A Review on Natural Fiber Reinforced Polypropelyne Composites: Application and Characteristic

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Abstract- *Modern scientific tools revolutionized the processing of polymers thus available synthetic polymers like useful plastics, rubbers and fiber materials. As with other engineering materials (metals and ceramics), the properties of polymers are related their constituent structural elements and their arrangement. The suffix in polymer 'mer' is originated from Greek word meros – which means part. The word polymer is thus coined to mean material consisting of many parts/mers.*

Natural Fiber-reinforced polymer matrix composites have gained commercial success in the semi structural and structural applications such as aircraft, automobiles, sporting goods, electronics, and appliances are quite dependent on natural fiber-reinforced plastics, and these composites are routinely designed, manufactured and used in place of synthetic fiber reinforced polymer composites.

The objective of this paper is to study the behaviour of composite materials. This chapter introduces classification of polymers, processing and synthesis of polymers, followed by mechanism of deformation and mechanical behaviour of polymers.

Keywords:- Composites, Polymers, Natural Fibers, Synthetic Fibers, Polymer Matrix Composites

I. INTRODUCTION

Composites can be defined as materials that consist of two or more chemically and physically different phases separated by a distinct interface. The different systems are combined judiciously to achieve a system with more useful structural or functional properties non attainable by any of the constituent alone. These separate constituents act together to give the necessary mechanical strength or stiffness to the composite part. Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents.

Polymeric materials reinforced with synthetic fibers such as glass, carbon, and aramid provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. wood, concrete, and steel. Despite these advantages, the widespread use of synthetic fiber-reinforced polymer composite has a tendency to decline because of their high-initial costs, their use in non-efficient structural forms and most importantly their adverse environmental impact. On the other hand, the increase interest in using natural .bres as reinforcement in plastics to substitute conventional synthetic .bres in some structural applications has become one of the main concerns to study the potential of using natural fibers as reinforcement for polymers. In the light of this, researchers have focused their attention on natural fiber composite (i.e. bio-composites) which are composed of natural or synthetic resins, reinforced with natural fibers. Accordingly, manufacturing of high-performance engineering materials from renewable resources has been pursued by researchers across the world owning to renewable raw materials are environmentally sound and do not cause health problem. The present work includes the processing, characterization of coconut fiber reinforced epoxy composites. . It further outlines a methodology based on Taguchi's experimental design approach to make a parametric analysis of erosion wear behaviour. The systematic experimentation leads to determination of significant process parameters and material variables that predominantly influence the wear rate.
The volume and number of applications of composite materials have gr own 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.

The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years.

For certain applications, the use of composites rather than metals has in fact resulted in savings of both cost and weight. Some examples are cascades for engines, curved fairing and fillets, replacements for welded metallic parts, cylinders, tubes, ducts, blade containment bands etc. Further, the need of composite for lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases dead weight but also absorbs the shock & vibration through tailored microstructures. Composites are now extensively being used for rehabilitation/ strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects. The design of a structural component using composites involves both material and structural design.

II. BACKGROUND/ HISTORY

For thousands of years, natural fibres have been at the core of the industry. From cloth, to paper and building materials, natural fibres were always the base material. Over the last fifty years composite materials, plastics and ceramics have been the dominant emerging materials and natural fibres have started to become displaced by synthetic, man-made materials such as polyester, acrylic and nylon. These materials are much cheaper and easier to manufacture in bulk, and easily create uniform colors, lengths and strengths of materials that can be adjusted according to specific requirements.

The first composite material known was made with clay and straw to build walls in Egypt 3,000 years ago. Fibres such as jute, sisal, coir and kapok only started to be imported into Europe from the nineteenth century. The common nettle has a long history as a source of fibre. Archaeological remains in Denmark and Britain show that it was used for string and cloth in Neolithic times. In post-medieval times drag nets for fishing were made of nettle fibre. Nettle cloth was manufactured in Scandinavia and Scotland from early times until the 19th century and was known as Scotch cloth in Britain. Shortages of cotton during the First World War forced the Germans to use nettles to make fabric. Hemp and linen are amongst the oldest plants used for fabric products. Hemp was cultivated in China in 2,800 BC. Cotton has been produced in India for millennia and was introduced into Europe in the 1300s. Some of the more recently introduced natural plant fibres reflect their origins and distribution. Jute originated in India and its name is Bengali meaning 'braid of hair'. The name 'ramie' comes from the Malay and has been variously known as grass linen, China linen and grass cloth. Another Malay word that has given itself to a fibre is 'kapok'. Kapok is a silky fibre from the east Indian tree which is sometimes called silk cotton or Java cotton. Phormium is the mane of the fibre from an evergreen tree native to New Zealand - also known as New Zealand flax.

