Influence of Additives on the Mechanical Behaviors of Natural Fiber-Polyester

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***Abstract*—The composites were prepared by means of Hand lay-up technique was used for the preparation of composites, and then the effects of sisal loading on mechanical properties such as impact strength, flexural strength, and wear resistance, tensile strength, hardness were investigated. These agricultural wastes can be used to prepare fiber reinforced polyester composites for commercial use. This report examines the different types of fibers available and the current status of research. A significant improvement in compressive and impact properties of Sisal/Glass additives hybrid composites has been found. The glass (additive) is also added to the resin in proportion of 25% by weight of resin respectively and Sisal/Glass additives hybrid composites were prepared by using this resin to study the effect of additives on compressive and Impact properties of these hybrid composites. It is also observed that as the additives quantity increases Compressive and impact properties are decrease. Results of the determination of the mechanical properties of sisal fibers and experiments on the mechanical behavior of a composite consisting of saturated polyester matrix and poly epoxy resin with additives reinforced sisal fiber with different percentages are presented in the project.**

Keywords—composite, reinforced polyester, additives, hybrid composites.

I. INTRODUCTION

1.1 Introduction

The global demand for wood as a building material is steadily growing, while the availability of this natural resource is diminishing. This situation has led to the development of alternative materials. Of the various synthetic materials that have been explored and advocated, polymer composites claim a major participation as building materials. There has been a growing interest in utilizing natural fibers as reinforcement in polymer composite for making low cost construction materials in recent years. Natural fibers are prospective reinforcing materials and their use until now has been more traditional than technical.

They have long served many useful purposes but the application of the material technology for the utilization of natural fibers as reinforcement in polymer matrix took place in comparatively recent years. Economic and other related factors in many developing countries where natural fibers are abundant demand that scientists and engineers apply appropriate technology to utilize these natural fibers as effectively and economically as possible to produce good quality fiber reinforced polymer composites for housing and other needs. Among the various natural fibers, sisal is of particular interest in that its composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocelluloses fibers.

In recent years, there has been an increasing interest in finding innovative applications for sisal fiber-reinforced composites other than their traditional use in making ropes, mats, carpets, handicrafts, and other fancy articles. Composites made of sisal fibers are green materials and do not consume much energy for their production.

The characteristics of composites depend on different parameters such as extraction of fiber, surface modification and the synthesis of composites. During synthesis, fiber length, orientation, concentration, dispersion, aspect ratios, selection of matrix, and chemistry of matrix have to be considered to achieve the required strength. Inorganic fibers have several disadvantages, including their non biodegradability, the abrasion in processing equipments, high cost and density, and the health problems caused to workers during processing and handling [5-9]. Commonly used composites, these days are, glass, aramid, carbon, and asbestos fibers filled in thermoplastic, thermoset, or cement composites. Yet natural fiber composites with equivalent characteristics to synthetic fiber composites are not available. Most of the plant fibers are hydrophilic in nature and water absorption may be very high. This may be controlled by different methods of interfacial surface modification [11, 12]. Because of the low density and high specific strength and modulus. Sisal fiber is a potential resource material for various engineering applications in the electrical industry, automobiles, railways, building materials, geotextiles, and defense in the packaging industry[10].

Flax	:	Borneo
Hemp	:	Yugoslavia, China
Sun Hemp	:	Nigeria, Guyana, Siera Leone, India
Ramie	:	Hondurus, Mauritius
Jute	:	India, Egypt, Guyana, Jamaica, Ghana, Malawi, Sudan, Tanzania
Kenaf	:	Iraq, Tanzania, Jamaica, South Africa, Cuba, Togo
Roselle	:	Borneo, Guyana, Malaysia, Sri Lanka, Togo, Indonesia, Tanzania
Sisal	:	East Africa, Bahamas, Antiqua, Kenya, Tanzania, India
Abaca	:	Malaysia, Uganda, Philippines, Bolivia
Coir	:	India, Sri Lanka, Philippines, Malaysia

Fig.1.*Stress Distribution at Transfer Module*

II LITERATURE SURVEY

This chapter outlines some of the recent reports published in literature on mechanical behavior of natural fiber based polymer composites with special emphasis on nature fiber reinforced polymer composites.

[1] Natural Fiber Reinforced Composites: The mechanical properties and physical properties of natural fibers vary considerably depending on the chemical and structural composition, fiber type and growth conditions. Mechanical properties [4] of plant fibers are much lower when compared to those of the most widely used competing reinforcing glass fibers (Table 4). However, because of their low density, the specific properties (property-to-density ratio), strength, and stiffness of plant fibers are comparable to the values of glass fibers.

