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MECHANICAL PROPERTIES OF SISAL/GLASS FIBER REINFORCED HYBRID COMPOSITES: A REVIEW

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Abstract. The natural fiber-reinforced polymer composite is swiftly growing both in phrases of their industrial applications and fundamental research. They are renewable, cheap, absolutely or in part recyclable and biodegradable. The incorporation of herbal fibers consisting of sisal with glass fiber hybrid composites has additionally received growing industrial packages. Herbal and synthetic fibers are mixed in the same matrix (unsaturated polyester) to make sisal/glass fiber hybrid composites and the mechanical residences of those hybrid composites had been studied. A giant development in mechanical homes of sisal/glass fiber hybrid composites has been observed. the chalk powder (additive) is likewise introduced to the resin (unsaturated polyester) in proportions of 1%, 2%, 3% by way of weight of resin respectively and sisal/glass fiber hybrid composites were organized through the usage of this resin to take a look at the effect of chalk powder on mechanical homes of those hybrid composites. It is also found that because the chalk powder quantity increases tensile and flexural residences are decreases.

Keywords. Sisal/glass fiber reinforced hybrid composites, Unsaturated polyester resin, Chalk powder.

INTRODUCTION

Now-a-days the engineers are searching for structural materials which have low density, high strength, stiffness, abrasion, impact resistance, low thermal expansion and corrosion resistance, at lower cost. In order to achieve above requirements it requires combining two or more different materials to get composite materials. When two or more materials with different properties are combined together, they form a composite material. Composite material comprise of strong load carrying material (reinforcement) imbedded with weaker materials (matrix). Composites can be classified according to different criteria.

Particle reinforced composites also called particulate composites consisting of reinforcing material that is in the form particle. The shape of reinforcing particle may either spherical, a platelet, cubic, tetragonal, or of other regular or irregular geometry. The arrangement of the particles in the composites may be either random or preferred orientation. Generally, particles are used in composites to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve mach inability, increase surface hardness and reduce shrinkage.

Fiber reinforced polymer composites *also* called fibrous composites consisting of fibers as the reinforcement. Now-a-days, these composites have found applications in various areas such as automotive, marine, aerospace etc. due to their high specific stiffness and strength.

Hybrid Composites are relatively new and obtained by using two or more kinds of fibers in single matrix. The hybrid composites have a better all around combination of properties than the composites containing single fiber type. Example the fibers may be aligned and mixed one another, the hybrid composites produced with the fiber mixer is one method.

Due to the growing global energy crisis and ecological risks, natural fibers reinforced polymer composites have attracted more research interests. The main advantages of natural fibers are their availability, biodegradable, renewable, environmental friendly, low cost, low density, high specific properties, good thermal properties, enhanced the energy recovery, low energy consumption, non-abrasive nature and low cost [1, 2].

In the recent years there is a vast growth in natural fiber based polymer composites due to its various attractive features likes biodegradability, no abrasiveness, flexibility, availability, low cost, light weight etc. Different researchers have performed various experiments to enhance the mechanical properties of natural fiber based polymer composites [3, 4, 5, 6, 7, 8, 9, 10, 11].

