A REVIEW PAPER ON EVALUTION OF MECHANICAL PROPERTIES BY INCORPORATING FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT

For the potential use and new applications of natural fibre reinforced plastics, it is crucial that the mechanical behavior of these composites is fully understood. Single fibre fragmentation tests were carried out to compare the fragmentation phenomenon in two natural fibres/polypropylene (PP) composites. Polypropylene was used with maleic anhydride (MAPP) as a coupling agent for this study. The SFFT test results are significantly affected by both sample preparation method and testing conditions. Therefore, the influence of sample preparation, gauge length as well as strain rate were studied. By considering test reproducibility and practical findings, a gauge length of 15.5 mm and a test speed of 0.2 mm/min were selected for interfacial shear strength (IFSS) characterization. Owing to the stiff nature of flax and ramie fibre, Weibull distribution was used to analyze fibre strength statistics

Keyword : - *Natural fibre, Fibre/matrix adhesion, Fragmentation, Interfacial shear strength*.

1. INTRODUCTION

Since the beginning of human existence people have developed plant fiber composites. These composites were used as a source of energy, to make shelters, clothes, construct tools and produce weapons. In ancient Egypt, 3000 years ago, clay was reinforced by straw to build walls. These composites were produced in simple shapes and easy structures by positioning the structural elements on top of each other to create the desired design. Some creative designs were also made but they were limited in shape and weight of the structural elements. Glue laminated beams were also introduced using in adhesive in 1893 in Basel, Switzerland.

In general, all these products were produced in flat sheets and in two-dimensional designs. Later on, the natural fiber composite lost much of its interest because more durable construction materials like metals were introduced. Engineering fiber composites were first used in 1940 when strong continuous filament glass fiber and unsaturated polyester resins became available. The rise of these composite materials began when glass fiber in combination with tough rigid resins could be produced on large scale. These fibers are being used as reinforcing agents in both thermosetting and thermoplastic polymers in automotive, aeronautical and aerospace industries In recent years, there has been a renewed interest in the natural fiber as a substitute for glass fiber because of the potential advantages of weight saving, lower raw material price, recyclable and renewable properties. Natural fiber reinforced plastic composites have been increasingly utilized in quite widespread applications. For example, hemp, jute, flax and sisal fibers are already used in automotive industry.

It has been estimated that there are at least 1000 types of plant that produce usable fibers or fiber bundles. However, the numbers that are currently grown, specifically for fiber production are relatively small. Natural fibers are obtained from different parts of the plants, e.g. palm-archontophoenix-beatrice fiber, jute, ramie, flax, kenaf and hemp are obtained from the stem. Sisal, banana and pineapple from the leaf, cotton and kapok from seed, coir from the fruit etc.

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.

1.1 Classification of Natural Fibers

Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope. They can be used as a component of composites materials. They can also be matted into sheets to make products such as paper or felt. Fibers are of two types: natural fiber and manmade or synthetic fiber. Natural fibers include those made from plant, animal and mineral sources.

Natural fibers can be classified according to their origin.

- Animal fiber
- Mineral fiber
- Plant fiber

1.2 Structure and Chemical Constituents of Natural Fiber

All plant species are built up of cells. When a cell is very long in relation to its width it is called a fiber. The components of natural fibers are cellulose, hemicellulose, lignin, pectin, waxes and water-soluble substances. The cellulose, hemicellulose and lignin are the basic components of natural fibers, governing the physical properties of the fibers.

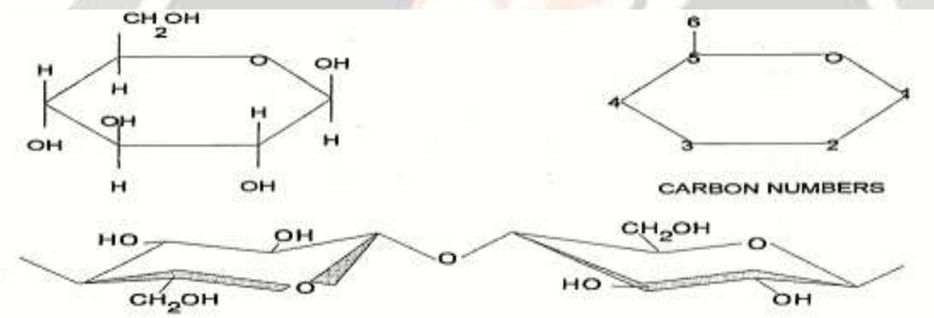

Figure 1.1 The chemical structure of glucose showing the carbon numbers and two glucose to form cellobiose.

