“STUDY OF MECHANICAL PROPERTIES OF POLYPROPYLENE NATURAL FIBER COMPOSITE”

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By

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CERTIFICATE

This is to certify that the thesis work entitled **"STUDY OF MECHANICAL PROPERTIES OF POLYPROPYLENE NATURAL FIBER COMPOSITE"** submitted by **DANISH ANIS BEG, Enrollment No.** 1100101223 in partial fulfillment for the award of **Master of Technology** degree in **Mechanical Engineering Department** with specialization in Production and Industrial Engineering, to Integral University, Lucknow (U.P.). He has carried out his thesis work under my supervision and guidance and to the best of my knowledge; the matter embodied in this thesis has not been submitted to any other University/Institute for award of any degree to the candidate or to anybody else.

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ABSTRACT

The term hybrid composite refers to the composite containing more than one type of fiber material as reinforcing fillers. It has become attractive structural material due to the ability of providing better combination of properties with respect to single fiber containing composite. The eco-friendly nature as well as processing advantage, light weight and low cost have enhanced the attraction and interest of natural fiber reinforced composite. The objective of present research is to study the mechanical properties of jute-coir fiber reinforced hybrid polypropylene (PP) composite according to filler loading variation. In the present work composites were manufactured by using hot press machine at four levels of fiber loading (5, 10, 15 and 20 wt %). Jute and coir fibers were utilized at a ratio of (1:1) during composite manufacturing. Tensile, flexural, impact and hardness tests were conducted for mechanical characterization. Tensile test of composite showed a decreasing trend of tensile strength and increasing trend of the Young's modulus with increasing fiber content. During flexural, impact and hardness tests, the flexural strength, flexural modulus, impact strength and hardness were found to be increased with increasing fiber loading. Based on the fiber loading used in this study, 20% fiber reinforced composite resulted the best set of mechanical properties.

CHAPTER-1
INTRODUCTION

1.1 INTRODUCTION

Now a days hybrid composites are receiving considerable attention for its capability of providing designers new freedom of tailoring composites and thus achieving properties that can not be attained in binary systems containing one type of fiber dispersed in a matrix. It has also provided a more cost-effective utilization of expensive fibers by replacing them partially with less expensive fibers. Hybrid composites provide the potential of achieving a balanced pursuit of stiffness, strength and ductility, as well as bending and membrane related mechanical properties with weight savings, reduced notch sensitivity, improved fracture toughness, longer fatigue life and excellent impact resistance [1]. Increasing environmental awareness has promoted designs that are compatible with environment, non toxic to human body so eco-friendly. Natural fiber reinforced composites are inexpensive and could minimize environmental pollution due to their characteristics bio-degradability [2]. Apart from this, the lignocellulosic fibers are light weight, reduce wear in the equipment used for their production, easily available, renewable, non-abrasive, require less energy for processing, reduce the density of furnished products and absorbed CO2 during their growth[1] [2] . The lignocellulosic fibers can be mixed either with thermosetting or thermoplastic polymer matrix to produce composite. The composite using thermosetting polymer shows brittleness and inability to repair. Many of the thermoplastic-based composites offer excellent resistance to impact loading, the possibility of thermoforming and shaping at elevated temperatures and the potential for thermal joining and repair as well as recycling [3]. Among various natural fibers, both coir and jute fibers are widely available and cheap in context to the economic condition of Bangladesh. Coir and jute are lignocellulosic fibers mainly consisted of cellulose, lignin and hemicelluloses. High content of lignin in coir than jute fiber has made it high weather resistant. The coir fiber is relatively water-proof and is one of the few natural fibers resistant to damage by saltwater. They absorb water to a lesser extent compared to all the other natural fibers including jute due to its less cellulose content. Both fibers are biodegradable and recyclable. They are renewable resources and these materials are CO2 neutral [10]. Furthermore, these fibers are typically less abrasive than glass or carbon fibers. Jute fiber has low density and high mechanical strength. Among different thermoplastics polypropylene possesses outstanding properties such as low density, good flex life, sterilizability, good surface hardness, abrasion resistance and excellent electric properties [4]. Although natural fibers lag behind from the impressive property of synthetic fiber, their eco-friendly nature has made them attractive. The objective of present research is to develop hybrid composite by using two lignocelllosic fibers which are abundant, inexpensive and eco-friendly and improving the new era of green composite.

In present scenario waste material of plants are considered very useful for industrial purposes and in this prospect natural fibers are playing very dominant role. The use of natural fibers in matrices is highly beneficial because the strength and toughness of resulting composites are greater than unreinforced plastics. So, it is found good to use natural fibres in place of plastics and other environment unfriendly materials. Natural fibres are of great importance, decreasing forest cover, low availability of natural products like wood leads towards the need of alternatives with similar properties and these fibers are also a good alternative of plastics because of properties like bio-degradability, recyclability. It is known that composite materials are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct within the finished structure. Most composites have strong, stiff fibres in a matrix and some are weaker and less stiff. The objective is usually to make a component which is strong and stiff, often with a low density. Commercial material commonly has glass or carbon fibres in matrices based on thermosetting polymers, such as epoxy or polyester resins. But in today’s context natural fibers plays dominant role because of its multiple characteristics. Fiber reinforced composites are used in almost every type of advanced engineering structure, with their usage ranging from aircraft, helicopters and spacecraft through to boats, ships and offshore platforms and to automobiles, sports goods .

A key factor driving the increased applications of composites over the recent years is the development of new advanced forms of fiber reinforced materials. Fiber reinforced composites are lightweight, no-corrosive, exhibit good specific strength and good stiffness, are easily constructed, and can be tailored to satisfy performance requirements. Apart from these characteristics natural fibers are still expensive today as compare to traditional materials because of less demand of products manufactured from these fiber materials because of less knowledge of these fibers applications. But in present scenario demand is increasing due to increased applications which will lead towards its less cost.

Technological development mostly depends onadvancements in the field of engineering materials.Conversely, in any field of endeavour, the final hurdle, facing constant advancements, is with materials. Composite materials in this regard represent nothing less than a giant step in the ever constant effort toward optimization in materials,Chawla (1998). Currently, the lightweight of composites that allows for lower fuel consumption has increased their use in a broad range of applications, including in the aerospace, automotive, and rail sectors. In the aerospace industry, the current emphasis on fuel efficiency favors the use of polymer matrix composites (PMCs) instead of aluminum and its alloys. Also, the production of a new class of aircraft - micro-jets – has called for an extensive use of lightweight composites. In the automotive industry, manufacturers are recognizing the advantages of weight reduction, parts consolidation, and design freedom that PMCs afford,Mazumdar (2002);Brostow*et al.* (2010). So far, most of the PMC materials used in different sectors are principally fabricated using thermosetting matrices. However, thermosets have inherent disadvantages such as brittleness, long cure cycles, and difficult to repair and recycle damaged parts. These limitations led to the development of the thermoplastic matrix composite system. Compared with thermosets, composites fabricated from thermoplastic materials typically have more shelf life, greater strain to failure, rapid consolidation, excellent chemical resistance, better damping characteristics, low noise emission, and are repairable. Polypropylene (PP) is one of the most extensively used thermoplastic in industry due to its high chemical and wear resistance, low cost, easy process-ability and excellent mechanical properties, Mukhopadhyay and Srikanta(2008); Chand and Dwivedi (2006). Natural fibres become superior alternatives ofsynthetic fibres as reinforcements for polymeric composites due to their high flexural modulus and impact strength. In addition, natural fibers are environmentally friendly, biodegradable, abundantly available, renewable with low density and cheap. The biodegradability of natural fibres can contribute to a healthy ecosystem while their low cost and high performance fulfils the economic benefits of industries. Applications of natural fiber based polymeric composites are found in such products as housing construction materials, furniture, and automotive parts,Larbig*et al.*(1998);Eleiche and Amin(1986);Nirmal*et al.* (2010); El-Tayeb(2008). Pineapple leaf, oil palm fibre, hemp, sisal, Jute, kapok, rice husk, bamboo, and wood are some of the natural fibres most commonly used as reinforcement materials in polymer composites, Gujjala*et al.* (2013).Among all the plant fibres, Jute appears to be the most useful, and inexpensive fiber, that can be moulded to different shapes,Zaman*et al.*(2010).

