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Synthesis and Analysis of Reinforcements of Basalt Fiber, Palm Fiber and Sea Shell Powder

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ABSTRACT: The demand for eco-friendly and sustainable materials in various industries has led to extensive research into natural fiber-reinforced composites. In this study, investigation of the mechanical properties of epoxy composites reinforced with basalt fiber, palm fiber, and sea shell powder is done. Basalt fiber offers high tensile strength while palm fiber provides flexibility and biodegradability. The composites were fabricated using a hand lay-up technique, with varying weight percentages of each reinforcing material. The incorporation of basalt fiber, palm fiber, and sea shell powder offers a promising approach to develop sustainable and high-performance epoxy composites with potential applications.

Testing including tensile, flexural, hardness, and impact tests were conducted to evaluate the composite's performance and also ANOVA one way analysis is performed. The composite exhibited enhanced tensile and flexural strength, as well as improved impact resistance compared to neat epoxy and also the ranking of the composites is given by using Topsis method.

I. INTRODUCTION

Natural fiber composites (NFCs) are bio based composites with a natural fiber reinforcement and matrix. Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is obvious, especially for composites, that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals

Natural fibres can be classified according to their origin. The vegetable, or cellulose-base, class includes such important fibres as cotton, flax, and jute. The animal, or protein-base, fibres include wool, mohair, and silk. An important fibre in the mineral class is asbestos. The vegetable fibres can be divided into smaller groups based on their origin within the plant. Cotton, kapok, and coir are examples of fibres originating as hairs borne on the seeds or inner walls of the fruit, where each fibre consists of a single, long, narrow cell. Flax, hemp, jute, and ramie are bast fibres, occurring in the inner bast tissue of certain plant stems and made up of overlapping cells. Abaca, henequen, and sisal are fibres occurring as part of the fibro vascular system of the leaves. Chemically, all vegetable fibres consist mainly of cellulose, although they also contain varying amounts of such substances as hemicelluloses, lignin, pectin's, and waxes that must be removed or reduced by processing. The animal fibres consist exclusively of proteins and, with the exception of silk, constitute the fur or hair that serves as the protective epidermal covering of animals. Silk filaments are extruded by the larvae of moths and are used to spin their cocoons. With the exception of mineral fibres, all natural fibres have an affinity for water in both liquid and vapour form. This strong affinity produces swelling of the fibres connected with the uptake of water, which facilitates dyeing in watery solutions. Unlike most synthetic fibres, all natural fibres are non-

thermoplastic; that is, they do not soften when heat is applied. At temperatures below the point at which they will decompose, they show little sensitivity to dry heat, and there is no shrinkage or high extensibility upon heating, nor do they become brittle if cooled to below freezing. Natural fibres tend to yellow upon exposure to sunlight and moisture, and extended exposure results in loss of strength. All natural fibres are particularly susceptible to microbial decomposition, including mildew and rot. Cellulosic fibres are decomposed by aerobic bacteria (those that live only in oxygen) and fungi. Cellulose mildews and decomposes rapidly at high humidity and high temperatures, especially in the absence of light. Wool and silk are also subject to microbial decomposition by bacteria and moulds. Animal fibres are also subject to damage by moths and carpet beetles. Termites and silverfish attack cellulose fibres. Protection against both microbial damage and insect attacks can be obtained by chemical modification of the fibre substrate; modern developments allow treatment of natural fibres to make them essentially immune to such damage.

II. LITERATURE REVIEW

“A Short Review on Basalt Fiber” Kunal Singha

A hard, dense, inert rock found worldwide, basalt is an igneous rock, which is solidified volcanic lava. Cast basalt liners for steel tubing shows very high abrasion resistance in various industrial applications. In recent years, continuous basalt fibers extruded from naturally fire-resistant basalt are attracting attention as a replacement for asbestos fibers. In the last decade, basalt has emerged as a contender in the fiber reinforcement of composites. Some manufacturer of basalt claims it offers performance similar to S-2 glass fibers at a price point between S-2 glass and E-glass, and may offer manufacturers a less-expensive alternative to carbon fiber. Basalt fibre (BF) is capable to withstand very high temperature and can act as fire blocking element.