Density (cm^3/g)	0.7
Rate of recovery (%)	14
Aspect	Brown-colored coarse fibers
Touch	Rough
Tenacity (N/tex)	14.04
Absolute elongation (mm)	14.27
Relative elongation (%)	8%
Breaking load (n)	4.45
Diameter (mm)	0.3
Linear density (g/km)	27.2
The smoothness (m/g)	37
Thermal conduction	Good thermal conductor
Combustion	Burns quickly with a sharp flame by releasing a paper flaring odor

Fig.2. *Mechanical Properties of Natural Fibers*

[2] Sisal Fiber Reinforced Composites: Alkali-treated sisal fibres were used as novel reinforcement to obtain composites with self-synthesized urea formaldehyde resin as matrix phase. The composites were prepared by means of compression molding, and then the effects of sisal loading on mechanical properties such as impact strength, flexural strength, and wear resistance were investigated. In addition, water uptake was studied and structural features were revealed by the scanning electron microscopy (SEM). The composite with 30 wt% sisal fibres gives excellent flexural strength, water absorption, and especially the wear resistance showing that it has the most superior bonding and adhesion of all the composites [36]. In particular, the highest value 9.42 kJ/m2 of charpy impact strength is observed in the composite with 50 wt% sisal fibre. SEM micrographs of impact fractured and worn surfaces clearly demonstrate the interfacial adhesion between fibre and matrix. This work shows the potential of sisal fibre (SF) to improve the composite wear resistance and to be used in fibre board.

[3] Coir Fiber Reinforced Composites**:** Many aspects of the use of coir fibers as reinforcement in polymer–matrix composites are described in the literature. Coir is an abundant, versatile, renewable, cheap, and biodegradable lignocellulosic fiber used for making a wide variety of products. Coir has also been tested as filler or reinforcement in different composite materials. Furthermore, it represents an additional agro-industrial nonfood feedstock (agro industrial and food industry waste) that should be considered as feedstock for the formulation of eco compatible composite materials. Coconut coir is the most interesting products as it has the lowest thermal conductivity and bulk density [4-9]. The addition of coconut coir reduced the thermal conductivity of the composite specimens and yielded a lightweight product. Development of composite materials for buildings using natural fiber as coconut coir with low thermal conductivity is an interesting alternative which would solve environment and energy concern. We have studied the dynamic mechanical behavior of natural rubber and its composites reinforced with short coir fibers.

[4] Abaca Fiber Reinforced Composites**:** Abaca fiber reinforced PP composites were fabricated with different fiber loadings (20, 30, 40, 50 wt% and in some cases 35 and 45 wt%). Flax and jute fiber reinforced PP composites were also fabricated with 30 wt% fiber loading. The mechanical properties, odour emission and structure properties were investigated for those composites. Tensile, flexural and Charpy impact strengths were found to increase for fiber loadings up to 40 wt% and then decreased. Falling weight impact tests were also carried out and the same tendency was observed. Owing to the addition of coupling agent (maleated polypropylene -MAH-PP), the tensile, flexural and falling weight impact properties were found to increase in between 30 to 80% for different fiber loadings [13,16].

[5] Kenaf Fiber Reinforced Composites**:**In this study, the reinforced kenaf fibers using polyester resin composites were processed through vacuum infusion method. Before infusion and reinforced applied, the long kenaf fibers were treated by various concentration of sodium hydroxide(NaOH). The

effects of the modification on fiber and also the effect of fiber alkalization on composites then is analyzed for mechanical properties and by using the scanning electron microscopy (SEM).

III PROBLEM IDENTIFICATION

Sisal fiber (SF), a member of the Agavaceae family is a biodegradable and environmental friendly crop. Moreover, sisal is a strong, stable and versatile material and it has been recognized as an important source of fibre for composites [2–4].It is generally accepted that the mechanical properties of fiber reinforced polymer composites are controlled by factors such as nature of matrix, fiber-matrix interface, fiber volume or weight fraction, fiber aspect ratio etc. Many scientists are working in this field and the reinforcement of polyester with SF has been widely reported. Low-density polyethylene-sisal [5], Polyester-sisal [6], epoxy sisal [7], polypropylene-sisal [8, 9], urea-formaldehyde- sisal [10], phenol-formaldehyde-sisal [11, 12], polyvinyl-acetate-sisal [13], and starch-based sisal [14] are some of the promising systems.

Increasing the needs for different engineering applications invite the development of new materials. In the present research new natural fiber sisal was introduced for the preparation of sisal fiber reinforced polyester (FRP) composites. Already established several natural fibers were also extracted for the preparation of natural FRP composites and to determine tensile properties [27-29]. The tensile properties of sisal FRP composites were compared with natural FRP composites. Hand lay-up technique was used for the preparation of composites.