1.3 Properties of Natural Fiber

Natural fibers have always found wide applications from the time they gained commercial recognition. Their versatility is based on the following desirable material properties. Plant fibers are a renewable raw material and their availability is more or less unlimited.

(a) Their mechanical properties, especially tensile strength in relation to their weight.
(b) Very good heat, acoustic and electrical insulating properties.
(c) As a result of their tendency to absorb water, natural fibers will biodegrade under certain circumstances through the actions of fungi and/or bacteria.
(d) The abrasive nature of natural fiber is much lower compared to that of glass fiber, which leads to advantages with regard to technical, material recycling or processing of composite materials in general.
(e) The hydroxyl groups present in the cell wall constituents not only provide sites for water absorption but also chemical modification (e.g. introduction of dimensional stability, durability or improved oil/heavy metal absorption properties).

1.5 End Use and Economics of Natural Fiber Composites

a) Comparative weight reduction of 10-30% in comparable parts.
b) Good mechanical and manufacturing properties.
c) The possibility of forming complex components.

d) Relatively good impact performance with high stability and minimal splintering.
e) Occupational health advantages in assembly and handling compared to glass fiber where airborne glass particles can cause respiratory problems.
f) Moulding off cuts can be re-used unlike fiber glass.

2. LITERATURE REVIEW

A.K. Bledzki, J. Gassan [1] has reported that hemicellulose and lignin can be removed by hydrothermolysis or alkali reactions. The hemicellulose is responsible for a great amount of the moisture absorption. The lignin is the connecting cement between the individual fiber cells.

Anders Thygesen [2] has worked on hemp fiber polymer composites and reported that the hemp has been cultivated for at least 6000 years and it may be one of the oldest non-food crops. The most usual purpose of hemp cultivation is to isolate the fibers present in the bark on the hemp stem surface for production of ropes, textiles and paper. Other useful materials from hemp are the seed, which can be used for oil production and cannabinoids for medical, spiritual and recreational purposes. The strength of single fibers of hemp is only 800-2000 MPa. The chemical and physical property of fiber and composite of hemp are collected for the comparison with palm.

Andrzej K. Bledzki [3] has worked on PLA (Polylactide) biocomposites with abaca and man-made cellulose fibers were processed by using combined moulding technology, two-step extrusion coating process and consecutively injection moulding. By adding 30 wt% of man-made cellulose, the Charpy impact strength at ambient temperature increased by factor 3.60, compared to unreinforced PLA. Tensile strength rose by factor 1.45 and stiffness by approx. 1.75. Reinforcing with abaca fibers (30 wt %) enhanced both E-Modulus and tensile strength by factor 2.40 and 1.20, respectively. The Charpy A-notch impact resistance of PLA/abaca could be improved by factor 2.4.

Carlo Santali [4] a survey is given on some aspects, crucial for the use of glass/plant fiber hybrid laminates in structural components, performance of hybrids when subjected to impact testing, the effect of laminate configuration, and manufacturing procedure and fiber treatment on impact properties of the composite. Finally, indications are provided for a suitable selection of plant fibers with minimal extraction damage and sufficient toughness, for introduction in an impact resistant glass/plant fiber hybrid laminate.

