reinforcement.

FIGURE 1. Compression molding machine

TABLE 2. composition of composite

SPECIMENS	EPOXY%	BASALT FIBER%	RICEHUSK POWDER%
A	60%	30%	10%
B	55%	30%	15%
C	60%	30%	20%

FIGURE 2. A Rockwell Hardness Tester

Mechanical properties: Hardness: Rockwell hardness tester is used to measure the depth of penetration and hardness of the specimen as shown in Fig 3. The test was carried out on the specimen as per ASTM 111 standard. The specimen for hardness test is given in Fig 4. Rockwell D-scale is used for the depth of penetration of an indenter under a load of 100 kgf and the values are tabulated. Hardness test were performed at room temperature. The hardness was measured at four different places and the average values are tabulated.The result obtained from the hardness test by Rockwell testing machine is shown in Table 4.1.

TABLE 3. Hardness value obtained from Rockwell test

S.NO	A	B	C
1	50	52	75
2	38	65	40
3	44	40	46
4	38	35	48

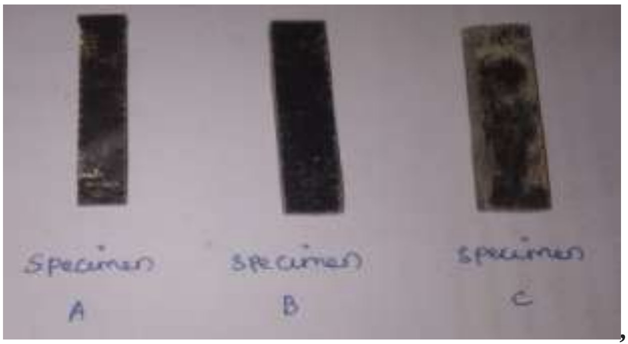

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FIGURE 3. Hardness test specimen; **FIGURE 4.** Impact Testing Machine

Impact test: Impact test was carried out using impact testing machine by Charpy method as shown in Fig 5. Table 4.2 indicates the values for impact strength as shown in below. The test was carried out on the specimen as per ASTM.It is conducted based on the loss of energy due to friction. Mainly the testing is used to measure the impact energy need to break the specimen which is recorded.

TABLE 4. Tabulation for charpy test

S.NO	A	B	C
1	10J	15.5J	21.2J
2	10J	15.5J	21.2J

3. Result and Discussion

Hardness: Table-4.1 shows the hardness value obtained from the Rockwell hardness tester with increases in the RHP. From the table it is found that the hardness value increases from 43.75 to 52.25 as the RHP increases from 10 to 20% in weight fraction as shown in Fig 6. From the result it seen that, the increase in RHP increases the strengthening mechanism of the fabricated composite by proper diffusion of RHP with epoxy polymer and basalt fiber. From the result obtained, it is seen that the rice husk particle (RHP) plays a vital positively increasing the hardness of composite.

