Sisal and Glass Fiber Hybrid Composite - A Comparative Study on Mechanical Properties with and without Cryogenic Treatment

Chandan Chawan R.[1] Dr.G.B.Krishnappa[2] Dr. Keerthi Prasad K.S.[3] Dr. B. Sadashive Gowda[4]
[1]M.Tech Student [2,3]Professor & Head [4]Principal
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4,]Vidyavardhaka College of Engineering, Mysuru, Karnataka, India

Abstract— Nowadays, the natural fibers from renewable natural resources offer the potential to act as reinforcing materials for polymer composites, alternative to the use of glass, carbon and other man-made fibers. Among various natural fibers, Sisal and sisal are most widely used natural fibers due to their advantages like easy availability, low density, low production cost and good mechanical properties. Attempts have been made in this project work to study the effect of fiber loading and orientation on the mechanical properties of Sisal and glass fiber reinforced epoxy based hybrid composite with and without cryogenic treatment. Improvement in the mechanical properties of hybrid composite has been observed after cryogenic treatment.

Key words: Cryogenic Treatment, E-Glass, Sisal Fiber

I. INTRODUCTION

In recent years, the concept of 'eco-materials' has gained key importance due to the need to preserve our environment. The meaning of eco-material includes 'safe' material systems for human and other life forms at all times. Past experiences have shown that it is necessary to characterize materials and determine those which are safe for both short and long-term utilization. Selection of a material system that satisfies not only industrial requirements but also this wider definition of eco-materials, as described above, is an urgent necessity. Here, the most appropriate concept for material selection is composite materials with natural fiber reinforcement. The interest in natural fiber reinforced composites is growing rapidly both in terms of their industrial applications and fundamental research. Their availability, renewability, low density and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and other man-made fibers used for the manufacturing of composites. However natural fiber composites absorb moisture which degrades the performance. Hence natural and synthetic hybrid composites are better option.

II. THE RAW MATERIALS

Sisal fiber is obtain from the leaves of the plant (Agave Sisa1ana), which was originate from Mexico and is now mostly cultivated in East Africa, India and Indonesia. Sisal fibers are group under the heading of "hard fibers" between which Sisal fibers have long stability and strength. The Sisal fiber is extract from the leaf either by retting process. Usually it is obtain by machine decortications in which the leaf is compressed between ro1lers and then mechanica1ly scraped. The fiber is then wash and dried out by natural means. The Sisal plant is shown in Fig.1**.** Bi-directional fabric type of Sisal fiber is used in this study and is shown in Fig.2 and the reasons for selection are as follows: Its leaves can be treated with natural borax for fire resistance properties and Low maintenance and recyclable.

Fig. 1: Sisal Plant

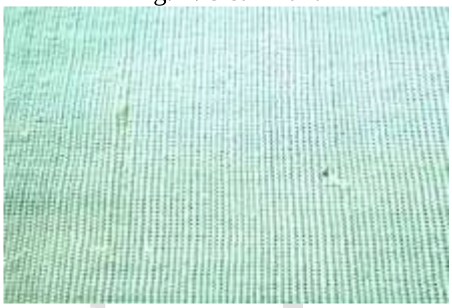

Fig. 2: Sisal fabric

Properties of the Sisal fiber are as follows

– Specific gravity	[kg/m3]	-	1371
– Water absorption	[%]	-	12
– Tensile strength	[MPa]	-	350-800
– Stiffness	[KN/mm2]	-	15-20

A. E-Glass Fiber

In the present study, woven glass plain weave fabrics made of 200 gsm, containing E-glass fibers of thickness of 0.162-0.192mm have been used as the reinforcing material in all the composites. Glass is the most common fiber used in polymer matrix composites. Its advantages include its high strength, low cost, corrosion resistance, high chemical resistance and good insulating properties. E-glass fiber has an elastic modulus of 72.40 GPa, ultimate tensile strength of 3447MPa and possesses a density of 2.55 g/cm^3.The present work utilizes the Bi-directional Glass plain woven roving type of E-Glass and is shown in Fig 3. The reasons for selecting E-Glass fibers are as follows.