However, it has a downside that may pale these advantages: Jute fibre shares the major weakness of all natural fibres such as low thermal resistance, hygroscopic in nature, inherent polarity, less dimensional stability, and anisotropic fibre properties. These disadvantages cause in weak fibre-resin interaction,Khan*et al.*(2013). The mechanical propertiesof a natural fibrepolymer matrix composite are controlled mainly by the efficiency of the bonding at the fibre-matrix interfacial boundary. The principal function of the interface is to facilitate the transfer of stress from fibre to fibre, across the matrix,Sangthong*et al.* (2009). Numerous research studies conducted over the last decade have reported successful use of natural fibres as reinforcement to enhance the mechanical properties of the

poly-matrix composites, Mukhopadhyayand Srikanta (2008);Larbig*et al.*(1998);Eleiche and Amin (1986); Nirmal*et al.*
(2010); El-Tayeb (2008); Sangthong*et al*. (2009); El- Shekeil*et al*. (2012); Bledzki*et al*. (2009). By contrast, We don't find much work reported particularly on the woven Jute fibre mat reinforced polypropylene matrix composite, Gujjala*et al.* (2013); Khan *et al.* (2010);Zaman*et al.* (2010);Zaman*et al* (2009); Shah andLakkad(1981);Gowda*et al*. (1999). Therefore, the aim of the current study is to investigate the effect of weight percentage of Jute, coir fibre reinforcement on then mechanical properties of polypropylene based composite.

1.2. OBJECTIVES OF THE CURRENT RESEARCH WORK

The main objectives of current research work which are outlined as follows:

1. Fabrication of short Jute, coconut fiber based polypropylene composites.
2. Evaluate the mechanical properties such as impact strength, tensile strength, flexural strength and hardness of fabricated composites.
3. To study their influence of fiber loading on mechanical properties of composite.

1.3 OUTLINE OF THESIS STRUCTURES

The following is a summary of the thesis structures.

Chapter 1: Contains the introduction to the project. It covers brief introduction about the research background, problem statements, research objectives and outline of the thesis structure.

Chapter 2: Contains the literature review. it covers brief explanations and classification Regarding fiber reinforced polypropylene FRPP composite materials, natural fibre-based FRPP, types of composites.

Chapter 3: Contains the information about the materials specifications, samples preparations, experimental procedures and equipment used in this study. Testing of mechanical properties of composite.

Chapter 4: Contains results and discussion of this study. Design philosophy and design methods are developed according to both numerical and analytical model results.

Chapter 5: Contains conclusions of the research and suggestions for future studies. It proposes to further study by incorporating the hybrid composites.

CHAPTER- 2

LITERATURE SURVEY

LITERATURE SURVEY

This chapter outlines some work and report available in past related to mechanical properties of natural fiber based polypropylene composites.

The mechanical behaviour of a natural fiber based polypropylene composite depends on numerous factors, for example, fiber length and quality, matrix, fiber-matrix adhesion bond quality and so forth.

Composite materials are created by combining two or more components to achieve desired properties which could not be obtained with the separate components. During the last few years, a series of works have been done to replace the conventional synthetic fiber with natural fiber composites. For instant, hemp, sisal, jute, cotton, flax and broom are the most commonly fibers used to reinforce polymers. In addition, fibers like sisal, jute, coir, oil palm, bamboo, wheat and flax straw, waste silk and banana have proved to be good and effective reinforcement in the thermoset and thermoplastic matrices. Composites made from non-traditional materials obtained directly from agro-wastes such as coir fiber, coconut pith, jute sticks, ground nut husk, rice husk, reed, and straw became one of the main interests of researchers.

The properties of natural-fiber reinforced composites depend on a number of parameters such as volume fraction of the fibers, fiber aspect ratio, fiber-matrix adhesion, stress transfer at the interface, and orientation. Most of the studies on natural fiber composites involve study of mechanical properties as a function of fiber content, effect of various treatments of fibers, and the use of external coupling agents. Both the matrix and fiber properties are important in improving mechanical properties of the composites. The tensile strength is more sensitive to the matrix properties, whereas the modulus is dependent on the fiber properties. To improve the tensile strength, a strong interface, low stress concentration, fiber orientation is required whereas fiber concentration, fiber wetting in the matrix phase, and high fiber aspect ratio determine tensile modulus.

The aspect ratio is very important for determining the fracture properties. In short-fiber-reinforced composites, there exists a critical fiber length that is required to develop its full stressed condition in the polymer matrix. Fiber lengths shorter than this critical length lead to failure due to debonding at the interface at lower load. On the other hand, for fiber lengths greater than the critical length, the fiber is stressed under applied load and thus results in a higher strength of the composite. For, good impact strength, an optimum bonding level is necessary. The degree of adhesion, fiber pullout, and a mechanism to absorb energy are some of the parameters that can influence the impact strength of a short-fiber-filled composite. The properties mostly vary with composition as per the rule of mixtures and increase linearly with composition.

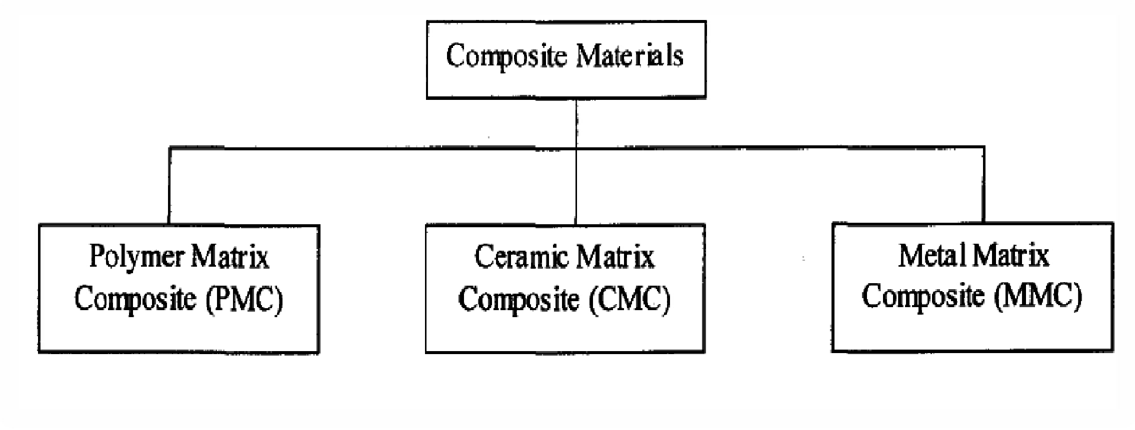
In the literature, many works devoted to the properties of natural fibres from micro to nano scales are available. In these, the effects of reinforcement of matrix (thermoplastic starch) by using cellulose whiskers, commercial regenerated cellulose fibres are also proposed. A number of investigations have been conducted on several types of natural fibers such as kenaf, hemp, flax, bamboo, and jute to study the effect of these fibers on the mechanical properties of composite materials .

The properties of natural-fiber reinforced composites depend on a number of parameters such as volume fraction of the fibers, fiber aspect ratio, fiber-matrix adhesion, stress transfer at the interface, and orientation. Most of the studies on natural fiber composites involve study of mechanical properties as a function of fiber content, effect of various treatments of fibers, and the use of external coupling agents. Both the matrix and fiber properties are important in improving mechanical properties of the composites. The tensile strength is more sensitive to the matrix properties, whereas the modulus is dependent on the fiber properties. To improve the tensile strength, a strong interface, low stress concentration, fiber orientation is required whereas fiber concentration, fiber wetting in the matrix phase, and high fiber aspect ratio determine tensile modulus.