C. Gonzalez [5] has worked on the effect of joint geometry on the strength of natural fiber composite joints. Epoxy-bonded single lap shear joints (SLJs) between henequen and sisal fiber composite elements were manufactured and tested in tension to assess the shear strength of the structural bonds. The performance of co-cured joints, termed ‘‘intermingled fiber joints” (IFJs) and ‘‘laminated fibre joints” (LFJs) was also evaluated. These IFJ and LFJ configurations possess much higher lap shear strengths than the single lap shear joints and the failure modes of the three joint configurations are compared. SLJ and LFJ joints have been modeled using finite element analysis, allowing interpretation of the experimental observations

D. Bachtiar [6] studied the effect of alkaline treatment on tensile properties of sugar palm fibre reinforced epoxy composites is presented in this paper. The treatment was carried out using sodium hydroxide (NaOH) solutions at two different concentrations and three different soaking times. The composite specimens were tested for tensile property determination. Some fractured specimens were examined under scanning electron microscope (SEM) to study the microstructure of the materials. Inconsistent results were obtained for tensile strengths, which indicate that the treatment is not very effective yet to improve the interfacial bonding.

Goulart S.A [7] has reported that harvesting palm for paper pulp and textiles. Palm seeds are used for food and oil production while palm fibers are used to make woven or non-woven fiber mats for textile or technical use. In addition, palm stems can be used for building applications. The moisture content at the time of harvesting is about 54%. For storage of dry palm, the moisture content must be less than 15% to avoid fiber decay by micro-organisms. The crop is cut, and then the stalks are allowed to rett in the field to loosen the fibers. During this process, most of the nutrients extracted by the plant are returned to the soil as the leaves decompose.

Moshibudi Caroline Khoathane [8] has reported that a number of viable alternative materials for composites material applications do exist. Some have been tested and used more extensively than others. Many researchers have found that the conditioning, the manufacturing process, specific surface, the content of added fiber and the processing parameters are the most important influencing factors on the mechanical properties of the final product. In addition, the results of the mechanical properties of the composite material are dependent on the type of compatibiliser used.

R.C. Ghai, J.S. Jangi [9] has worked on banana fiber reinforced composite material. Banana fiber has been prepared manually. Banana fiber composite materials are developed for various percentage of banana fiber content. Optimum percentage of banana fiber content is obtained to give the best results for tensile strength tests. Other tests were carried out on this percentage of banana fiber content which was found to be 28% by weight of resin. Detailed analysis of the results is done regarding the mechanical properties of 28% banana fiber composite material.

Stamboulis. A [10] has reported that the chemical constituents of plant fiber have specialised functions in the cell wall. Cellulose forms strong and stiff crystalline regions, cellulose and hemicellulose form semi-crystalline regions, which provide necessary flexibility while the amorphous regions of lignin give toughness and cohesion.

Sangeeta Nangia, Soumitra Biswas [11] has worked on jute and glass fiber and reported that the tensile strength and young's modulus of jute are lower than those of glass fibers, the modulus of jute fiber is superior to that of glass. Therefore, where high strength is not a priority, jute may be used to fully or partially replace glass fiber without entailing the introduction of new techniques of composite fabrication.

V.S. Sreenivasan [12] In this work composites were fabricated using raw short Sansevieria cylindrical fibers (SCFs) with varying fiber lengths and weight percents of fiber. When the length of the SCFs was increased, the tensile, flexural and impact properties of the composite were increased up to a 30-mm fiber length, and then a curtailment in properties occurred for higher fiber length composites. SCFP composites showed a regular trend of an increase in properties with fiber weight percent until 40% and afterwards a decrease in properties for composites with greater fiber weight percent.

Gassan. J [68] the influence of the fiber-matrix adhesion in jute fiber-reinforced polypropylene on the materials behavior under fatigue and impact loadings was investigated throughout this study. It was shown that a strong interface is connected with a higher dynamic modulus and reduction in stiffness degradation with increasing load cycles and applied maximum stresses. The specific damping capacity resulted in higher values for the composites with poor bonded fibers. Furthermore, the stronger fiber-matrix adhesion reduced the loss-energy by non-penetrati -on impact tested composites with roughly 30%. Tests which were performed at different temperatures, showed higher loss energies for cold and warm test conditions compared with room temperature.

Jae Gyoung Gwon [69] has worked on chemical modification of the wood fiber with NaOH and various coupling agents were performed for wood fiber composites. Wood fibers treated with NaOH, APTES, TEVS, and BC coupling agents were compounded with PP matrix for measuring physical properties. All those chemical treatments increased physical properties much compared to the untreated case because of the elimination of impurities by NaOH treatment and because of the introduction of compatible molecular structure onto the wood fiber surfaces.