The Swiss Lake Dwellers in 8000 BC cultivated flax and wove linen into fabrics. By 3000 to 2000 BC, the use of fibers was well developed, and the weaving of cotton was well established in India and Pakistan. Improvements in machines for spinning, weaving, etc., beginning in the 1700s, revolutionized the processing of fibers. Eli Whitney's invention of the cotton gin in 1793 helped cotton become king of the fibers. In recent decades the textile industry was revolutionized again by many technological developments, including the creation of synthetic and modification of natural fibers. Today the world and United States fiber markets are dominated by the natural and man-made fibers, respectively. In spite of gains by the man-made fibers, both the world and United States production of cotton increased during the decade of the seventies.

History of PP

Phillips Petroleum chemists J. Paul Hogan and Robert L. Banks first polymerized propylene in 1951. Propylene was first polymerized to a crystalline isotactic polymer by Giulio Natta as well as by the German chemist Karl Rehn in March 1954. This pioneering discovery led to large-scale commercial production of isotactic polypropylene by the Italian firm Montecatini from 1957 onwards. Syndiotactic polypropylene was also first synthesized by Natta and his coworkers.

Polypropylene is the second most important plastic with revenues expected to exceed US$145 billion by 2019. The sales of this material are forecast to grow at a rate of 5.8% per year until 2021.

III. COMPOSITES

A typical composite material is a system of materials consisting of two or more materials (mixed and bonded) on a macroscopic scale.

- Composites are a combination of two materials in which one of the material is called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other material called the matrix phase.
- Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material.

Hybrid Composites

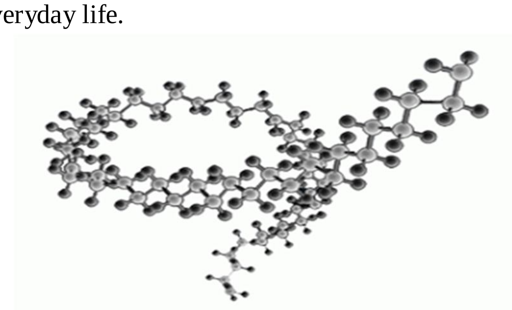
Hybrid composites are those composites that have a combination of two or more reinforcement materials (continuous or fragments) in a matrix or binder. This type of composite is usually used when a combination of properties provided by different types of fibers is desired, or when longitudinal as well as lateral mechanical performances are required.

Mixing or hybridizing different types of reinforcement fibers within a structure can be accomplished in two ways: 1) interply hybridization, where layers (lamina) of different fiber types are laminated together, and 2) intraply hybridization, where different fiber types are mixed within the individual layers (lamina).

Composite materials represent acoustically and thermally heterogeneous materials where a variety of defects with different dimensions may be formed. Typical defects of composite materials include fiber breaks, micro cracks, micro splits, foreign objects, and pores in the bonding medium, and detachment of fibers from the bonding material.

IV. POLYMER

- A polymer is a large molecule composed of many repeated subunits, known as monomers. Because of their broad range of properties, both synthetic and natural polymers play an essential and ubiquitous role in everyday life.



Polymerization is the process of combining many small molecules known as monomers into a covalently bonded chain or network. During the polymerization process, some chemical groups may be lost from each monomer.

Most of the polymers are basically organic compounds, however they can be inorganic (e.g. silicones based on Si-O network).

Modification of natural polymers

Naturally occurring polymers such as cotton, starch and rubber were familiar materials for years before synthetic polymers such as polyethene and perspex appeared on the market.

Polymer properties

Polymer properties are broadly divided into several classes based on the scale; Physical basis which describes its identity of constituent monomers and microstructure. Chemical basis, at the nano-scale, describe interaction at various physical forces and at the macro-scale, the bulk polymer interacts with other chemicals and solvents.

Standardized polymer nomenclature

Basically two types of Industrial Plastics and their subtypes are used:

a) Thermo plastics

1. Acrylonitrile-butadiene-styrene (ABS):

Characteristics: Outstanding strength and toughness, resistance to heat distortion; good electrical properties; flammable and soluble in some organic solvents.

Application: Refrigerator lining, lawn and garden equipment, toys, highway safety devices.

2. Acrylics (poly-methyl-methacrylate)

Characteristics: Outstanding light transmission and resistance to weathering; only fair mechanical properties.

Application: Lenses, transparent aircraft enclosures, drafting equipment, outdoor signs

3. Fluorocarbons (PTFE or TFE)

Characteristics: Chemically inert in almost all environments, excellent electrical properties; low coefficient of friction; may be used to 260oC; relatively weak and poor cold-flow properties.