2.1 INTRODUCTION TO COMPOSITE MATERIALS

Composites are combinations of two materials in which one of the materials, called the reinforced phase, is in the form of fibres sheets, or particles or are embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer as in Figure 2.1. Typically, reinforcing materials are strong with low density while the matrix is usually ductile or tough material If the composite is designed and fabricated correctly, it combines the strength and the reinforcement with the toughness of the matrix to achieve the combination of desirable properties not available in any single conventional material.

Figure 2.1: Classification scheme of composite materials.



Natural fibre such as jute, kenaf, sisal, kapok and several waste cellulosic products have been used as suitable alternatives to synthetic reinforcements for composites in many applications. The natural fibres more benefits such as less pollutant emission, low density, biodegradability, high specific properties and low cost production (Behzad and Sain, 2007; Josh~ Drzal *et a!.*, 2004; Mohanty, Misra *et a!.*,2002). Many studies have been carried out to develop different manufacturing processes and to study the mechanical performances of natural fibre composites (Herrera-Franco and Valadez-Gonzalez, 2004; Cantero *et a!.*, 2003; Jacob *et a!.*, 2004). Composite is a combination of two or more materials to exhibits a significant mechanical characteristic such as stiffness, toughness, and ambient and high temperature strength (Callister, 1999). There are also many numbers of composites that occur in nature. For example, wood consists of strong and flexible cellulose fibres surrounded and held together by a stiffer material called lignin. Classification of composite materials is based on of three main divisions; particle reinforced; fibre reinforced; and structural composites. Technologically, the most important composites are those in which the dispersed phase is in the form of a fibre. Design goals of fibre-reinforced composites often include high strength and/or stifthess on a weight basis. These characteristics are expressed in terms of specific strength and specific modulus parameters, which correspond respectively to the ratios of tensile strength to specific gravity and modulus of elasticity to specific gravity. Fibre reinforced composites with exceptionally high specific strength and modul have been produced that utilize low-density fibre and matrix materials. As shown in Figure 2.2, fibre-reinforced composites are sub classified by fibre length. For short fibre, the fibres are too short to produce a significant improvement in strength.

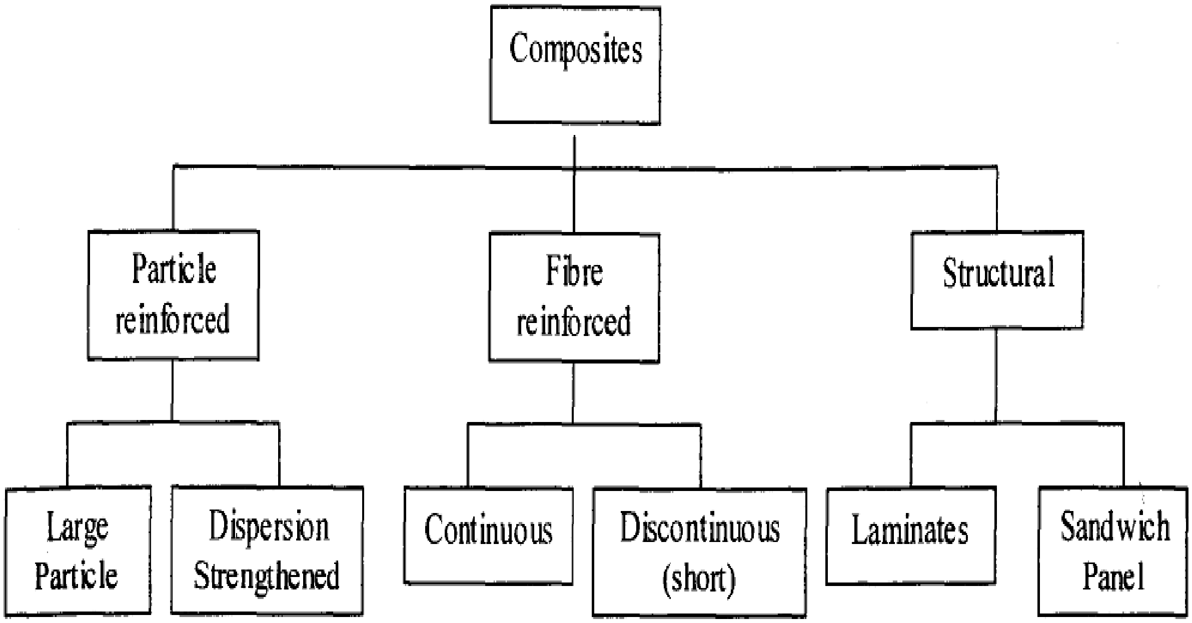


Figure 2.2: A classification scheme for the various polymer reinforced composite types.

Ceramic matrix composite: The composite which is consisting of a ceramic combined with aceramic dispersed phase. Because of availability of new technologies, the demand for high products and processing methods, have together improve the growth of advanced ceramic products, but brittleness of ceramics still retain a major disadvantage.

Polymer matrix composite: Polymer matrix composites are recognized to be a more conspicuous class of composites when contrasted with artistic or metal lattice composites once in business requisitions. It includes a matrix from thermoplastic (polystyrene, nylon) or thermosetting (epoxy, unsaturated polyester) or and inserted steel, glass carbon, or Kevlar strands.

Metal matrix composite: Composites consisting of metal matrix such as Mg, Al, Fe is called metal matrix composites. The interest in metal matrix composites is due to many reasons such as their engineering properties. They are of exhibit good stiffness, light weight, and low specific weight as compared to other metal alloys and metals. Although it has many advantages, low cost remains a major point of interest for many applications.

Among these all types of composites, polymer matrix composite is most commonly used composites, because of its advantages such as high strength, low cost, simple manufacturing principle. The requirement of polymer material in this modern dynamic world is increasing day by day because it has wide range of advantages over traditional material in terms of high strength to weight ratio, cost, high toughness, high tensile strength and high creep resistance at increase in temperatures. Polymer matrix composites have three types of polymer which have been used as matrix. These are thermoplastics, thermosetting and elastomer polymer.

Thermoplastic polymer is that polymer which are over and again diminished and transformed by heating. A few illustrations of thermoplastics are PVC, LDPE and HDPE. Thermoplastic materials are shaped when they are in softened or melted. Thermoplastic have numerou properties, for example, light weight, low thickness, which are relying on science they could be similar to elastic, and strong as aluminum.

Thermosetting polymer is the polymer which has hard and firm cross-interfaced materials. They are not moldable when and soften when they are warmed. Epoxy is the most normally utilized thermosetting polymer. They have numerous advantages, for example, better grip to different materials, great mechanical properties, and great electrical protection.

Elastomer is a kind of polymer is determined from flexible polymer, is frequently utilized reciprocally with the term elastic, despite the fact that the last is favored when alluding to vulcanizes.

Elastomers have numerous properties which having low density and high disappointment strain compare with other material.

The other sort of constituents of composites is reinforcements. Reinforcements are generally used to upgrade general mechanical properties of matrix and offer quality to composites. The reinforcement in composites is either fibrous or non-fibrous. Again fibrous composites are either natural fiber reinforced or synthetic fiber reinforced composites. There are many factors affecting the properties of fiber reinforced polymer composites such as fiber parameters, matrix fiber-matrix interfacial bonding etc. A great deal of work has been done on the different kinds of natural fiber based polymer composites .