Table 1: Physical properties of natural fibers

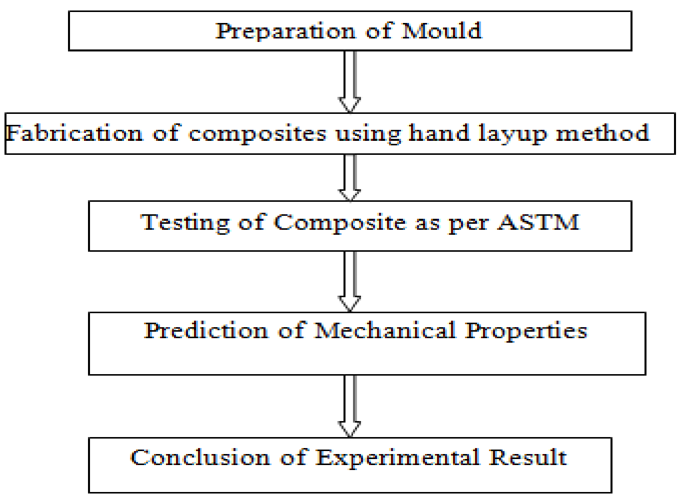
Fiber	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation at Break (%)	Density (g/cm^3)
Abaca	400	12	3 - 10	1.50
Alfa	350	22	5.80	0.89
Bagasse	290	17	--	1.25
Bamboo	140 - 230	11 - 17	--	0.60 – 1.10
Banana	500	12	5.90	1.35
Coir	175	4 - 6	30	1.20
Cotton	287 - 597	5.50 – 12.60	7 - 8	1.50 – 1.60
Curaua	500 - 1150	11.80	3.70 – 4.30	1.40
Date Palm	97 - 196	2.50 – 5.40	2.00 – 4.50	1.00 – 1.20
Flax	345 - 1035	27.60	2.70 – 3.20	1.50
Hemp	690	70	1.60	1.48
Henequen	500 - 700	13.20 ± 3.10	4.80 – 1.10	1.20
Isora	500 - 600	--	5 - 6	1.20 – 1.30
Jute	393 -773	26.50	1.50 – 1.80	1.30
Kenaf	930	53	1.60	--
Nettle	650	38	1.70	--
Oil Palm	248	3.20	25	0.70 – 1.55
Piassava	134 - 143	1.07 – 4.59	21.90–7.80	1.40
Pineapple	1.44	400 - 627	14.50	0.80 – 1.60
Ramie	560	24.50	2.50	1.50
Sisal	511 - 635	9.40 – 22.00	2.00 – 2.50	1.50
E-glass	3400	72	--	2.5

METHODOLOGY

Mechanical properties of materials are very essential in order to construct a mechanically sound structure. Mechanical properties can be determined by conducting experimental tests on specimen. These properties determine the behaviour of materials under applied forces [18]. Materials are tested using Stress-Strain Curve, Stress, Strain, Elongation, Proportional Limit, Modulus of Elasticity, Yield Point, Ultimate Strength, Yield Strength, Secant Modulus, for one or more of the following purposes [19].

1. To assess numerically the fundamentals mechanical properties of ductility, malleability, toughness, etc.
2. To determine data, i.e., force-deformation (or stress) values to draw up sets of specifications upon which the engineer can use his design.
3. To determine the surface or sub-surface defects in raw materials or processed parts.
4. To check chemical composition.
5. To determine suitability of a material for a particular application.

METHODOLOGY OF WORK:



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Also there are number of mechanical tests, which are carried out to determine the suitability of a metal, yet the following are importing from subject point of view-

1) Tensile test,
2) Fatigue test,
3) Impact test,
4) Hardness test,
5) Compressive test,
6) Creep test.

In the present work, unsaturated polyester as matrix, Methyl ethyl Ketone peroxide as catalyst, cobalt napthenate as accelerator, sisal as natural fibre, glass fibre as synthetic fibre are used as reinforcements and chalk powder as additive**.** The test specimens are prepared to conduct tensile test, compressive test, flexural test, impact test. For these test specimens are cut as per American standard testing method (ASTM).

Tensile testing specimen: The tensile test specimens were prepared from a sheet of 280mm x 170mm x 3mm as per the dimensions shown in fig 4.1 according to ASTM.D638

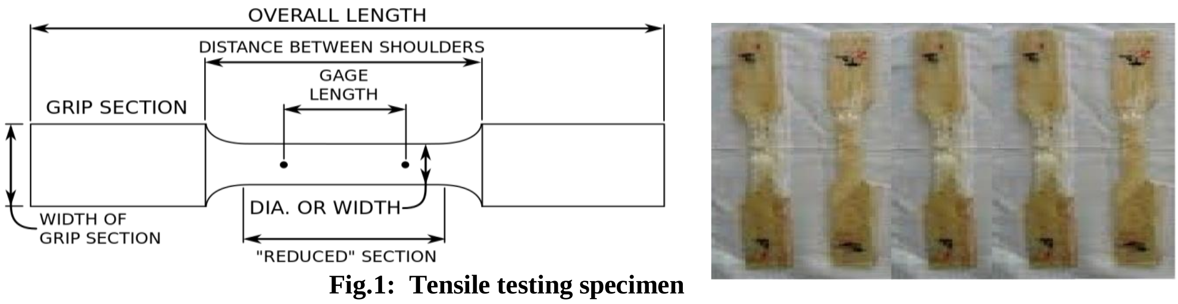
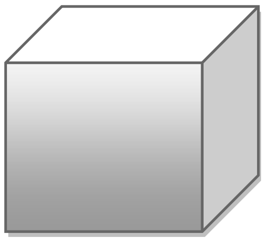


Fig.1: Tensile testing specimen

Compressive Testing Specimen: A cube of 10mm side is prepared as a specimen for compressive test from a sheet of 150mm x 150mm x 10mm as per ASTM.D695.