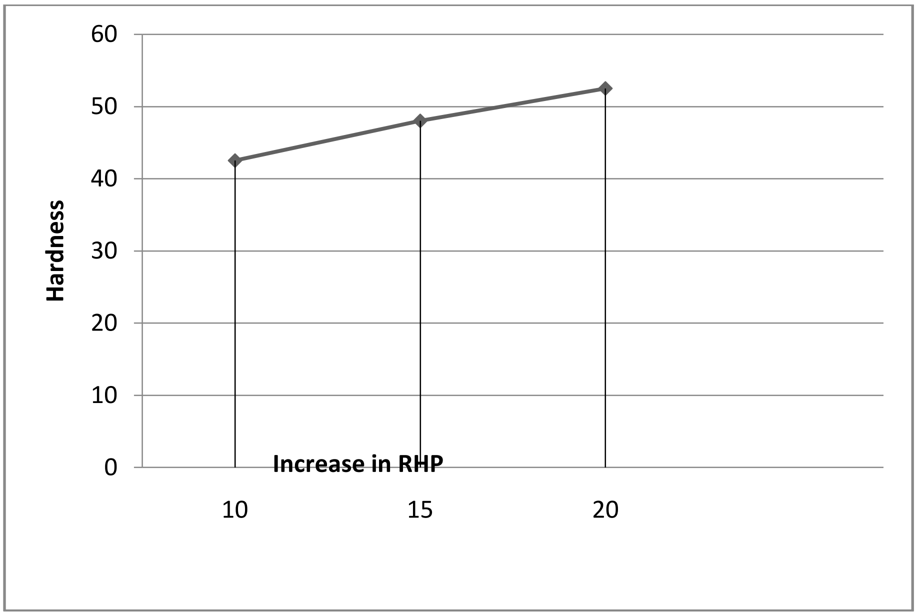

FIGURE 5. Hardness of the Composite Specimen With Standard Deviation

FIGURE 6. Impact test specimen

Impact strength: The impact test was performed to study the impact characteristics of the composite. The values obtained from the impact test as shown in the Table-4.2.After the impact test the specimens are damaged as shown in Fig 7. From the table it is inferred that as the RHP increase from 10 to 15% then, the impact strength of fabricated composite is increased by 55% and as the particle RHP increase further from 15 to 20% then, the impact strength of fabricated composites is increased by 26% as shown in Fig 8. The increase in the RHP increases the impact strength of fabricated composite.

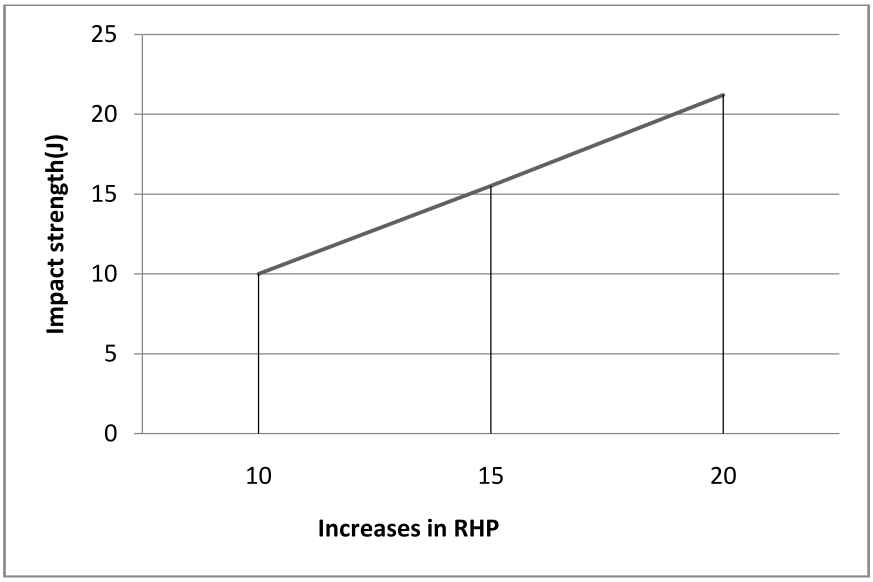

FIGURE 7. Impact strength of the composite specimen with standard deviation.

4. Conclusion

The mechanical properties of the rice husk powder and basalt fiber reinforced with epoxy polymer composites have been studied in this researchpaper.The result obtained from the experimentation as shown in below: The composite specimens are successfully fabricated by compression molding method. As the rice husk particle increases from 10 to 15% then, the hardness of fabricated composite is increased by 9% and further it increase of RHP from 15 to 20% then, the hardness of fabricated composite is increased by 16%. In the case of Impact strength, the values increase from 10 to 2.2 J as the RHP increases from 10 to 20% in weight fraction. So that the impact strength is increased by 26%. From the result it seen that the increase in RHP increases the strengthening mechanism of the fabricated composite by proper diffusion of RHP with epoxy polymer and basalt fiber. It is observed from the study, the RHP plays a vital role in increasing the mechanical properties of the fabricated composite materials which could be used as an alternative material in automotive application.

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