2.2 FIBRE REINFORCED POLYMER(FRP)

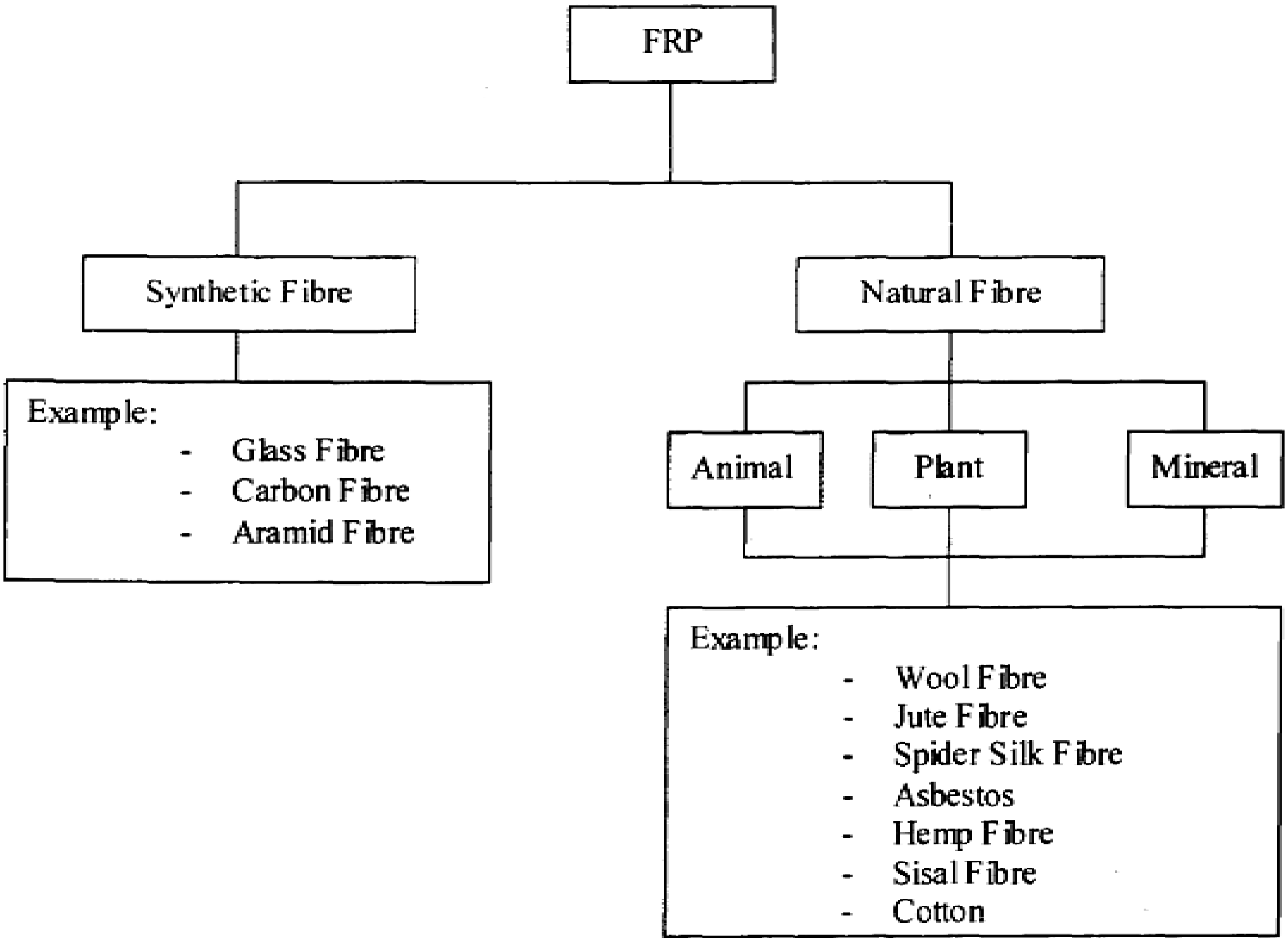


Figure 2.3 Deviation of Fibre Reinforced Polymer (FRP) commonly used in composite Application (Ritchie *et al.,* 1991; George *eta/.,* 2001; Bakis *et al.,* 2002).

Fibre Reinforced Polymer comprises of two different types namely synthetic and natural fibres as shown in Figure 2.3. Now a days, the composite :fabrication were commonly based on the synthetic fibre due to the high mechanical strength, corrosive and chemical resistance, high durability and many more as mentioned by many researchers (Ahmed *et al.,* 2007; Joshi *et al.,* 2004; Wonderly *et al., 2005;* Wambua *et a/.,* 2003; Paciornik *eta/.,* 2003). But as industry attempts to lessen the dependence on synthetic fibre reinforced composite, there is an increasing need to investigate and explore more environmentally friendly, sustainable materials to replace the existing fibre. With this highly concern, natural fibre reinforced composite were introduced a'i early as 1908 (Bledzki and Gassan, 1999). The types of natural fibre can be divided into 3 groups; animal fibre, plant fibre, and mineral fibre as shown in Figure 2.3. Agricultural crop from plantation are greatly produced in billion of tones around the world represent an abundant, inexpensive, and readily available sources of natural fibre reinforced composites. Among these enormous amounts of agricultural crops, only a minor quantity of residue is reserved as animal feed or house hold fuel and the major portion of the straw is burned in the field creating the environmental pollution (Sain and Panthapulakka~2006). The exploration of these inexpensive agricultural crops for making industrial composite products will open a new avenue or the utilization of agricultural crops by reducing the need or disposal and environmental deterioration through pollution, and at the same time add value to the creation of rural agricultural based economy. These limitations led to the development of the thermoplastic matrix composite system. Compared with thermosets, composites fabricated from thermoplastic materials typically have more shelf life, greater strain to failure, rapid consolidation, excellent chemical resistance, better damping characteristics, low noise emission, and are repairable. Polypropylene (PP) is one of the most extensively used thermoplastic in industry due to its high chemical and wear resistance, low cost, easy process-ability and excellent mechanical properties, Mukhopadhyay and Srikanta (2008); Chand and Dwivedi (2006).

2.2.1 Synthatic fiber

2.2.1.1 Glass Fibre Reinforced Polymers (GFRP)

Glass fibre has seen limited usage in the construction and building industry fur decades (Chambers, 1965; Halloway and Robinson, 1981; Green, 1987). This is because of the need to repair and retrofit the rapidly deteriorating infrastructure in recent years, the potential for using glass fibre reinforced composites become popular in a wide range of applications recently (Barbero and GangaRao, 1991). Glass fibre materials exhibit better resistance to environmental agents, and futigue as well as the advantages of high stiffuess to weight and strength to weight ratios compared to other synthetic fibres (Liao, *et a!.,* 1999). Many researchers reported that the construction industry recently had fucused on lower cost glass reinfOrcement rather than the carbon fibre reinforced in the aerospace applications.

Glass fibre is a material made from extremely fme fibre of glass. It is used as reinfOrcing agent fur many polymer products, and resulting in a composite material properly known as glass-reinfOrced polymer (GRP). It is furmed when thin strands of silica-based or other formulation glass is extruded into many fibres with small diameters suitable for the textile fubrication. The technique of heating and drawing glass into fme fibres has been known fur millennia; however, the use of these fibres fur textiles applications is more recent. The mechanical properties of the glass fibre and other synthetic fibres can be seen in Table 2.1.

	Fiber glass	**Carbon**	**Aramid(Kevlar 149)**
E stic Modulus E(GPa)	79	230	160
Tensile Stress 6(GPa)	2.4	4.9	1.7
Tensile Strain ε(%)	3.04	2.1	1.0
Density ρ(g/cm^3)	2.5	1.8	1.47
Fiber Diameter (μm)	15	7	12.4

Table 2.1: Some mechanical properties of synthetic fibre .

2.2.1.2 Carbon Fibre

Carbon fibre is a material consisting of extremely thin fibres about 0.005-0.010 mm in diameter and composed mostly of carbon atoms. The carbons atoms are bonded together in microscopic crystals that are more or less aligned parallel to the long exist of the fibre. The crystal alignment makes the fibre very strong for its size. Several thousand carbon fibre are twisted together to form a yarn, which may be used by it self or woven into a fabric. Carbon fibre has many different weave patterns and can be combined with plastic resins and wound or molded to form composite materials. such as Carbon Fibre Reinforced Polypropylene (CFRPP) to provide a high strength to weight ratio material The density of carbon fibre is considerably lower that the density of steel~ making it ideal fur applications requiring low weight. The properties of carbon fibre such as high tensile strength, low weight and low thermal expansion make it popular in aerospace, civil engineering, military and motorsports along with other competition sports. However, it is relatively expansive when compared to similar materials such as fibreglass. Carbon fibre is very strong when stretched or bend, but weak when compressed or exposed to a high impact.