Application: Anticorrosive seals, chemical pipes and valves, bearings, anti-adhesive coatings, high temperature electronic parts.

4. Polyamides (nylons)

Characteristics: Good mechanical strength, abrasion resistance, and toughness; low coefficient of friction; absorbs water and some other liquids.

Application: Bearings, gears, cams, bushings, handles, and jacketing for wires and cables

5. Polycarbonates

Characteristics: Dimensionally stable: low water absorption; transparent; very good impact resistance and ductility.

Application: Safety helmets, lenses light globes, base for photographic film

6. Polyethylene

Characteristics: Chemically resistant and electrically insulating; tough and relatively low coefficient of friction; low strength and poor resistance to weathering.

Application: Flexible bottles, toys, tumblers, battery parts, ice trays, film wrapping materials.

7. Polypropylene

Types: Homopolymer, random copolymer and block copolymer.

Characteristics: Light, High heat resistance temp, Excellent chemical resistance, High bending fatigue strength (hinging resistance properties), Improved transparency, heat sealability and impact strength, improved low-temperature impact resistance, Improved rigidity at high temp, Low yield

Application: Injection molding, Film, Daily goods, Sheets, Transparent injection moldings, Home appliances, Automobiles, Industrial materials etc.

b) Thermo setting polymers

1. Epoxies

Characteristics: Excellent combination of mechanical properties and corrosion resistance; dimensionally stable; good adhesion; relatively inexpensive; good electrical properties.

Application: Electrical moldings, sinks, adhesives, protective coatings, used with fiberglass laminates.

2. Phenolics

Characteristics: Excellent thermal stability to over 150oC; may be compounded with a large number of resins, fillers, etc.; inexpensive.

Application: Motor housing, telephones, auto distributors, electrical fixtures.

Processing of Plastics

- Thermoplastic
  - can be reversibly cooled & reheated, i.e. recycled
  - heat until soft, shape as desired, then cool
  - ex: polyethylene, polypropylene, polystyrene.

- Thermoset
  - when heated forms a molecular network (chemical reaction)
  - degrades (doesn’t melt) when heated
  - a prepolymer molded into desired shape, then chemical reaction occurs
  - ex: urethane, epoxy

V. LITERATURE REVIEW

- Fatih Mengeloglu et.al., 2008, This study evaluated the thermal degradation of neat and wheat straw flour filled recycled thermoplastic composites. The study also investigated the effect of maleated polyolefins as a coupling agent on the mechanical properties and the morphology of recycled wheat straw flour filled recycled thermoplastic composites.
- Ramakrishna Malkapuram, et.al., 2009, This review article describes the recent developments of natural fiber reinforced polypropylene (PP) composites. The chemical, mechanical, and physical properties of natural fibers have distinct properties; depending upon the cellulosic content of the fibers which varies from fiber to fiber.
- Mei-po Ho, et.al., 2011, In this paper, different manufacturing processes and their suitability for natural fibre composites, based on the materials, mechanical and thermal properties of the fibres and matrices are discussed in detail.
- Gunti Rajesh, et.al., 2012, The present study evaluation of mechanical properties of untreated jute fiber reinforced PP composite are compared to plain PP and treated jute fiber reinforced composites.
- Thanh Duy Tran, et.al., 2013, here the effect of rice husk flour and maleic anhydride grafted polypropylene content on properties of composites was investigated.
- R. Siva Shankar, 2014, In this work, a review on the performances of wheat flour/wheat husk/wheat grain by adding natural fibers, composites are obtained by extrusion process. The mechanical, morphological, chemical, water absorption and thermal properties of biocomposites were studied.

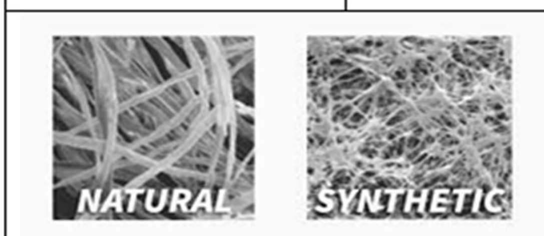
- Yashwant S. Munde, et.al., 2015, paper compares the different mechanical properties of NFRPC using practical model using compression moulding machine and practical results were made for ASTM D638-01 UTM, and theoretical models as parallel and series, Halpin-Tsai, for mechanical tensile test.
- Shailesh Kumar singh, et.al, 2015, this paper fabrication with Hand lay out method, flexure testing using UTM and application of Sunnhemp raw materials with PP has been discussed.