- Good tensile, compressive strength and stiffness.
- Good electrical properties and relatively low cost.
- Very economical when compared to other type of fibers.
- Wide ranges of yarn sizes and weave patterns provide unlimited design potential

Fig. 3: E-Glass fabric

B. Epoxy Resin

1) Lapox L-12 (Epoxy)

Lapox L-12 is a liquid, unmodified epoxy resin of medium viscosity which can be used with various hardeners for making reinforced composite and laminates. The choice of hardener depends upon the processing method to be used and on the properties required of the cured composite.

2) Hardener K-6

Hardener K6 is a low viscosity room temperature curing liquid hardener. Hardener is used to cure the epoxy by additional reaction. This hardener is commonly employed in engineering system where low viscosity and fast setting at ambient temperature is desired. It is commonly employed for hand layup application. The hardener used in the current manufacturing process is of grade K-6, which was added to epoxy resin to provide proper strengthening.

III. HAND LAY-UP TECHNIQUE

Hand layup, which is one of the oldest and simplest procedure for forming open mould composite processing method. In this process the reinforcement and resin are placed on the mold layer by layer, and plied manually onto an open mould surface until the desired thickness of the component is obtained. The lay-up normally cures at room temperature or may be heated to accelerate the curing process. For better quality surface finish, a gel is coated to the surface of the mould. Hand lay-up method was first used to manufacture large boats and boat hulls, ducts, helmets and automobile components.

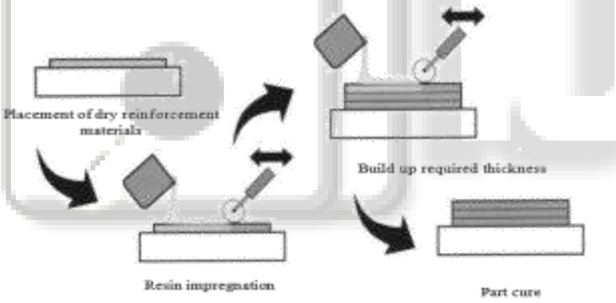

Fig. 4: Hand Lay-Up Technique

IV. EXPERIMENTATION

A. Tensile Test

The tensile test specimen is prepared according to the ASTM D-638 standard. The commonly used specimen for tensile test is the dog-bone type as shown in Fig.5. The test is used to determine the tensile strength and young's modulus of the material. The specification of the specimen is as follows.

Total length (mm)	Gage length (mm)	Width of grip section (mm)	Width of gage section (mm)	Thickness (mm)
150	50	20	10	4

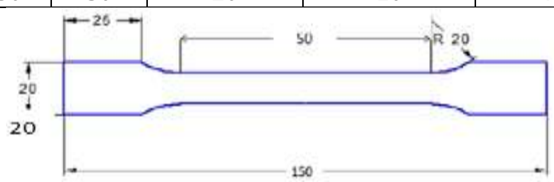

Fig. 5: Specification of tensile test specimen according to ASTM standard

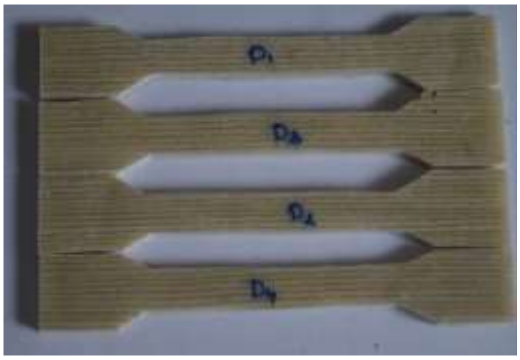

Fig. 6: Tensile Test specimens

B. Flexural Test

The flexural test specimens were prepared according to ASTM D-790 test standard. The dimensional of the specimens is shown in Fig.7. Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. The specification of the specimen is as follows.

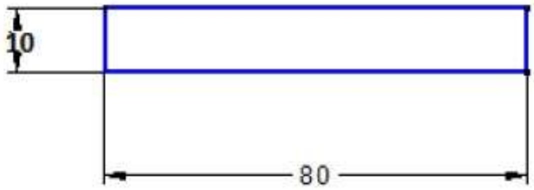

Fig. 7: Specification of flexural test specimen according to ASTM standard

Total length (mm)	Gage length (mm)	Width of grip section (mm)	Thickness (mm)
80	50	10	4

Fig. 8: Flexural Test specimens

C. Impact test

The impact test specimens were prepared according to ASTM D256 test standard. The dimensional of the specimens is shown in Fig.9. The test is used due to determine the impact strength. The specification of the specimen is as follows.