2.2.1.3 Aramid Fiber

Aramid fibre is an attractive organic fibre with the combination of stiffness, high strength, high fracture strength, and having a low density (Liu *et al.*, 2008). Advance composites made from aramid fibres have comparable axial properties like inorganic fibre reinfurced composites as well as significant reduction in weight. Aramid fibres have poor interfacial bonding with most of the commercially available resins used in composite because of its inertia surface, high crystallization, and poor off-axis strength. The carbon fibres are used in aerospace and military applications, fur ballistic rated body armor mbric and ballistic composites, in bicycle tires, and as an asbestos substitute. The name is a shortened furm of "aromatic polyall}ide". They are fibres in which the chain molecules are highly oriented along the fibre axis, so the strength of the chemical bond can be exploited.

2.2.2 Natural Fiber

A Natural fiber made from plant, animal or mineral sources, and is classified according to the origin. Plants that produce natural fibers are categorized into primary and secondary depending on the utilization. Primary plants are grown for their fibers (examples, Jute, hemp, kenaf, and sisal) while secondary plants are plants where the fibers are extracted from the waste product (examples, Pineapple, Bagasse, oil palm and coir). There are six major types of fibers namely; best fibers (jute, flax, hemp, ramie, baggase, linen, bamboo, and kenaf), leaves fibers (abaca, banana, sisal and pineapple), leaflets (palm, coconut, etc.) seed fibers (coir, cotton and kapok), grass and reed fibers (wheat, corn and rice) and all other types (wood and roots) .

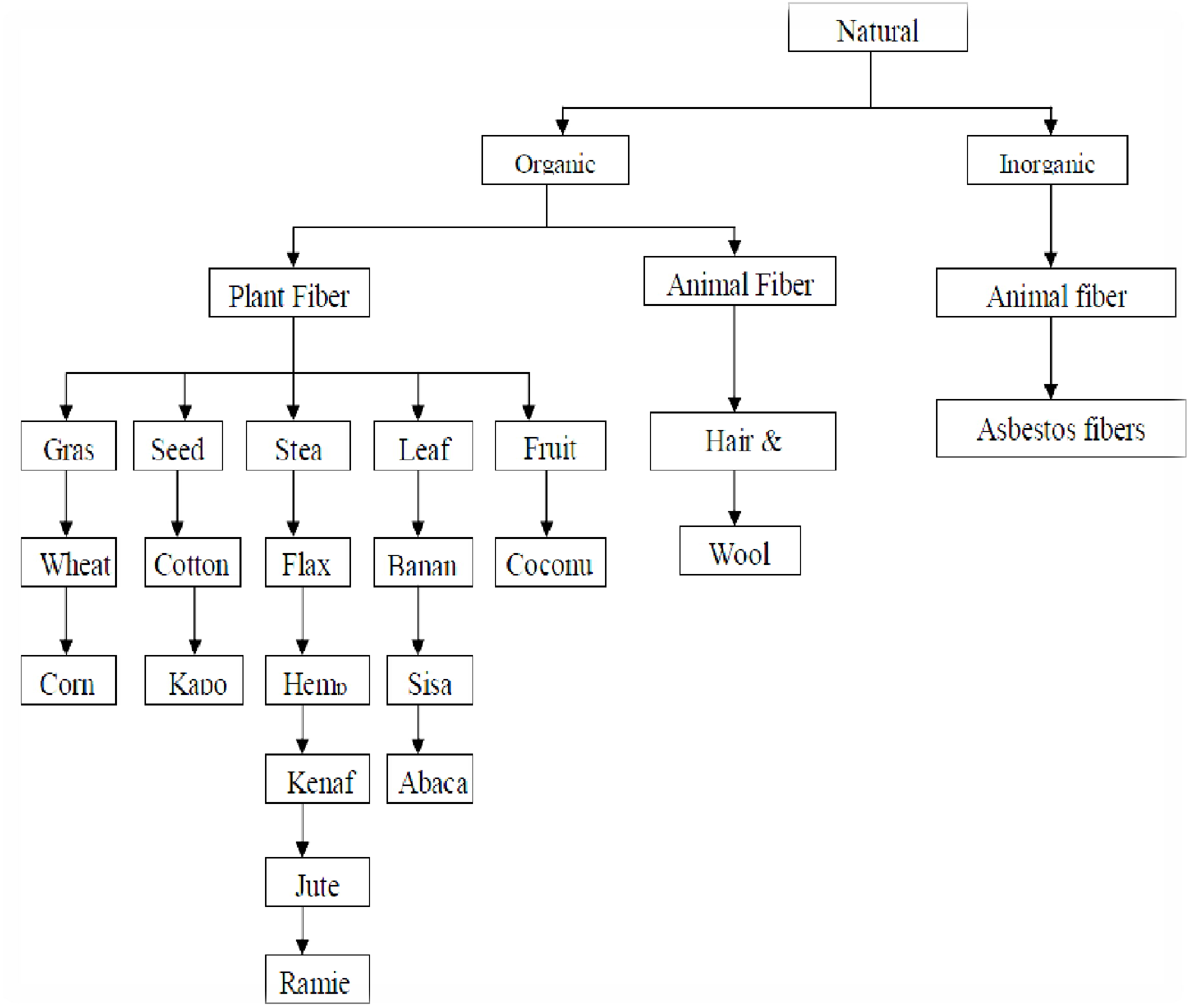


Figure 2.4 Classification of Natural Fibers.

Natural fibers are classified on the basis of the origin of source, into three types

1. Plant Fibers

2. Mineral Fibers

3. Animal Fibers

1. Plant Fibers: Plant fibers are usually consists of cellulose: examples cotton, jute, bamboo, flax, ramie, hemp, coir and sisal. Cellulose fibers are used in various applications. The category of these fibers is as following: Seed fibers are those which obtain from the seed e.g. Kapok and cotton. These fibers having superior tensile properties than the other fibers. Because of these reason these fibers are used in many applications such as packaging, paper and fabric. Fruit fibers are the fibers generally are obtain from the fruit of the plant, e.g. banana fiber and coconut fiber. Similarly, stalk fiber are the fibers which are obtain from the stalks (rice straws, bamboo, wheat and barley). Leaf fibers are the fibers those are obtain from the leaves (agave and sisal).

2. Mineral Fibers*:* Mineral fibers are those which are get from minerals. These are naturally happening fiber or somewhat changed fiber. It has different classifications they are taking after: Asbestos is the main characteristically happening mineral fiber. The Variations in mineral fiber are the serpentine, amphiboles and anthophyllite. The Ceramic filaments are glass fiber, aluminum oxide and boron carbide. Metal filaments incorporate aluminums strands.

3. Animal Fibers: Animal fiber by and large comprises of proteins; cases, silk, alpaca, mohair,downy. Animal hair are the strands got from creatures e.g. Sheep's downy, goat hair, horse hair, alpaca hair, and so forth. Silk fiber is the filaments gathered from dry saliva of bugs or creepy crawlies throughout the time of planning of cocoons. Avian strands are the fiber from fowls . Composites of natural fiber used for drives of structural, but typically with synthetic thermoset matrix which of course bound the environmental benefits. Now a days natural fiber composites application are usually found in building and automotive industry and the place where dimensional constancy under moist and high thermal conditions and load bearing capacity are of importance . Natural fibers like cotton, sisal, jute, abaca, pineapple and coir have already been studied like a reinforcement and filler in composites. Among various natural fibers, banana fiber is considered as a potential reinforced in polymer composites due to its many advantages such as easy availability, low cost, comparable strength properties etc. Generally, natural fibers are consists of cellulose, lignin, pectin etc.