VI. METHODS FOR FABRICATION OF POLYMER COMPOSITES

– Hand Lay –Up Method
– Spray up moulding
– Compression moulding
– Injection Moulding
– Reaction Moulding
– Pultrusion
– Filament

VII. NATURAL FIBERS vs. SYNTHETIC FIBERS

Natural Fibers	Synthetic Fibers
Natural fibers are extracted from plants and animals	synthetic fibers are obtained by artificial or man-made processes
Natural fibers are found on creatures like sheep and silk worms,	synthetic threads must be produced using laboratory procedures.
Natural polymeric materials such as wool, silk and natural rubber have been used for centuries. A variety of other natural polymers exist, such as cellulose or Lignocelluloses, Animal Based (Protein), Minerals which is the main constituent of wood and paper	Synthetic polymers include synthet ic rubber, nylon, PVC, poly ethylene, polypropylene, silicone, and many more.
Examples of natural fibers are sheep's wool and linen that comes from plants.	Examples of synthetic fibers are acrylic and nylon.



ADVANTAGES

Natural Fibers	Synthetic Fibers
1. Comfortable Clothes made by natural fibres are more comfortable than those made by synthetic fibres. 2. Environment Producing materials from natural fibres are less harmful to our environment. 3. Fire resistant Natural fibres are resistant to fire but polymer based fibres will melt.	1. Strong Synthetic fibres are strong so they can take up heavy things easily. 2. Retain their original shape Synthetic fibres retain their original shape so it's easy to wash and wear. 3. Elastic Can easily be stretched out. 4. Soft Synthetic fibres are generally soft so they are used in clothing materials. 5. Colour Varieties of colours are available as they are manufactured. 6. Cost Clothes made by synthetic fibres are generally cheaper than those made by natural fibres.

DISADVANTAGES

Natural Fibers	Synthetic Fibers
1. Expensive Materials produced by natural fibres are generally expensive as synthetic fibres can be made easily by manufacturing. 2. Shrink Natural fibres might shrink due to aggressive washing.	1. Does not absorb moistures Synthetic fibres do not absorb sweat, trapping heat in our body. 2. Rough feel Synthetic fibres may give rough feel, making it unsuitable for pyjamas, underwear, etc.

VIII. APPLICATIONS OF NATURAL FIBER COMPOSITES

The reasons for the application of natural fibers in the automotive industry
include:

a. Low density: which may lead to a weight reduction of 10 to 30%?
b. Acceptable mechanical properties, good acoustic properties.
c. Favorable processing properties, for instance low wear on tools, etc.
d. Options for new production technologies and materials.
e. Favorable accident performance, high stability, less splintering.
f. Favorable ecobalance for part production.
g. Favorable ecobalance during vehicle operation due to weight savings.
h. Occupational health benefits compared to glass fibers during production.
i. No off-gassing of toxic compounds (in contrast to phenol resin bonded wood and recycled Cotton fiber parts).
j. Reduced fogging behavior.
k. Price advantages both for the fibers and the applied technologies.
l. Use of composite material is spreading from cutting edge technology to everyday applications like: fuel cylinder of natural gas, bridges and even in paper making rollers.
m. NFRP: Power generation and Transmission, bridge building, surface transportation, automobile railways and the telecommunication industries.

The natural fiber composites can be very cost effective material for following applications:

a. Building and construction industry, storage devices, furniture: chair, electric devices everyday applications, transportation, toys, etc.

IX. ADVANTAGES OF COMPOSITES

Advantages of natural fiber composites over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as strength-to-weight ratio. Some advantages of composite materials over conventional ones are as follows:

a. Tensile strength of composites is four to six times greater than that of steel or aluminium (depending on the reinforcements).
b. Low specific weight, resulting in a higher specific strength and stiffness than glass fiber.
c. It is a renewable source, the production requires little energy, and CO2 is used while oxygen is given back to the environment.
d. Producible with low investment at low cost, which makes the material an interesting product for low wage countries.
e. Reduced wear of tooling, healthier working condition, and no skin irritation.
f. Lower embedded energy compared to other structural metallic materials like steel, aluminium etc.
g. Thermal recycling is possible while glass causes problem in combustion furnaces.
h. Good thermal and acoustic insulating properties.

X. CONCLUSION AND DISCUSSION

The resistivity of fiber reinforced composites depend on the moisture content, crystalline and amorphous component present, presence of impurities, chemical composition, cellular structure, microfibrillar angle etc. The shapes of reinforcement determine the interparticle contact, which affect the conductivity of the system. This paper explains the study of history, uses and advantages of using natural fiber products for reduction in cost of product and to save the environmental problems faced by using with polymers. It has also been observed that natural fiber reinforced materials may be the good substitute of polymers.

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