John Leslie dowel [70] has reported that the palm fiber is obtained from the stem of the plant palm, which was originated from Mexico and is now mainly cultivated in East Africa, Brazil, Haiti, India and Indonesia. It is grouped under the broad heading of the "Hard Fibers". It is one of the most extensively cultivated hard fibers in the world. The reason is due to the fact that palm plants grow easily in all kinds of environments and have short renewing times. Another remarkable environmental benefit of growing palm is that it consumes carbon dioxide and it is an ideal rotation crop. Palm grows successfully at a density of up to 150 plants per square meter and reaches a height of between two and five meters in a three-month growing season. Comparison the chemical composition of plant fibers is also important, since it can affect their ultimate utilisation.

Krishnan Jayaraman [76] has worked on sisal–polypropylene composites and suggested that Common methods for manufacturing natural fiber-reinforced thermoplastic composites, injection moulding and extrusion, tend to degrade the fibers during processing. Development of a simple manufacturing technique for sisal fiber-reinforced polypropylene composites, that minimizes fiber degradation and can be used in developing countries, is the main objective of this study. Composite sheets with a fiber length greater than 10 mm and a fiber mass fraction in the range 15% to 35% exhibited good mechanical properties.

3. MATERIALS AND METHODS

Composite material signifies that two or more materials are combined on a macroscopic scale to form a useful material. Composite materials exhibit best qualities of their constituents and often some qualities that neither constituent possess. The properties that can be improved by forming a composite material include the following:

- Strength
- Stiffness
- Corrosion resistance
- Wear resistance
- Attractiveness
- Weight
- Fatigue life
- Temperature-dependent behavior
- Thermal insulation
- Thermal conductivity
- Acoustical insulation

Plant fiber	Plant fiber% wt.	Max. total fiber % wt	Manufacturing method
Bamboo	15–35	40	Injection moulding
Bamboo	9–15	30	Compression moulding
Banana	25–37	40	Vacuum impregnation & hand-layup
Coir	30	45	Pre-preg and punch pressing
Flax	20–44	50	Hot pressing
Jute	16–33	75	Filament winding
Jute	14.5–31	30	Hand lay-up
Jute	25–27	35	Compression moulding
Oil palm	4–36	40	Vacuum impregnation
Oil palm	8–32	40	Pre-preg & Intermingled mats
Palmyra	48	48	Hand lay-up
Sisal	6–14	20	Compression moulding
Sisal	2–6	14	Hand lay-up
Sisal	4–16	20	Injection moulding after
Flax	6–31	41	Compression moulding

Table 3.1 *Various fibers with their manufacturing methods*

3.1 Advantages of fiber-reinforce composite materials

Following are the advantages of fiber reinforced composite materials:
a)Low specific weight, resulting in a higher specific strength and stiffness than glass fiber.
b)It is a renewable source, the production requires little energy, and CO2 is used while oxygen is given back to the environment.
c)Producible with low investment at low cost, which makes the material an interesting product for low wage countries.
d)Reduced wear of tooling, healthier working condition, and no skin irritation.
e)Thermal recycling is possible while glass causes problem in combustion furnaces.

4. CONCLUSIONS

- The numbers of fibers are more and dense at outer periphery than the inner periphery. The average density of fiber is 0.846 gm / cm3 whereas the diameter of fiber is 1.12 mm. At this diameter the tensile strength is 152.43 MPa which is better than coir and banana.
- The fibers near the outer periphery are almost circular, whereas the same at the inner portion are elliptical.
- The abrasive nature of palm fibers is much lower compared to that of glass fibers, which leads to advantages with regard to technical, material recycling or process of composite materials in general.

5. FUTUREWORK

- New method of manufacturing employing spraying technique, compression moulding or other effective way may be developed; where the percentage of fiber use is increased by maintaining homogenous distribution of resin in the PFCM.
- The strength can be increased by surface treatment of fiber.
- The hybrid composite can be manufactured.

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