Natural and synthetic fibers are combined in the same to make Sisal/Glass additives hybrid composites and the compressive and impact properties of these hybrid composites were studied. A significant improvement in compressive and impact properties of Sisal/Glass additives hybrid composites has been found [25]. The glass (additive) is also added to the resin in proportion of 25% by weight of resin respectively and Sisal/Glass additives hybrid composites were prepared by using this resin to study the effect of additives on compressive and Impact properties of these hybrid composites [22].

It is observed that the glass fiber composite is exhibiting higher compressive strength [10] than the sisal fiber reinforced composite. The sisal / glass additives hybrid composite compressive strength is higher than sisal reinforced composite but lower than glass fiber reinforced composite. The increase in compressive strength of hybrid composite is because of glass additives content.

IV METHODOLOGY

4.1 Manufacturing Methods Fiber Composite:

There are several methods for making of natural fiber composites. Most of the techniques commonly used for making glass fiber composites are applicable for making natural fiber composites. However, the well known method for composites making are as followings: Hand Lay-up/Spray up is one of the cheapest and most common processes for making fiber composite products. In this process, the mold is waxed and sprayed with gel coat and cured in a heated oven. In the spray up process, catalyzed resin is sprayed into the mold, with chopped fiber where secondary spray up layer imbeds the core between the laminates resulting a composite. In hand layup processing, both continuous fiber strand mat and fabrics are manually placed in the mold. Each ply is sprayed with catalyzed resin and with required pressure compact laminate is made [11-15].

Resin transfer molding (RTM) provides high quality finished surface on both the sides of composites with a relatively low energy makes perfect shapes. The fabricator generally gel coats the mold halves, then lays continuous or chopped strand mat and closes the mold. Resin transfers into mold through injection pressure, vacuum pressure, or both. Cure temperature depends on the resin system. Compression molding is a molding technique for making composite materials with low unit cost with faster cycle times [22-25]. Sheet molding compounds (SMC) is a sheet that sandwiches fiber between two layers of resin paste. Fiber/Fabric drop onto the paste and a second film carrier faces with another layer of resin. When the SMC is ready for molding, the mold is closed, clamped, and between 500 and 1,200 psi pressure is applied. After curing, mold is opened and the sheets were removed manually or through an injector system and ready for use.

Automated injection molding of thermoset bulk molding compound (BMC) has increasingly taken over markets previously held by thermoplastics for application in electrical and automotive components, housing appliances, and motor parts. BMC is a low-profile (nearly zero shrinkage) formulation of a thermoset resin mix with 15–20% chopped fiber. Injection molding is a fast, high volume, low pressure, and closed process. Injection speeds are typically 1–5 s and nearly 2,000 small parts can be produced per hour. A ram or screw type plunger forces a material shot through the machine's heated barrel and injects it into a closed, heated mold. Heat build-up is carefully controlled to minimize curing time. After cure and injection, parts need only minimal finishing. Filament winding is an automated, high volume process that is ideal for manufacturing pipe, tank, shafts and tubing, pressure vessels, and other cylindrical shapes. The winding machine pulls dry fibers from supply racks through a resin bath and winds the wet fibre around a mandrel. Pultrusion is the continuous, automated closed-molding process that is cost effective for high volume production of constant cross sectional parts. Pultruded custom profiles include standard shapes such as channels, angles, beams, rods, bars, tubing and sheets.

4.2 Extraction of Sisal Fiber:

Sisal fiber can be extracted from its leaves by Retting, Boiling and Mechanical extraction methods. Water retting is a traditional biodegradation process involving microbial decomposition (breaking of the chemical bonds) of sisal leaves, which separates the fiber from the pith. The fibers are washed and processed further. This process takes 15–21 days for a single cycle of extraction and degrades the quality of fiber. Retting is a very slow, water intensive process, unhygienic, and not eco-friendly. Fiber extracted by this method is poor in quality.

Fig.3.*Sisal Fiber Extraction*

Boiling is another extraction method, in which leaves of sisal plant are boiled, subsequently beating is done then after washing and sun drying we may get the usable clean fiber. This method is not suitable for large-scale extraction. Mechanical extraction involves inserting leaves into a machine “raspador machine “and pulling the raw material out (Fig 3.2.1).

This process does not deteriorate fiber quality and is suitable for small-scale operations and is efficient, versatile, cost effective and eco-friendly process. Residues produced during and after extraction of fiber are about 96% which is useful for biogas generation, composting, and isolation of a steroid, ecogenin, making paper, biodegradable polymer and wax[19-26].

4.3 Materials:

Sisal (Agaves Veracruz) fiber (300mm long short fiber) obtained from local sources and the chopped strand of Glass additives [9] were used for present work. Methyl Ethyl Ketone Peroxide as accelerator and Cobalt Naphthenate as catalyst. The glass is used as additive for present work. Processing equipment included mould, digital weighing scale, personal protective equipment (PPE), melting pan, stirring stick, brushes, flexural test machines, tape measure, verniercalipher and product testing facilities.