“STUDIES ON MECHANICAL BEHAVIOUR OF BASALT FIBER COMPOSITE” B.Vijaya Ramnath , C. Elanchezian, J. Aravind, L. Sushil, A. Arun Kumar

Natural fiber reinforced composites is an emerging area in polymer science. These natural fibers are low cost fibers with low density and high specific properties. In this paper, hybrid composite is fabricated with basalt fibre as a major constituents and glass fibre reinforced polymer as are in forcing agent. The method used for manufacturing the composite is hand lay method in which all the operations are done manually at room temperature. The objective of this investigation was to study the effect of surface modifications and also the mechanical properties, including shear and impact strengths of composite fibre. Variations in mechanical properties such as the impact strength of various specimens were calculated using a computer assisted universal testing machine and an Izod Impact testing machine.

“BASALT FIBER AS A REINFORCEMENT OF POLYMER COMPOSITES” Tibor CZIGÁNY, János VAD and Kornél PÖLÖSKEI

The applicability of basalt fibers as reinforcing materials has been examined in a polypropylene (PP) matrix. The brittle basalt fibers have been mixed with the PP fibers by carding combined with needle punching and the composite sheets have been produced by pressing. SEN-T fracture mechanical specimens have been cut out of the sheets and the sensitivity to crack propagation has been examined in the composites. It has been proven that fracture toughness increases as a result of reinforcing. The toughness of the composite increased compared to the matrix due to the gravels appeared at the end of basalt fibers. It has been pointed out that the gravels are results of the Junkers production technology. The observations have also been proven by electron microscopic images. A model has been outlined for investigation of influence of change of technological parameters on basalt fiber production.

“Mechanical Properties of Epoxidized Palm Oil / Epoxy Resin Blend” Zyad Salem Alsagayara , Abdul Razak Rahmath, Agus Arsadc , Alireza Fakhari d and Wan Nurhayati Binti Wan Tajulruddin,e

In this paper, a blend of epoxy resin and epoxidized palm oil (EPO) was prepared to investigate its mechanical properties. Epoxy and EPO were mixed for 20 minutes at room temperature before mixed with hardener and followed by curing for 2 hours at 100 oC. Tensile, flexural and impact tests were conducted to characterize the blend. In general, the tensile and flexural properties of epoxy resin/EPO decreased when the amount of EPO increased. However, strain at break, toughness and impact strength was slightly increased when the amount of EPO was increased up to 20%. The mechanical properties were reduced due to the reduction of the cross linking density and effect of plasticizer.

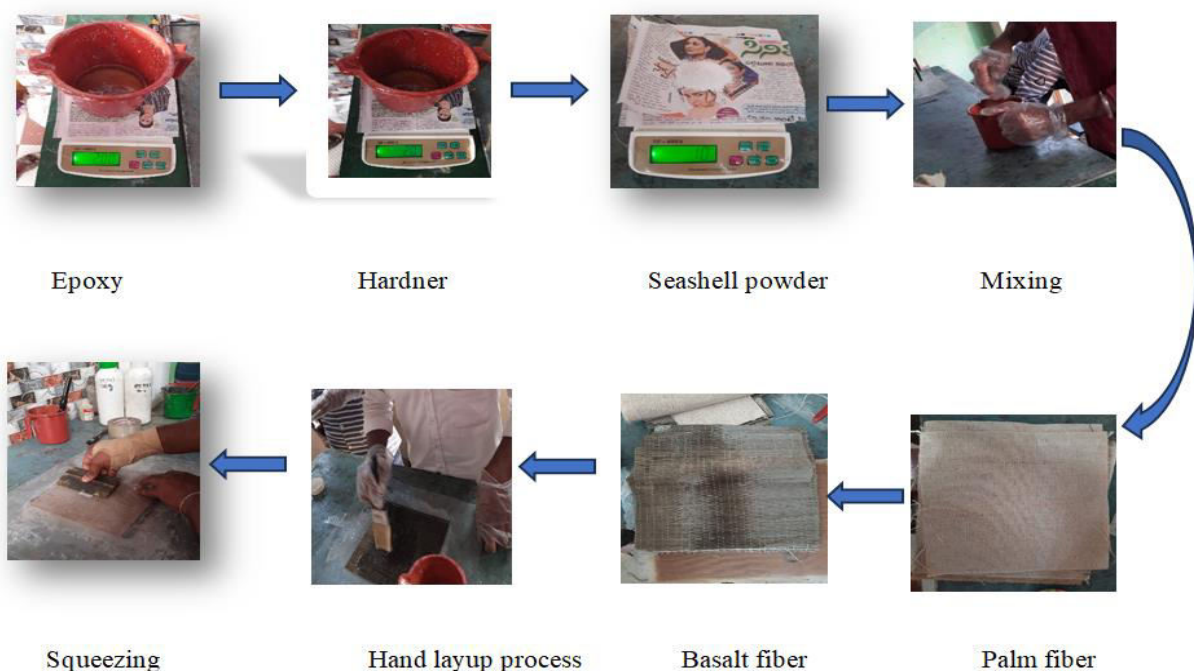
“Incorporation of Palm Fiber to Enhance the Mechanical Properties of Epoxy” Samah M. Hussein