Jute

Flax

Hemp

Bagasse

Bomboo

Kenaf

Ramie

Banana

Abaca

Sisal

Pincapple

Coconut Shell

Plam

Coir

Cotton

Kapok

Rise

Wheat

Corn

Wood

Root Henequen Gomuti Aramid

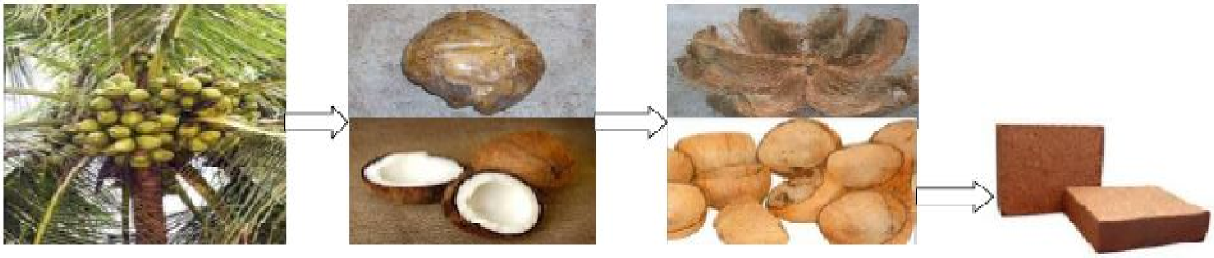


Fig. 2.5. Picture of natural fiber.

A large variation is found in the mechanical and physical properties of natural fibers. Those properties are affected by many factors of natural fibers. The experimental conditions are different such as type of fibers, moisture content and form of fibers (yarn, woven, twine, chopped, felt, etc.). Moreover, the properties are also affected by the place where the fibers are grown, cultivation condition. The part of the plant they are harvested from growing period and retting or extracting process.

Type of fiber	**Diameter (µm)**	**Texture and colour**
Hemp	26.5	Silky-fine; White to light brown
Sisal	50-200	Coarse-stiff; White
Jute	25-200	Fine; light brown
Coir	100-450	Coarse; White to brown
Gomuti (Sugar-palm fiber)	50-800	Coarse-stiff; brown to black
Coconut fiber	Minimum13 cm	Clear light brown

Table-2.2 Outlines the Physical Appearance of Natural fiber.

An Improved understanding of the chemical composition and surface adhesive bonding of natural fiber is essential for developing natural fiber-reinforced composites. The components of natural fibers are such as cellulose, hemicellulose, lignin, pectin, waxes and water soluble substances.

Type of fiber	Cellulose (%)	Hemicellulose (%)	Legnin (%)	Pectin (%)	Ash (%)	Moisture (%)	Micro fibrillar Angle(deg)	Waxes
Bast F.								
Flax	71	18.6-20.6	2.2	2.3	-	10	5-10	1.7
Hemp	57-77	14-22.4	3.7-13	0.9	0.8	9	2-6.2	0.8
Jute	45-71.5	13.6-21	12-26	0.2	0.5-2	13	8	0.5
Kenaf	31-57	21.5-23	15-19	-	0.5-2	-	-	-
Ramin	68.6-91	5-16.7	0.6-0.7	1.9	-	16	16	2
Leaf F.								
Sisal	47-78	10-24	7-11	10	0.6-1	16	16	2
Abaca	56-63	15-17	7-9	-	-	8	-	<1
Banaa	64	10	5	11	-	-	-	-
Seed F								
Cotton	88	5.7	16	8	-	-	-	-

Table-2.3 The Composition of selected Natural Fibers.

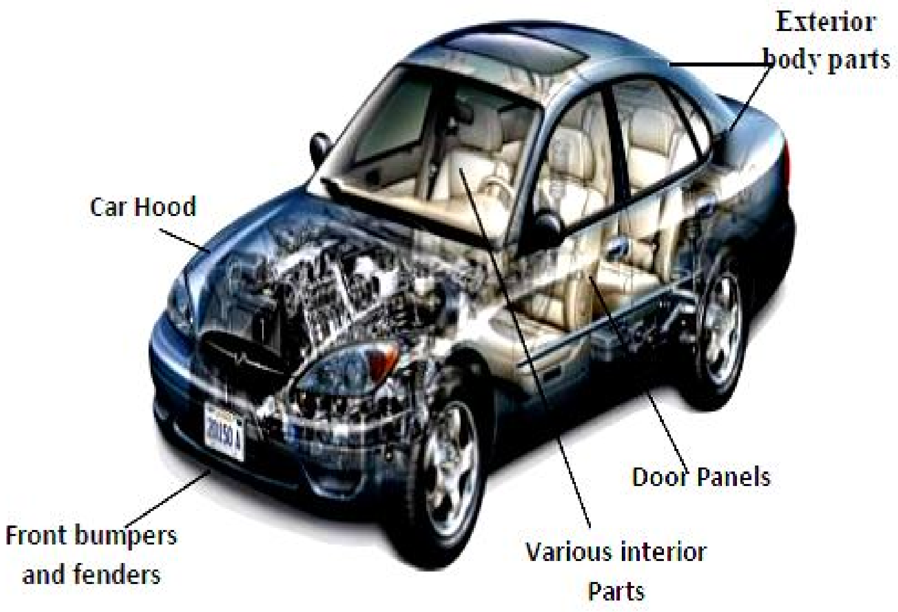
Type of fiber	Density (g/cm^3)	Tensile strength (MPa)	Young’s modulus (GPA)	Elongation %
Hemp	1.48	514	24.8	1.6
Flax	1.50	345-1100	27.6	1.2-3.2
Jute	1.3-1.45	393-773	13-26.5	1.3-4.6
Ramie	1.5	220-938	44-128	2-3.8
Sisal	1.45	468-640	9.4-22	2-14
Coir	1.2	175-220	4-6	5-30
Cotton	1.5-1.6	287-597	5.5-12.6	3-10
Softwood	1.5	1000	40	-
Bamboo	1.4	500-740	30-50	2
E-glass	2.5	2000-3500	70	2.5-3
S-glass	2.5	45-70	86	2.8
Carbon	1.4	3000-3150	63-67	3.3-3.7
Aramide	1.4	4000	230-240	1.4-1.8

Table-2.4 Mechanical Properties of the Common Natural Fibers as Compared to Conventional Reinforcing fiber.

2.2.2.1 Application of natural fiber

Natural fiber composites are very cost effective material and widely used for following applications:

Building and construction industry*:* panels for partition and false ceiling, partition boards, wall, floor, window and door frames, roof tiles, mobile or pre-fabricated buildings which can be used in times of natural calamities such as floods, cyclones, earthquakes, etc. Storage devices**:** (post-boxes, grain storage silos, bio-gas containers, etc.),Furniture: (chair, table, shower, bath units, etc.),Electric devices: (electrical appliances, pipes, etc.),Everyday applications:(lampshades, suitcases, helmets, etc.),Transportation**:** (automobile and railway coach interior, boat, etc.),The reasons for the use of natural fibers in the automotive industry Include: Low density: which may lead to a weight reduction of 10 to 30%?,Acceptable mechanical properties, good acoustic properties, Favorable processing properties, for instance low wear on tools, Options for, new production technologies and materials Favorable accident performance, high stability, less splintering, Occupational health benefits compared to glass fibers during production, No off-gassing of toxic compounds (in contrast to phenol resin bonded wood and recycled Cotton fiber parts),Reduced fogging behavior, Price advantages both for the fibers and the applied technologies.