Fig. 2: Compressive Testing Specimen



Flexural Testing Specimen: The flexural test specimens with dimensions 100mm x 127mm x 3mm are cut as per ASTM D618 specifications from a sheet of 280mm x 170mm x 3 mm .

Fig.3: Flexural Testing Specimen

Impact Test Specimen: The Impact test specimens with dimensions 63.5mm x 12.7mm x12.7mm were cut as per ASTM D256 specifications from a sheet of 150mm x 150mm x 12mm.

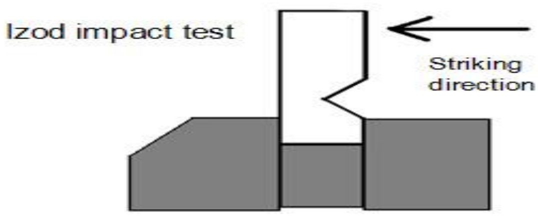


Fig.4: Impact test specimen

RESULT ANALYSIS AND DISCUSSION

The natural fibers are renewable, cheap, environmentally friendly and do not cause any problem. But mechanical properties of natural fibers are much lower than the synthetic fibers. The synthetic fibers exhibit good mechanical properties, but they are costlier and non renewable. More over the energy that is to be spent to process the synthetic fibers is much higher than the natural fibers. To take advantage of both natural and synthetic fibers, they are combined in the same matrix to get hybrid composites sisal and glass fiber are cut into 2cm long short fibers and are mixed homogeneously. This fiber mixture is incorporated randomly into the matrix to produce hybrid composites. Unsaturated polyester is used as matrix for the present work. In the present work, chalk powder is used as an additive in proportion of 1%, 2%, 3% by weight of resin. The chalk powder is mixed with the resin and this resin is used to produce hybrid composites. These hybrid composites are tested to know the effect of fiber content and the effect of chalk powder addition on mechanical properties.

Table.2: Tensile properties of sisal/glass fiber hybrid composite

Sr. No	Fiber	Tensile Strength MPa Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	21.707	17.984	15.66	14.902
2	Glass Fiber	28.312	22.07	19.725	17.433
3	Sisal / Glass Fiber Hybrid composite	24.505	19.66	18.84	16.796

Table.3: Tensile Modulus of Sisal / Glass Fiber Hybrid Composites

Sr. No	Fiber	Tensile Strength GPa Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	6.6	5.9	4.5	2.8
2	Glass Fiber	8.9	8.3	8.2	7.4
3	Sisal / Glass Fiber Hybrid composite	7.1.	6.5	5.2	4.5

Table.4: Compressive properties of sisal/glass fiber hybrid composite

Sr. No	Fiber	Compressive Strength MPa Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	111.97	85.89	84.806	81.21
2	Glass Fiber	150.397	143.052	124.831	114.716
3	Sisal / Glass Fiber Hybrid composite	127.065	113.732	112.554	99.986

Table .5: Compressive Modulus of Sisal / Glass Fiber Hybrid Composites

Sr. No	Fiber	Compressive Modulus GPa Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	1.1067	0.0855	0.733	0.561
2	Glass Fiber	1.697	1.146	0.991	0.953
3	Sisal / Glass Fiber Hybrid composite	1.13	1.035	0.912	0.637

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Table.6: Impact properties of sisal/glass fiber hybrid composite

Sr. No	Fiber	Impact Strength KJ/M^2 Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	6.35	5.526	5.276	4.286
2	Glass Fiber	13.09	10.982	10.765	9.618
3	Sisal / Glass Fiber Hybrid composite	12.22	8.874	8.626	8.13