4.4 Preparation of composites:

The matrix of unsaturated polyester and monomer of styrene are mixed in the ratio of 100:25 parts by weight respectively. Later the additive glass is mixed thoroughly and then the accelerator of methyl ethyl ketene peroxide 1% by weight and catalyst of Cobalt Naphthenate of 1% by weight were added to the mixture and mixed thoroughly. In present work the composites were prepared by hand lay-up technique, the releasing agent of silicon is sprayed to glass mould and the matrix mixture is poured in to the mould. The fiber is added to matrix mixture, which was poured in the glass mould. The excess resin was removed from the mould and glass plate was placed on top.

Fig.4.*Sisal Fiber Composites*

Table.1. *ASTM standard for specimen preparations*

S.No	Type Of Test	ASTM Standard	Specimen Size (mm)
1	Impact Testing	D 4812	64x10x10
2	Tension Test	D 3039	250x20x17
3	Flexural Test	D 790	154x13x4
4	Water Absorption Test	D 570	25x25

The two methods used for mat manufacturing. In these methods, a mixture of sisal and glass additives was used. The total fiber volumetric fraction of the composites used in this work was 25%, within this percentage, the volumetric relation between glass additives and sisal fiber was modified according to the following compositions:

a) 0% glass additives and 100% sisal fiber;

b) 25% glass fiber and 75% sisal fiber;

Table.2. *Chemical Composition of Sisal Fiber:*

S.NO	COMPONENT	PROPORTIONS %
1	Cellulose	70
2	Lignin	12
3	Pectin	10
4	Hemicelluloses	14

V RESULT AND DISCUSSION

5.1 Impact strength of sisal / glass additives hybrid composite

The impact strength of sisal / glass additives hybrid composites is presented in table-15. It is observed that the glass fiber composite is exhibiting higher impact strength [10] than the sisal fiber reinforced composite. The sisal / glass additives hybrid composite impact strength is higher than sisal reinforced composite but lower than glass fiber reinforced composite. The increase in impact strength of hybrid composite is because of glass additives content. The variation Impact strength with fiber content is shown in figure.15. The effect of additives on impact strength of sisal /glass additives hybrid composite is shown in figure.15. It is observed that the composite without chalk powder addition is exhibiting higher impact strength, as the additives quantity in sisal / glass additives hybrid impact increases then the impact strength is decreases.

Table.3*.Observations for Impact (Izod) Test:*

S.No	Material	Energy absorbed force (a) J	Energy spend to break the specimen (b) J	Energy absorbed by the specimen (a-b) J	Impact strength N/mm
1	Specimen 1	60	37	23	230
2	Specimen 2	60	27	33	330

Formula:

Impact strength= [energy observed / area of the cross section] N/mm

5.2 Tension Testing

Specimens for tension test were carefully cut from the laminate and shaped to the accurate size using emery paper. Tests were conducted using Shimadzu make testing machine (model: AG-IS 50 KN, capacity: 5T, and accuracy: 0·2%) at a cross head speed of 5 mm/min as per ASTM D3039. Five identical specimens numbered S1 and S2were tested and average result derived. The tested mechanical property values for with additives on sisal composites and without additives on sisal composites are given in tables 16.

The sisal hybrid composites exhibited average tensile strength values of 13.46 MPa. The average tensile strength of without additives in sisal hybrid composites was found to be 10.58 MPa. The increase of tensile strength and modulus values in sisal hybrid composite is due to the addition of additives on the sisal fiber composites. The increased additives of glass mats increase the mechanical properties (Mallick 1993).

Table.4. *Tabulated Value for Tensile Test:*

S.No	Material	Maximum Stress (N/mm^2)	Maximum Strain	Maximum Load (N)
1	Specimen 1	10.58	0.44	$3.6x10^3$
2	Specimen 2	13.46	0.032	$5x10^3$

5.3 Flexural Testing

The flexural test specimen dimension is 154x 13 × 4 mm. Flexural test was conducted as per ASTM D 790 using Instron machine (Model no: 3382) with Series IX software and load cell of 10 kN at 2·8 mm/min rate of loading. The modulus values for with additives on sisal composites and without additives on sisal composites are given in tables 17 and 18 respectively.

The point of deviation from linearity is the indication of failure initiation due to development of crack on the tension side. The without additives in sisal hybrid composite exhibited the average value of flexural strength to be 82.63 MPa, whereas with additives in sisal hybrid composite exhibited 113.61 MPa. But their mechanical properties were slightly different because of testing direction.