In the recent years, the work in composite industry needed new ecofriendly resources to improve the original properties of current materials. Many researches attempted to find alternative additives to be used with the current systems which provide a new material that is environmentally friendly and has better performance than the synthetic counterparts. This paper presents the study of mechanical characteristics, including bending, impact, tensile and hardness tests, of date palm fiber (DPF)/ epoxy composite. The composite plate was constructed by hand-layup technique. The filler content values (wt %) were 5%, 10%, 15% and 20%. Young's modulus, impact strength and hardness were shown to be increased with increasing fiber content. Tensile strength was increased only by using 5% and 10%, where as it was decreased by increasing fiber content.

III. METHODS

wet hand lay up technique

Hand lay-up technique is the simplest method of composite processing. The Infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after Perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed. The time of curing depends on type of polymer used for composite processing. For example, for epoxy based System, normal curing time at room temperature is 24-48 hours. This method is mainly suitable for thermosetting polymer based composites. Capital and infrastructural requirements less as compared to other methods. Production rate is less and high volume fraction of reinforcement is difficult to achieve in the processed composites. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, daises board, and deck.



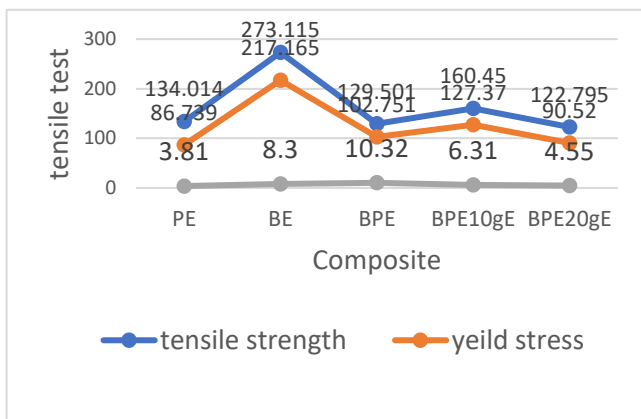
IV. RESULTS AND DISCUSSIONS

4.1.TENSILE TEST

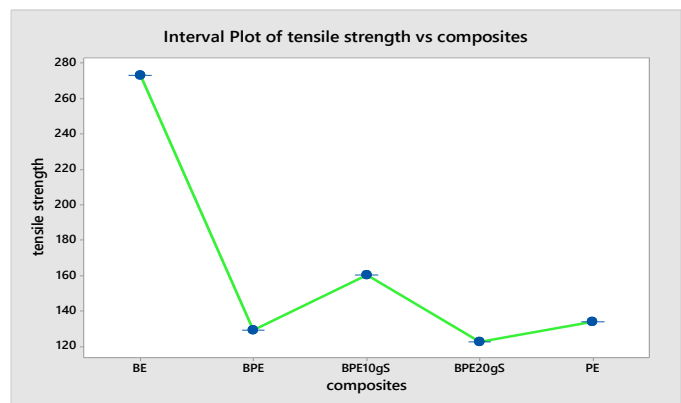
4.1.Tensile test results:

S.No	COMPOSITES	OUTPUT PARAMETERS		
		(tensile) Tensile strength(N/MM ²)	Yield stress(N/MM ²)	% of elongation
1.	Palm +epoxy	134.014	86.739	3.81
2	Basalt +epoxy	273.115	217.165	8.3
3	Basalt +palm +epoxy	129.501	102.751	10.32
4	Basalt+palm+10g sea shell powder +epoxy	160.45	127.37	6.31
5	Basalt+palm+20g sea shell powder +epoxy	122.795	7.208	4.55

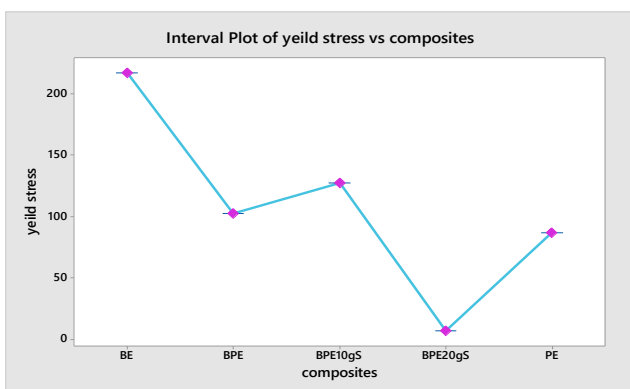
- The tensile strength and yield stress of the composite-2(basalt+ epoxy) is more when compared to remaining composites that is 273.115 N/mm² and 217.165 N/mm².
- The % of elongation of composite-3 (basalt +palm +epoxy) is more when compared to the other composites that is 10.32.



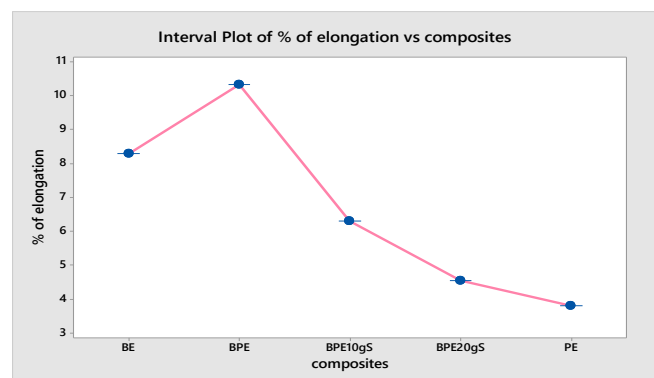
4.1.1 Graphical representation of tensile test results



4.1.2. ANOVA-Tensile strength vs composites



4.1.3 ANOVA - yield stress vs composites



4.1.4. ANOVA- % of elongation vs composites

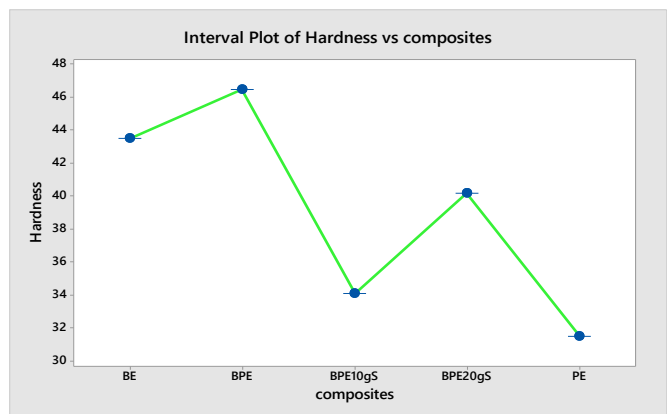
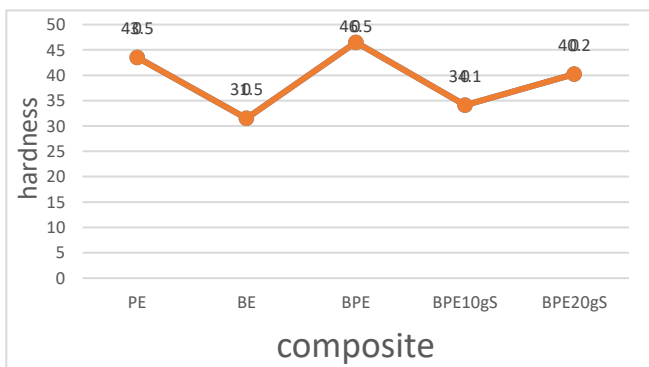
4.2.HARDNESS TEST RESULTS:

4.2.Hardness test results

S.No	composites	Output parameters
		Hardness numbers
1.	Palm +epoxy	31.5
2	Basalt +epoxy	43.5
3	Basalt +palm+ epoxy	46.5
4	Basalt+palm+10g sea shell powder +epoxy	34.1
5	Basalt+palm+20g sea shell powder +epoxy	40.2

- 1) 1/16 ball indenter.
- 2) Load -100kgf.

- The hardness number of composite-2 (basalt +epoxy) is more when compared to the remaining composites that is 43.5



4.2.1 Graphical representation of hardness test

4.2.2 ANOVA- Hardness vs composite

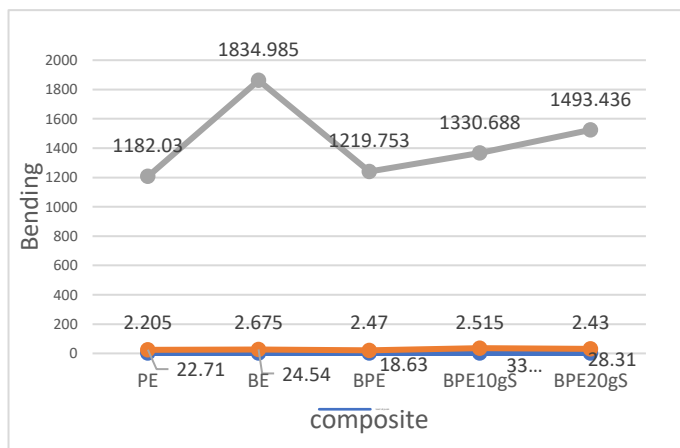
- The combination of basalt fiber and palm fiber with epoxy likely results in synergistic effects, enhancing the mechanical properties and hardness of the composite material compared to basalt fiber and epoxy alone.
- Palm fibers may possess superior mechanical properties such as stiffness and strength compared to basalt fibers alone. When combined with basalt fibers, they could reinforce the epoxy matrix more effectively, leading to higher hardness.
- The orientation and distribution of fibers within the composite can significantly impact its mechanical properties. It's possible that the arrangement of basalt fibers within the epoxy matrix resulted in a higher hardness compared to palm fibers.

4.3.BENDING TEST RESULTS:

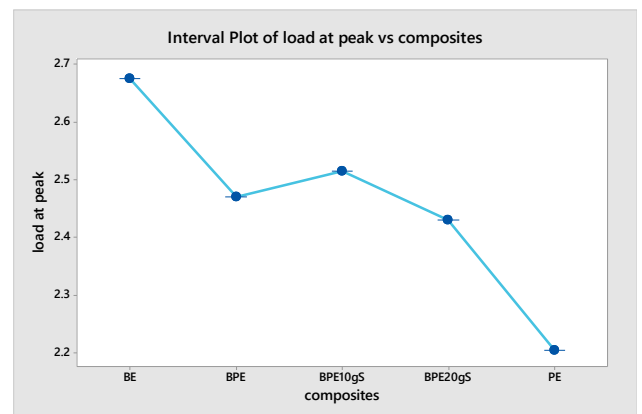
4.3.Bending test results

S.No	composites	OUTPUT PARAMETERS(bending)		
		Load at peak(KN)	C.H transverse at peak(mm)	Transverse strength(N/mm ²)
1.	Palm +epoxy	2.205	22.710	1182.030
2	Basalt + epoxy	2.675	24.540	1834.985
3	Basalt + palm+ epoxy	2.470	18.630	1219.753
4	Basalt+palm+10g sea shell powder +epoxy	2.515	33.410	1330.688
5	Basalt+palm+20g sea shell powder +epoxy	2.430	28.310	1493.436