Low cost housing construction made with coconut shells in concrete production

HOUSES IN EUROPE Houses in south africa

Figure -2.6 Natural Fiber Applications in the Automobile Sector, Building Construction and Accessorie

CHAPTER-3

MATERIAL AND METHODOLOGY

MATERIAL AND METHODOLOGY

This chapter describes the materials required, fabrication method and the experimental procedures followed for their characterization. It presents the details of the characterization and tests which the composite specimens are subjected to raw materials used in the present research work are:

This chapter consists of two parts

(1) Details of processing of the specimen preparation.

(2) Testing of mechanical properties of composites.

The materials used are:

I- Jute fiber

II-Polypropylene

III- Coir

3.1. SPECIMEN PREPARATION METHOD

3.1.1. Materials

A commercial grade polypropylene (PP), coir and jute were used in this study. All of them were collected from the local market. The (fig. 3.1) was write in colour and granular in from having a melting point of 160^0C. jute fiber was extracted from coir and also the. The die use to prepare composite was made of aluminium. The die was made by machining aluminium plate to a desired shape (2.54cmX18.8cm)and depth 0.8cm.

Fig.3.1 Image of Polypropylene(PP) Granules.

3.1.2. Manufacturing of Composites

Hybrid composite of polypropylene matrix and varying amount of coir and jute fiber were manufactured using hot press technique in a 2.54cm X 18.8cm X 0.8cm die as mentioned in the previous section. A hydraulic type machine having maximum load of 35kN and maximum temperature of 300^0C was utilised. The fiber loading was varied at 5, 10,15, and 20 wt% with the ration of jute to coir of 1:1. Fiber went cut to 3-5mm length. Firstly required amount of fiber and PP were weighed in a balance. Then to allow the removal of moisture, fiber and polypropylene were dried in an oven at 80^0C for 20 minutes before preparing each composite. in some case they were mixed properly in a container by applying heat from a hot plate. The application of heat (much below the melting point of PP) during mixing enable the fiber to adhere with the PP granules. Since no additional adhesive had been used. The fiber and PP mixture was then placed inside the die. The fiber matrix mixture was allowed to press at 30kN pressure. The temperature was initially raised to 160^oC and hold there for around 12-15 minutes, after that the temperature was raised to $(180\text{-}185)^0$C depending on the thickness required. The die was cooled to room temperature, pressure was released and the composite were withdrawn from the die. Since compression temperature was higher than the melting point of PP (160^0C), the matrix melted but the fiber (melting point>220^0C), the matrix melted but the fiber (melting point>220^0C) remained intact.

Table 3.1 Designation of Composites

S. No.	Composite	Composition
1	PPJCF-1	PP (90 wt%) +Jute (5 wt%) + Coir (5 wt%)
2	PPJCF-2	PP (80 wt%) +Jute (10 wt%) +Coir (10 wt%)
3	PPJCF-3	PP (70 wt%) +Jute (15 wt%) + Coir (15 wt%)
4	PPJCF-4	PP (60 wt%) +Jute (20 wt%) + Coir (20 wt%)

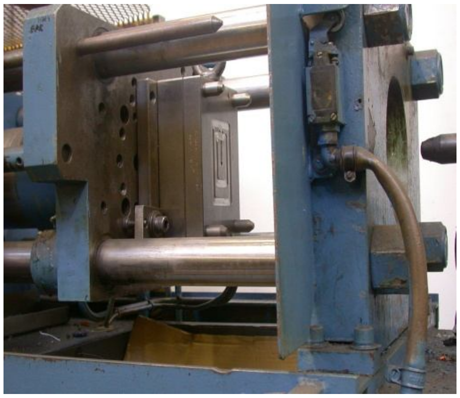


Fig. 3.2 Hot hydraulic press machine.

3.2   MECHANICAL PROPERTIES TESTING

Tensile, Impact and hardness tested were carried out. In each case ,four sample were tested and average values were reported. Tensile tests were conducted according to ASTM D 638-01 using a universal testing machine at a crosshead speed of 4mm/min. Each test was continued until tensile failure. Static flexural test were carried out according to ASTM D 790-00 using the same Testing machine mentioned above at same crosshead speed . The dynamic charpy impact test of the composite was conducted using an impact tester MT 3016 according to ASTM D 6110-97. The hardness of the composite of was measured using a shore hardness testing machine.

Tensile Strength Test

Fabricated composite was cut to get the desired dimension of specimen for mechanical testing. For the tensile test, the specimen size was 100 mm × 20 mm . Tensile strength was tested in Instron machine. The specimen with desired dimension was fixed in the grips of the Instron machine with 7 mm gauge length. The experimental set up for tensile test is shown in Figure 3.3

Figure 3.3 Experimental set up for tensile test.

Flexural Strength Test

Specimen dimension for flexural test was 150 mm × 20 mm and three point bend test method was used for finding the flexural strength using Universal Testing Machine Instron 1195. The loading arrangement for flexural strength is shown in Figure 3.4

Figure 3.4 Three point bend test loading arrangement.

Impact Strength Test

Specimen dimension for impact test was 50 mm × 20 mm. Impact testing was conducted in impact testing machine. Izod impact testing is a method of determining the impact resistance of composites. In impact test, an arm held at a specific height is released during the testing. The arm impacted on the sample and breaks the sample. Its impact energy is obtained from the energy absorbed by the composite or sample. The experimental set up for impact test is shown in Figure 3.5

Figure 3.5 Experimental set up for Impact strengtH

Hardness Test

Fabricated composite was cut in dimension of 20 mm × 20 mm for hardness test. The hardness test was conducted in Vickers hardness test machine. The load was applied 0.3 kgf on the composite and the holding time was 10 second. Hardness is defined as the ability to oppose to indentation, which is obtained by measuring the stable depth of the indentation. In the Vickers hardness test a square base pyramid shaped diamond is used for testing. The experimental set up for hardness test is shown in Figure 3.6.

Figure 3.6 Experimental set up for hardness test

CHAPTER -4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter presents the mechanical properties of the Jute , Coir filled Polypropylene composites prepared for this present investigation. Details of processing of these composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here. This includes evaluation of tensile strength, flexural strength, impact strength and hardness has been studied and discussed. The interpretation of the results and the comparison among various composite samples are also presented.

4.1 MECHANICAL PROPERTIES OF COMPOSITE

Composite	Tensile Strength (MPa)	Flexural Strength (MPa)	Impact Strength (J/m)	Hardness
PPJCF-1	25.7	25.10	450	93
PPJCF-2	25.2	28.30	700	95
PPJCF-3	21.8	30.20	800	98
PPJCF-4	21.3	32.10	1100	99

Table 4.1 Mechanical Properties of Composite.

4.1.1 Tensile Strength

Tensile properties(Young's modulus and tensile strength) of the composite sample were measured for each fiber content (5, 10, 15 and 20 wt%) with the help of stress/strain curves. The tensile strength of raw coir and jute fiber reinforced hybrid polypropylene composite at different fiber loading is show in (fig. 4.1). The tensile strength decreased with an increase in fiber loading [6]-[10]. As the fiber loading increased, the interfacial area Between the fiber and matrix increased , which was weak because of worsening interfacial bonding between cellulose based hydraulic filler (jute and coir) and hydrophobic matrix. This consequently decreased the tensile strength[7] . The same trend was also observed by other researchers [15] [18].