During the mechanical test of without additives specimen, the sisal surface was only subjected to load, whereas in with additives specimen the sisal with additives glass surface was subjected to load. The failure rate is extended in without additives specimen because of sisal layers intermingling with polyester resin.

The Flexural Modulus:

$$E_f = mL^3/4bh^3$$

The Flexural Strength:

$$\sigma = 3P_{max}L /2bh^2$$

Where,

P_{max}- Maximum Load A Failure

b- Specimen Width

h- Specimen Thickness

l- Specimen Length Between The Two Support Points

Table. 5. *Flexural Observation For Specimen 1*

S.No	Load		Dial Gauge Reading		Flexural Modulus In Gpa	Flexural strength In (N/ mm^2)
	Kg	N	In Divisions	In mm		
1	0	0	0	0	0	82.63
2	1	9.81	180	1.80	13.88	
3	2	19.62	325	3.25	14.42	
4	3	29.43	483	4.83	14.48	
5	4	39.24	596	5.96	15.23	
6	5	49.05	710	7.10	15.24	
7	6	58.86	820	8.20	15.49	
8	7	68.67	940	9.40	15.61	
9	8	78.48	0	0	0	

Table.6. *Flexural Observation For Specimen 2*

S.No	Load		Dial Gauge Reading		Flexural Modulus In Gpa	Flexural strength In (N/ mm^2)
	Kg	N	In Divisions	In mm		
1	0	0	0	0	0	113.61
2	1	9.81	112	1.12	13.39	
3	2	19.62	221	2.21	14.41	
4	3	29.43	300	3.00	15.14	
5	4	39.24	390	3.90	15.99	
6	5	49.05	470	4.70	16.73	
7	6	58.86	560	5.60	17.58	
8	7	68.67	640	6.40	18.32	
9	8	78.48	1050	10.5	22.16	
10	9	88.29	1140	11.4	23.00	
11	10	98.1	1220	12.2	23.75	
12	11	107.91	1320	13.2	24.68	

5.4 Water Absorption Behavior of Composite**:**

The water absorption characteristics of sisal with glass additives hybrid fiber reinforced polyester composite were studied by immersion in distilled water at room temperature for 3, 6, 9 and 12 hours. The test specimens (25 mmx25 mm) were cut from composite and tested for water absorption as per ASTM D- 570. Edges of the sample were sealed with polyester resin. Samples were dried for 24 hours at 50^{o}C. After 24 hours samples were weighed accurately. Conditioned samples were then immersed in distilled water at room temperature for 3, 6, 9 and 12 hours. Samples were taken out of water after appropriate time period and wiped with a tissue paper to remove surface water. They were then weighed. Water absorption can be calculated by following formula: Moisture absorption % = W2-W1/W1 *100, W1=Initial weight of composite, W2=Final weight of composite.

Table.7. *Observation For Water Absorption Test:*

S.No	Time (Hours)	Weight of the Specimen 1 (g)	Weight of the Specimen 2 (g)
1	0	40	43
2	3	40.22	43.18
3	6	40.35	43.28
4	9	40.52	43.37
5	12	40.65	43.54

Table.8. *Tabulated Result for Water Absorption Test:*

S.No	Material	Amount Of Water Absorbed (g)	Percentage Of Water Absorbed (%)
1	Specimen 1	0.65	1.62%
2	Specimen 2	0.54	1.25%

Table.9. *Comparisons Of Sisal Fiber And Sisal/Glass Additives*

S.NO	Type Of Fiber	Impact Strength (N/mm)	Percentage Of Water Observed (%)	Tensile Strength (N/ mm^2)	Flexural Strength (N/ mm^2)
1	**Sisal**	230	1.62%	10.58	82.63
2	**Sisal With Additives**	300	1.25%	13.46	113.61