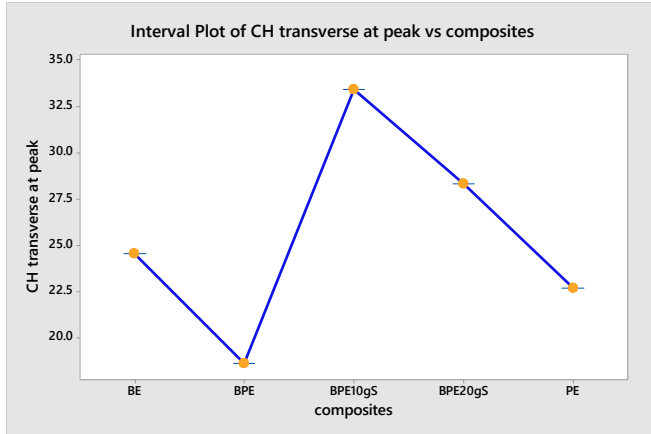
- The transverse strength and load at peak of the composite-2 (basalt+ epoxy) is more when compared to the other composites that is 1834.985 N/mm² and 2.675KN.
- The cross head transverse at peak for composite-4 (basalt+palm+10g sea shell+ epoxy) is more when compared to the remaining composites that is 33.410 mm.



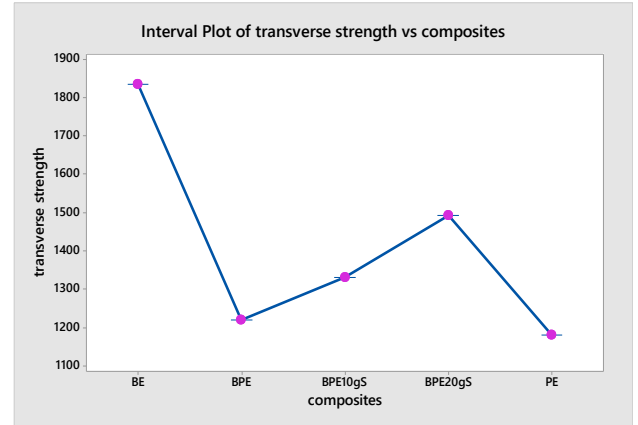
4.3.1. Graphical representation of bending test



4.3.2 ANOVA - Load at peak vs composites



4.3.3 ANOVA- CH transverse at peak vs composites



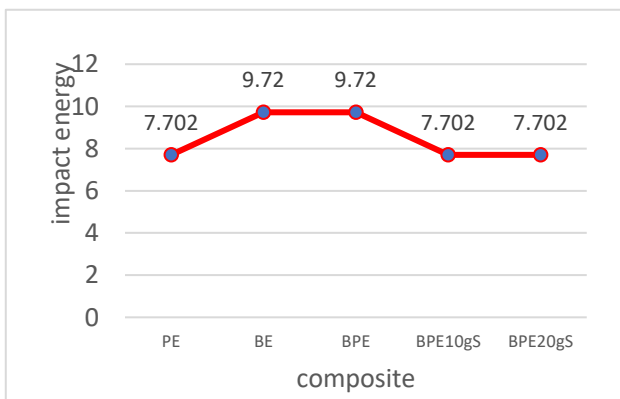
4.3.4 ANOVA -Transverse strength vs composites