Total length (mm)	Gage length (mm)	Width of grip section (mm)	Thickness (mm)
80	50	10	4

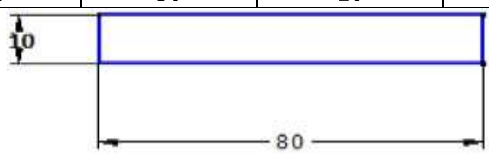

Fig. 9: Specification of impact test specimen according to ASTM standard

Fig. 10: Impact Test specimens

V. RESULT AND DISCUSSION

All three tests are conducted on 4 specimens each, for each fibre orientation (0^o, 30^o, 45^o) of the hybrid composite (Sisal + Eglass) .The average values of the results are considered for the study. Another set of specimens are treated in liquid nitrogen for one hour and all the three tests are conducted and results are tabulated.

A. Tensile Test Results

Materials	Orientation	Maxim. Load (N)	UTS (MPa)	Young's modulus (MPa)
Sisal/E-glass	0°	2077	51	2986
	30°	1591	39	2698
	45°	1192	29	2226

Table 1: Tensile test results of hybrid composite without cryogenic treatment

Materials	Orientation	Maxim. Load (N)	UTS (MPa)	Young's modulus (MPa)
Sisal/E-glass	0°	2193	55	3342
	30°	2045	51	2885
	45°	1381	34	2336

Table 2: Tensile test results of hybrid composite with cryogenic treatment

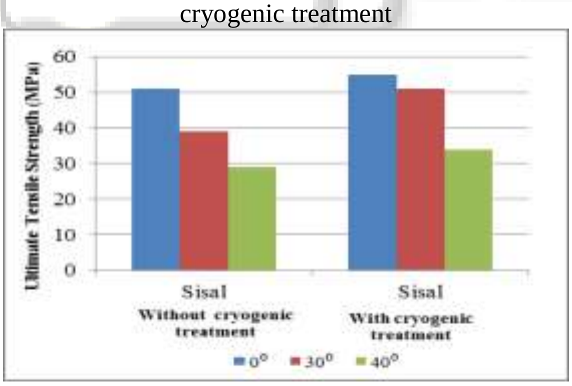

Fig. 11: Overall comparison of ultimate tensile strength With and without cryogenic treatment

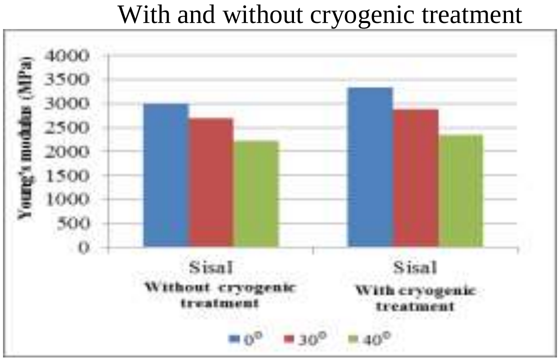

Fig. 12: Overall comparison of young's modulus with and without cryogenic treatment

From the results it is observed that the hybrid composites, tensile strength is maximum for 0° fiber orientation.

After treating with liquid nitrogen for one hour, the test specimens show increase in mechanical properties such as maximum load bearing capacity, ultimate tensile strength and young's modulus. The tensile strength is increased by about 12% in Sisal/E-glass hybrid composites.

Fig.11 and Fig.12 shows overall comparison of ultimate tensile strength and young's modulus with and without cryogenic treatment.

B. Flexural Test Results

Materials	Orientation	Maxim. Load (N)	Flexural strength (MPa)
Sisal/E-glass	0°	93.00	44.39
	30°	147.21	69.69
	45°	106.74	51.31

Table 3: Flexural test results of hybrid composite without cryogenic treatment

Materials	Orientation	Maxim. Load (N)	Flexural strength (MPa)
Sisal/E-glass	0°	146.00	68.79
	30°	197.27	92.65
	45°	192.20	90.78

Table 4: Flexural test results of hybrid composite with cryogenic treatment

From the results it is observed that the hybrids composite, flexural strength is maximum for 30° fiber orientation. After treating with liquid nitrogen for one hour, the test specimens show increase in mechanical properties such as maximum load bearing capacity and flexural strength. The flexural strength is increased by about 30% in Sisal/E-glass hybrid composites. Fig.13. shows Overall Comparison of flexural strength with and without cryogenic treatment.