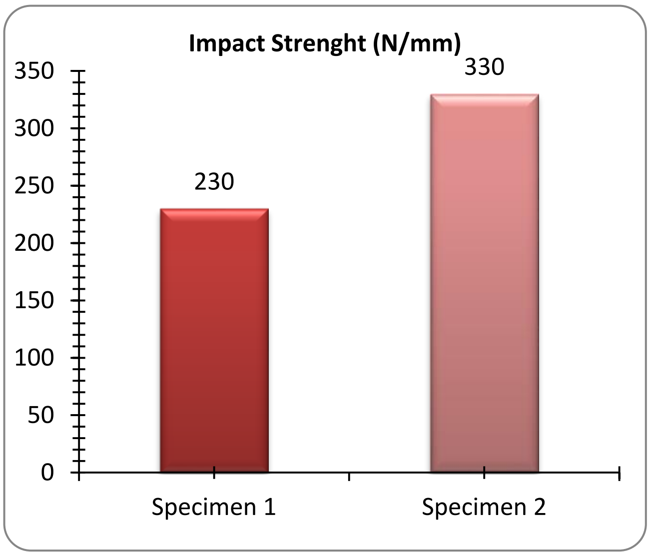

Fig .5. *Impact Strength N/mm*

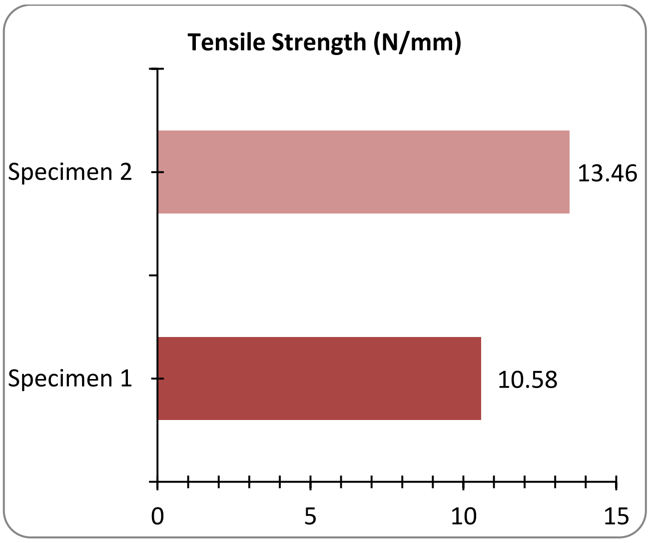

Fig.6.*Tensile Strength N/mm*^{2}

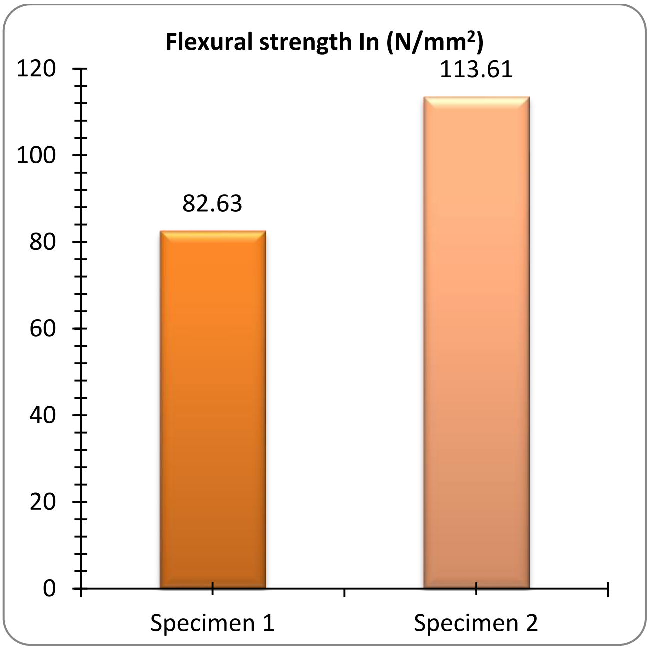

Fig.7. *flexural strength N/mm*^{2}

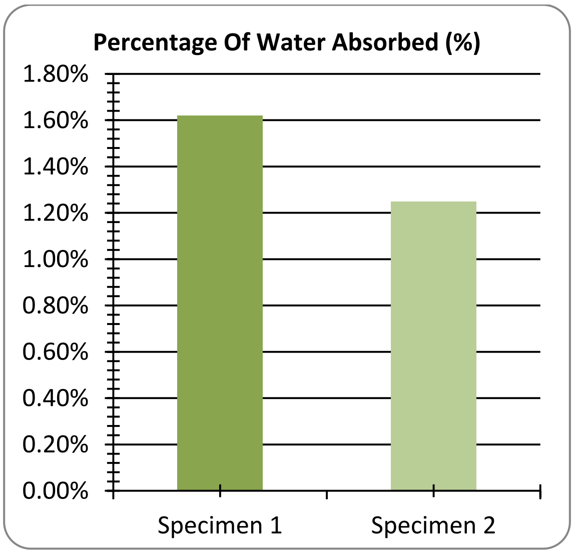

Fig.8. *Percentage of Water Absorbed (%)*

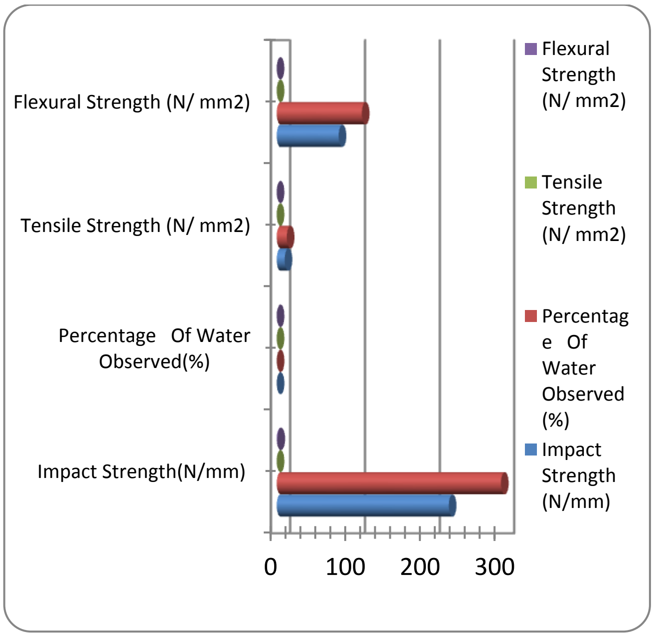

Fig.9. *Comparisons of Sisal Fiber And Sisal/Glass Additives*

VI CONCLUSION

The use of sisal fiber as reinforcing agent in polymer based composites were reviewed from viewpoints of status and future expectations of natural fibers in general, structure and properties of sisal fiber, fiber surface modifications, and physical and mechanical properties of sisal fiber based polymer composites. Sisal fibers have good potential as reinforcements in polymer (thermoplastics, thermoset and rubbers) composites. Due to the low density and high specific properties of sisal fibers, composites based on these fibers may have very good implications in the automotive and transportation industry. Natural fibers, when used as reinforcement, compete with such technical fibers as glass fiber. The advantages of technical fibers are good mechanical properties; which vary only little, while their disadvantage is difficulty in recycling. Several natural fiber composites reach the mechanical properties of glass fiber composites, and they are already applied, e.g., in automobile and furniture industries. Natural Fibers are renewable raw materials and they are recyclable.

However, suitable cost-effective design and fabrication techniques for manufacture should be developed. Sisal fiber polymer composites with and without hybridization should be developed and characterized so as to arrive at a series of composites which may find use in several areas such as marine, structural, consumer articles and industrials applications.

Hand lay-up technique can be used for the preparation of composite specimens successfully. Sisal individual fiber reinforced composites after adding additives is better choice than other composites studied because it shows highest tensile strength and tensile modulus and impact strength.