4.4. IMPACT TEST RESULTS (CHARPY TEST):

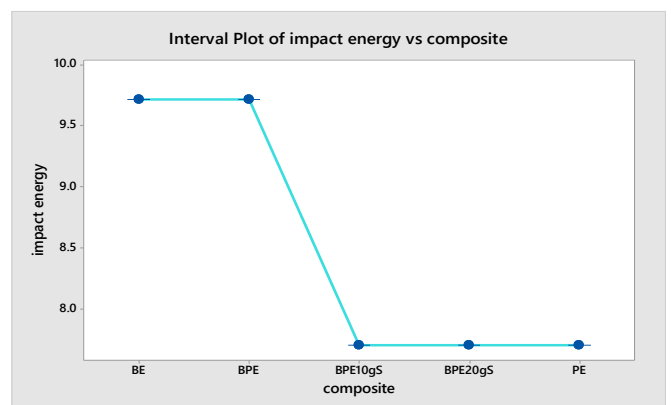
4.4. Impact test results

S NO	Test	Composite	Initial energy	Final angle	Rapture angle	Impact energy
1	Charpy	Palm +Epoxy	300J	8J	137	7.702J
2	Charpy	Basalt +Epoxy	300J	10J	136	9.72J
3	Charpy	Basalt +Palm +Epoxy	300J	9J	136	9.72J
4	Charpy	Basalt +Palm +10g sea shell +Epoxy	300J	7J	137	7.702J
5	Charpy	Basalt +Palm +20g sea shell +Epoxy	300J	8J	137	7.702J

- The impact energy of composite-2 and compsite-3 is more when compared to the remaining composites that is 9.72J.



4.4.1. Graphical representation of impact test



4.4.2. ANOVA- Impact vs composite

- The combination of basalt fibers, palm fibers, and epoxy in a composite material can lead to a balanced mechanical performance, including impact strength, through synergistic effects and optimized fiber-matrix interactions. However, the specific impact resistance will depend on various factors, including fiber composition, orientation, matrix adhesion, and manufacturing.
- The interaction between the fibers and the epoxy matrix is critical for transferring loads and absorbing impact energy. The presence of multiple fiber types may enhance the interfacial bonding with the epoxy matrix, leading to improved impact resistance by preventing delamination and promoting energy dissipation.

4.5. TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS):

4.5.1.DECISION MATRIX:

A decision matrix, also known as a decision-making matrix, is a tool used to compare and evaluate different options based on multiple criteria. It is particularly useful when faced with complex decisions involving several variables or factors.

4.5.1.Decision matrix

composites	Weightage	Tensile strength	% of elongation	Hardness	Transverse strength
1	0.25%	134.014	3.81	31.5	1182.03
2	0.25%	273.115	8.3	43.5	1834.985
3	0.25%	129.501	10.32	46.5	1219.753
4	0.25%	160.45	6.31	34.1	1330.688
5	0.25%	122.795	4.55	40.2	1493.436

4.5.2. NORMALIZED MATRIX:

A normalized decision matrix is a variation of the decision matrix that involves adjusting the scores to make them comparable across different criteria. This is often done by converting the scores for each option within each criterion to a common scale, typically ranging from 0 to 1. Normalization helps to remove biases that may arise from differences in the scales or units used for scoring each criterion.

4.5.2.Normalized matrix

Composite-1	0.345856	0.24076	0.49173	0.369145735
Composite -2	0.70484	0.52449	0.49173	0.573062348
Composite -3	0.334209	0.65214	0.52565	0.380926557
Composite -4	0.41408	0.38974	0.38547	0.415571347
Composite -5	0.316902	0.28752	0.45443	0.46639724

4.5.3. CLOSENESS COEFFICIENT:

4.5.3. Closeness coefficient

composites	Tensile strength	% of elongation	Transverse strength		Si+	Si-	pi	Rank
1	0.086464	0.08902	0.08902	0.0922	0.152	0.007	0.046	5
2	0.17621	0.13112	0.12293	0.1423	0.033	0.135	0.803	1
3	0.17621	0.16303	0.13141	0.09523	0.104	0.111	0.516	2
4	0.10325	0.09968	0.09637	0.1038	0.11	0.048	0.306	3

5	0.079226	0.07188	0.09637	0.1165	0.137	0.037	0.212	4
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V+	0.176221	0.16303	0.13141	0.143255
V-	0.079226	0.06019	0.08902	0.0922864

The ranks are provided to the composites by using Technique For Order Preference By Similarity To Ideal Solution (Topsis). By using topsis method composite-2 got rank-1, composite-3 got rank-2, composite-4 got rank-3, composite-5 got rank-4 and composite-5 got rank-5.