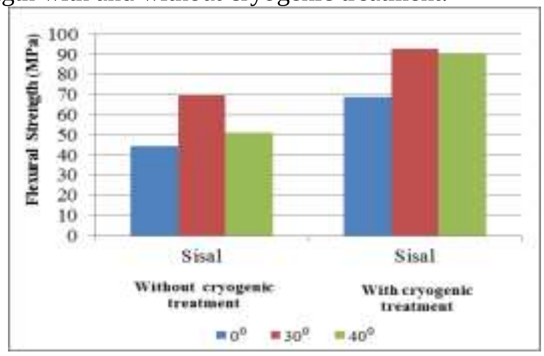

Fig. 13: Overall Comparison of flexural strength with and without cryogenic treatment.

C. Impact Test Results

Materials	Orientation	Impact strength (KJ/m^2)
Sisal/E-glass	0°	47.00
	30°	72.25
	45°	57.75

Table 5: Impact test results without cryogenic treatment

Materials	Orientation	Impact strength (KJ/m^2)
Sisal/E-glass	0°	56.50
	30°	80.50
	45°	68.25

Table 6: Impact test results with cryogenic treatment

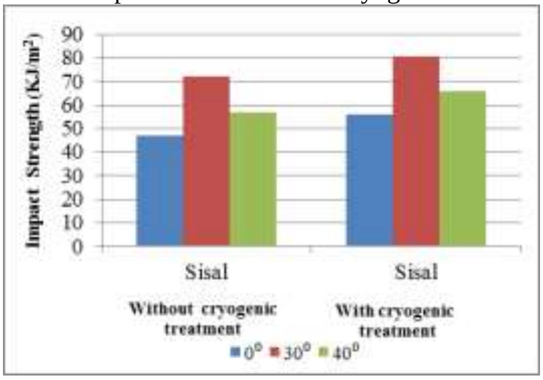

Fig. 14: Shows overall comparison of impact strength with and without cryogenic treatment.

From the results it is observed that the hybrids composite, impact strength is maximum for 30° fiber orientation. After treating with liquid nitrogen for one hour, the test specimens show increase in impact strength. The impact strength is increased by about 12% in Sisal/E-glass hybrid composites. Fig.14 shows Overall comparison of impact strength with and without cryogenic treatment.

VI. CONCLUSION

The natural (sisal) and synthetic (glass) hybrid composite is tested for tensile strength, flexural and impact strength. Enhancement of mechanical properties has been observed after cryogenic treatment.

- The Sisal/E-glass composite of 0^o fiber orientation shows maximum tensile strength of 55.13 MPa after cryogenic treatment.
- The Sisal/E-glass composite of 30^o fiber orientation sample shows maximum flexural strength of 92.65MPa after cryogenic treatment.
- The Sisal/E-glass composite of 30^o fiber orientation shows maximum impact strength of 80.50 KJ/m^2 after cryogenic treatment.

REFERENCES

[1] U.S.Bongarde, V.D.Shinde. “Review on natural fiber reinforcement polymer composites” ISSN: 2319-5967, Volume 3, Issue 2, March 2014
[2] Shao-yun fu “Cryogenic Properties of Polymer Materials” DOI 10.1007/978-3-642-35335-2.
[3] M. Ramesh, K. Palanikumar, K. Hemachandra Reddy. “Mechanical property evaluation of sisal–Sisal–glass fiber reinforced polyester composites” Composites Part B: Engineering Volume 48, May 2013, Pages 1–9
[4] Girisha K G, Anil K C & Akash. “Mechanical properties of Sisal and hemp reinforced epoxy/polyester hybrid composites” ISSN (E): 2321-8843; ISSN (P): 2347-4599, Vol. 2, Issue 4, Apr 2014, 245-248
[5] M. Ramesh, K. Palanikumar, K. Hemachandra Reddy. “Comparative Evaluation on Properties of Hybrid Glass Fiber- Sisal/Sisal Reinforced Epoxy Composites” Procedia Engineering 51 (2013) 745 –750.