The highest value of tensile strength, flexural strength and impact strength were obtained for sisal fiber composites with glass additives. The mechanical properties of natural fiber sisal composites were significantly improved by glass additives. From the results of this study, the following conclusions were drawn: The composites sisal layers of glass additives at the extreme plies and sisal mat exhibited higher value of mechanical properties, whereas the sisal mat without glass additives plies exhibited slightly less value of mechanical properties. The sisal layers with glass additives offered higher breaking resistance than the sisal mat without glass additives specimen.

The compressive strength and impact strength of unsaturated polyester based sisal/ glass additives hybrid composite have been studied as a function of fiber content. It is observed that the compressive and impact strength of sisal/glass additives hybrid component is higher than sisal fiber reinforced composite, but lower than the glass reinforced composite. When the load is applied on sisal/glass additives hybrid composite, first sisal fiber fails then the load is transferred to glass fiber. So that the presence of glass additives in the sisal /glass additives hybrid composite causes to improve the impact and compressive strength. At the same time the presence of sisal fiber in hybrid composite the causes to decrease the compressive and impact strength than the glass fiber composite. The effect of additives on compressive and impact strength of sisal/glass additives hybrid composite has also been studied and it is observed that as the additives quantity by weight of resin increases then the compressive and impact strengths decrease. Thus it can be concluded that with systematic and persistent research there will be a good scope and better future for sisal fiber – polyester composites in the coming years.

VII REFERENCES

[1] SILVA F.A., CHAWLA N., AND TOLEDO FILHO R.D., 2008. “Tensile behaviour of high performance natural (sisal) fibres. Composites Science and Technology” 68, pp.3438- 3443.

[2] Arbelaiz A, Fernandez B, Cantero G, Llano-Ponte R, Valea A and Mondragon I (2005) “Mechanical properties of flax fiber/poly propylene composites. Influence of fiber/matrix modification and glass fiber hybridization.” Composites Part A. 36, 1637-1644.

[3] Arifuzzaman Khan GM, Shaheruzzaman Md., Rahman MH, Abdur Razzaque SM, Sakinul Islam Md. And Shamsul Alam Md. (2009)” Surface modification of okrabast fiber and its Physico-chemical characteristics. Fibers & Polymers.” 1, 65-70.

[4] Arup Choudary, Sandeep Kumar and basudam adhikari (2007) “Recycled milk pouch and virgin LDPE/Linear LDPE based coir composites.” J. App. Poly. Sci. 106, 775-785.