V. CONCLUSION

The preparation of the composites by reinforcing basalt fiber, palm fiber and seashell powder and performing tensile test, hardness, bending test, impact test and ANOVA one way analysis is discussed in the present work. In this regard five composites with different fiber and epoxy compositions are prepared by hand layup process. Based on the experimental results following conclusions are drawn.

In the case of tensile test and bending test the composite-2 got the more significant parameters and in the case of hardness test the composite-3 got more significant parameters. Coming to the impact test composite-2 and composite-3 got more significant parameters.

The ranks are provided to the composites by using Technique For Order Preference By Similarity To Ideal Solution (Topsis). By using topsis method composite-2 got rank-1, composite-3 got rank-2, composite-4 got rank-3, composite-5 got rank-4 and composite-5 got rank-5.

REFERENCES

1. "A Short Review on Basalt Fiber" Kunal Singha.
2. "STUDIES ON MECHANICAL BEHAVIOUR OF BASALT FIBER COMPOSITE" B.Vijaya Ramnath , C. Elanchezhian, J. Aravind, L. Sushil, A. Arun Kumar.
3. "Durability of basalt fibers and composites in corrosive environments" Gang Wu^{1,2}, Xin Wang¹ , Zhishen Wu² , Zhiqiang Dong¹ and Guangchao Zhang.
4. "BASALT FIBER AS A REINFORCEMENT OF POLYMER COMPOSITES" Tibor CZIGÁNY*, János VAD and Kornél PÖLÖSKEI.
5. "Mechanical Behaviour of Palm Fiber (Palmyra Spout) – Basalt Fiber - Hybrid Composites "D. Prabu, A. Giriprasath, V. Prasanna, G. Mohanakrishnan, S. Viknesh.
6. "Review of research on basalt fibers and basalt fiber-reinforced composites in China (I): Physicochemical and mechanical properties "Li Yan, Faliang Chu, Wanyong Tuo , Xiaobo Zhao, Yan Wang, Pengqi Zhang and Yibin Gao.
7. "Mechanical and anticorrosion properties of furan/epoxy-based basalt fiber-reinforced composites" Zhi Wang, Ni Cao, Jing He, Ruikui Du, Yaqing Liu, Guizhe Zhao.
8. "Oil Palm Fibre Reinforced Polymer Composites: A Review" M.Y.M. Zuhri, S.M. Sapuan, and N. Ismail.
9. "Mechanical Properties of Oil Palm Fibre Reinforced Epoxy for Building Short Span Bridge "Mimi Azlina Abu Bakar, Valliyappan D. Natarajan, Anizah Kalam & Nor Hayati Kudiran.
10. "Mechanical Properties of Epoxidized Palm Oil / Epoxy Resin Blend" Zyad Salem Alsagayara , Abdul Razak Rahmatb, Agus Arsadc , Alireza Fakhari d and Wan Nurhayati Binti Wan Tajulruddin,e.
11. "Incorporation of Palm Fiber to Enhance the Mechanical Properties of Epoxy" Samah M. Hussein
12. "The Effect of Seashells as Filler in Epoxy Composites" Nor Azwin Ahad , Kwan Suk Lum and Khairulnisa Halim
13. "Characterization of green composites from biobased epoxy matrices and bio-fillers derived from seashell wastes" V. Fombuena¹ , L. Bernardi² , O. Fenollar¹ , T. Boronat¹ , R. Balart¹.
14. "The Production and Characterization of Seashell Reinforced Epoxy Composite Material "Cihat Aydina , Sinan Avcib.
15. Influence of Mechanical Properties in the Surface Modification of Palm Fiber/Epoxy Matrix Composite Parivendhan J Inbakumar, Sengottuvelu Ramesh & Satish Babu Boppana.



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