Table.7: Flexural properties of Sisal / Glass Fiber Hybrid composites

Sr. No	Fiber	Flexural Strength MPa Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	86.19	53.27	51.506	47.462
2	Glass Fiber	100.818	88.53	65.906	61.127
3	Sisal / Glass Fiber Hybrid composite	95.814	67.646	53.268	61.127

Table.8: Flexural Modulus of Sisal / Glass Fiber Hybrid Composites

Sr. No	Fiber	Flexural Modulus GPa Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	4.956	4.21	2.83	1.07
2	Glass Fiber	6.23	5.72	5.60	4.813
3	Sisal / Glass Fiber Hybrid composite	5.14	4.82	3.52	2.73

Table.9: Hardness Properties of Sisal / Glass Fiber Hybrid Composites

Sr. No	Fiber	Hardness Chalk Powder % by weight of resin			
		0%	1%	2%	3%
1	Sisal Fiber	94	92	90	89
2	Glass Fiber	103.	102	100	99
3	Sisal / Glass Fiber Hybrid composite	97	95	93	93

CONCLUSION

The experimental study on the effect of chalk powder addition, the resin is mixed with chalk powder in proportion of 1%, 2% and 3% by weight of resin and hybrid composites are made with this resin. The Mechanical Properties of sisal/glass fiber reinforced hybrid composites made with unsaturated polyester resin leads to the following conclusions:

1. The tensile strength and tensile modulus of sisal fiber reinforced composites are lower than the glass fiber reinforced composites.
2. The tensile strength and tensile modulus of sisal fiber reinforced composites are lower than the glass fiber reinforced composites.
3. The tensile strength and tensile modulus of sisal/glass fiber hybrid composites are higher than the sisal fiber reinforced composites, but lower than the glass fiber composites.
4. The presence of glass fiber in sisal /glass fiber hybrid composites causes to increase tensile strength and tensile modulus.
5. The tensile strength and tensile modulus are decreased with increase in chalk powder content in these composites.
6. The compressive strength and compressive modulus of glass fiber reinforced composites are higher than the sisal fiber reinforced composites.
7. The compressive strength and compressive modulus of sisal/glass fiber hybrid composites are higher than the sisal fiber reinforced composites, but lower than the glass fiber composites.

8. The presence of glass fiber in sisal /glass fiber hybrid composites causes to increase compressive strength and compressive modulus.
9. The compressive strength and compressive modulus decrease with increase in chalk powder content in these composites.
10. The impact strength of glass fiber reinforced composites are higher than the sisal fiber reinforced composites.
11. The impact strength of sisal/glass fiber hybrid composites is higher than the sisal fiber reinforced composites, but lower than the glass fiber composites.
12. The presence of glass fiber in sisal /glass fiber hybrid composites causes to increase impact strength.
13. The impact strength decrease with increase in chalk powder content in these composites.
14. The flexural strength and flexural modulus of glass fiber reinforced composites are higher than the sisal fiber reinforced composites.
15. The flexural strength and flexural modulus of sisal/glass fiber hybrid composites are higher than the sisal fiber reinforced composites, but lower than the glass fiber composites.
16. The presence of glass fiber in sisal /glass fiber hybrid composites causes to increase flexural strength and flexural modulus.
17. the flexural strength and flexural modulus decrease with increase in chalk powder content in these composites.
18. The hardness of glass fiber reinforced composites are higher than the sisal fiber reinforced composites.
19. The hardness of sisal/glass fiber hybrid composites is higher than the sisal fiber reinforced composites, but lower than the glass fiber composites.
20. The presence of glass fiber in sisal /glass fiber hybrid composites causes to increase hardness.
21. The hardness decrease with increase in chalk powder content in these composites.

The reasons for decrease in the mechanical properties with increase in chalk powder quantity in the hybrid composites are:

- The addition of chalk powder may cause reduction in the ductility of the matrix.
- The addition of chalk powder may reduce the cohesiveness of polyester resin.
- The size of chalk powder molecule may be same or larger than the polyester resin molecule and these molecules may be placed randomly.
- The crystal structure of chalk powder and polyester resin may not be same.

SCOPE

The present work may be extended to study other aspects of composites like natural fibers and evaluation of their dynamic mechanical, thermal, tri-biological properties and the experimental results can be similarly be analyzed.

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