[5] Baley C (2002)” Analysis of flax fibers tensile behavior and analysis of the tensile stiffness increase.” Composites Part A. 33, 939-348.

[6] Beckermann GW and Pickering K L (2008) “Engineering and evaluation of hemp fiber reinforced poly propylene composites: Fiber treatment and matrix modification” Composites Part A. 39, 979-988.

[7] Cao Y, Shibata S and Fukumoto I (2006) “Mechanical properties of biodegradable composites reinforced with bagasse fiber before and after alkali treatments.” Composites Part A. 37, 423-429.

[8] Demir H, Atikler U, Balkose D and Tihminlioglu (2006) “The effect of fiber surface treatments on tensile and water sorption properties of polypropylene-luffa fiber composites.”Composites Part A. 37, 447-456.

[9] Hamid Kaddami, Alain Dufresne, Bertine Khelifi, Abdelkader Bendahou, Moha Taourirte, Mustapha Raihane, Nathalie Issartel, Henry Sautereau, Jean- Francois Gerard, Noureddine Sami (2006) Short palm tree fibers – Thermoset matrices and composites. Composites Part A. 37, 1413-1422.

[10] Harriette L. Bos, Jorg Mussig, Martien JA and Van den Oever (2006) Mechanical properties of short-flax-fiber reinforced compounds. Composites Part A. 37, 1591- 1604.

[11] Munikenche Gowda T, Naidu ACB and Rajput Chhaya (1999) Some mechanical properties of untreated jute fabric-reinforced polyester composites. Composites Part A. 30, 277-284.

[12] Mohanty A. K., Misra M., Drzal L. T.: Surface modifications of natural fibers and performance of the resulting biocomposites: An overview. Composite Interfaces, 8, 313–343 (2001).

[13] Joseph K., Thomas S., Paul A.: Effect of surface treatments on the electrical properties of low-density polyethylene composites reinforced with short sisal fibers. Composites Science and Technology, 57, 67–79 (1997).

[14] Luyt A. S., Malunka M. E.: Composites of low-density polyethylene and short sisal fibres: the effect of wax addition and peroxide treatment on thermal properties. Thermochimica Acta, 426, 101–107 (2005).

[15] Kalaprasad G., Joseph K., Thomas S., Pavithran C.: Theoretical modelling of tensile properties of short sisal fibre-reinforced low-density polyethylene composites. Journal of Materials Science, 32, 4261–4267 (1997).

[16] Pal S., Mukhopadhayay D., Sanyal S., Mukherjea R.: Studies on process variables for natural fibre composites- effect of PEAP as interfacial agent. Journal of Applied Polymer Science, 35, 973–985 (1988).

[17] Bisanda E. T. N.: The effect of alkali treatment on the adhesion characteristics of sisal fibres. Applied Composite Materials, 7, 331–339 (2000).

[18] Joseph P. V., Joseph K., Thomas S.: Short sisal fiber reinforced polypropylene composites: the role of interface modification on ultimate properties. Composite Interfaces, 9, 171–205 (2002).

[19] Fung K. L., Xing X. S., Li R. K. Y., Tjong S. C., Mai Y-W.: An investigation on the processing of sisal fibre reinforced polypropylene composites. Composites Science and Technology, 63, 1255–1258 (2003).

[20] Wei C., Mu Q-H., Luo W-H.: Influences of treatment methods for sisal stems on properties of sisal fiber/formaldehyde resin composites. China Plastics, 17, 44–47 (2003).

[21] Niu Y-L., Zhong J-B., Yang X-W., Yu X-B., Wei C.: Effect of sisal fiber contents on wear resistance of sisal fiber/phenol formaldehyde resin in-situ composites. in 'Proceedings of 2005 International Conference on Advanced Fibers and Polymer Materials, Shanghai, China', 411–414 (2005).

[22] Zhong J-B., Niu Y-L., Lü J., Wei C.: Effect of steam explosion treatment on mechanical properties of sisal fiber/phenol-formaldehyde resin composite. China Plastics Industry, 34, 53–55 (2006).

[23] de Rodriguez N. L. G., Thielemans W., Dufresne A.: Sisal cellulose whiskers reinforced polyvinyl acetate nanocomposites. Cellulose, 13, 261–270 (2006).

[24] Alvarez V., Vazquez A., Bernal C.: Effect of microstructure on the tensile and fracture properties of sisal fiber/starch-based composites. Journal of Composite Materials, 40, 21–35 (2006).

[25] Mishra S., Mohanty A. K., Drzal L. T., Misra M., Parija S., Nayak S. K., Tripathy S. S.: Studies on mechanical performance of biofibre/glass reinforced polyester hybrid composites. Composites Science and Technology, 63, 1377–1385 (2003).