Composite	Tensile Strength(MPa)
PPJCF-1	25.7
PPJCF-2	25.2
PPJCF-3	21.8
PPJCF-4	21.3

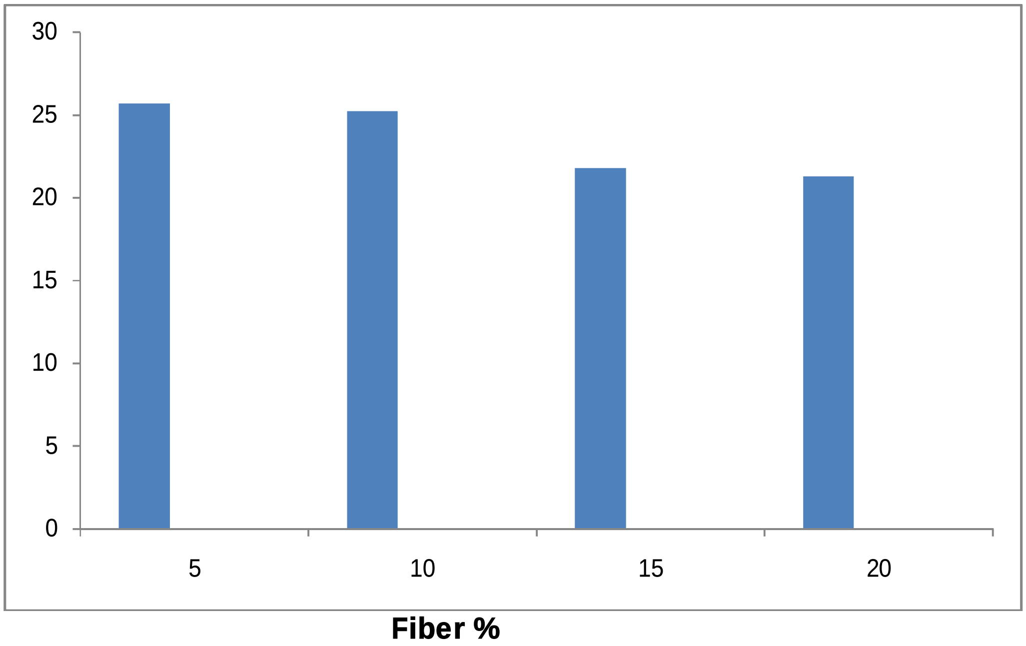


Fig. 4.1 Variation of tensile strength at different fiber content.

The Young’s modulus values of Jute, coir fiber reinforced polypropylene composites for different fiber loading are shown in “Fig.4.2”. It is observed that the Young’s modulus increased with an increase in fiber loading [6] [9] . This is because with an increase in fiber content, the brittleness of the composite increased and stress/strain curves becomes steeper. Poor interfacial bonding creates partially separated micro spaces which obstruct stress propagation between the fiber and the matrix [17]. As the fiber loading increases, the degree of obstruction increases, which in turn increased the stiffness.

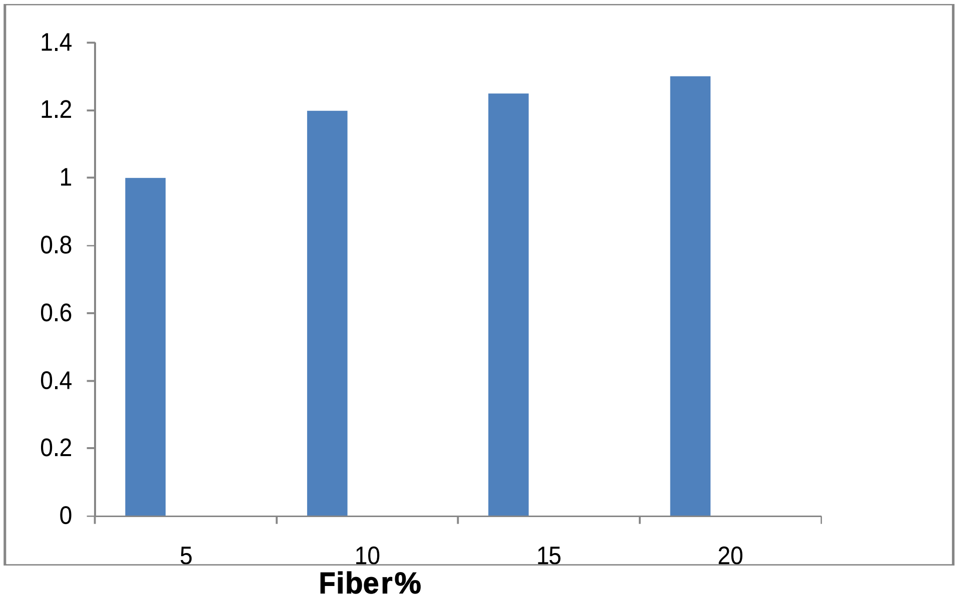


Fig. 4.2 Variation of Young’s modulus at different fiber content.

4.1.2. Flexural Properties

Flexural properties (Flexural strength and flexural modulus) were measured for samples of each fiber content (5, 10, 15 and 20 wt %) with the help of flexural stress/strain curves and respective equations. The flexural strength of raw coir and jute fiber reinforced hybrid polypropylene composites at different fiber loading, is shown in “Fig. 4.3”. The flexural strength increased with an increase in fiber loading which was in agreement with the findings by other researchers [8 9 16] . This may be due to the favourable entanglement of the polymer chain with the filler which has overcome the weak filler matrix adhesion with increasing filler content [18] .

Composite	Flexural Strength (MPa)
PPJCF-1	25.10
PPJCF-2	28.30
PPJCF-3	30.20
PPJCF-4	32.10

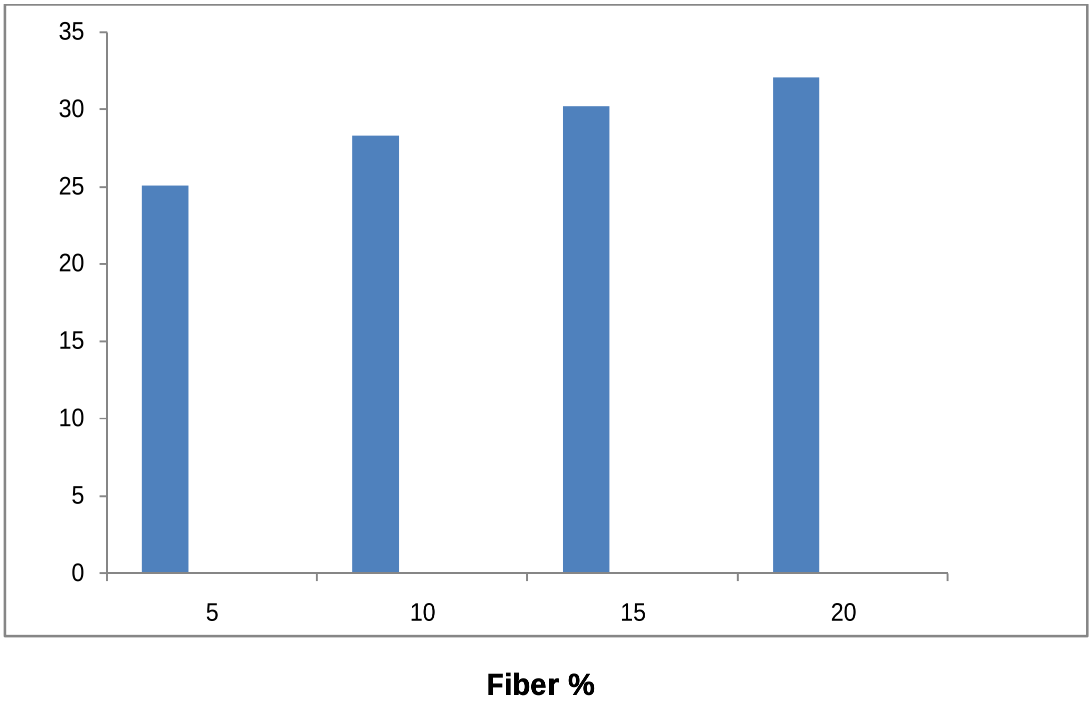


Fig. 4.3 Variation of flexural strength at different fiber content.

flexural modulus The values of raw coir and jute fiber reinforced hybrid polypropylene composites at different fiber loading is shown in “Fig. 4.4” the flexural modulus increased with an increase in fiber loading [6 8 16] . Since both coir and jute are high modulus material, higher fiber concentration demands higher stress for the same deformation [18] . So the incorporation of the filler (rigid coir and jute) into the soft polypropylene matrix results into the increase in the modulus.

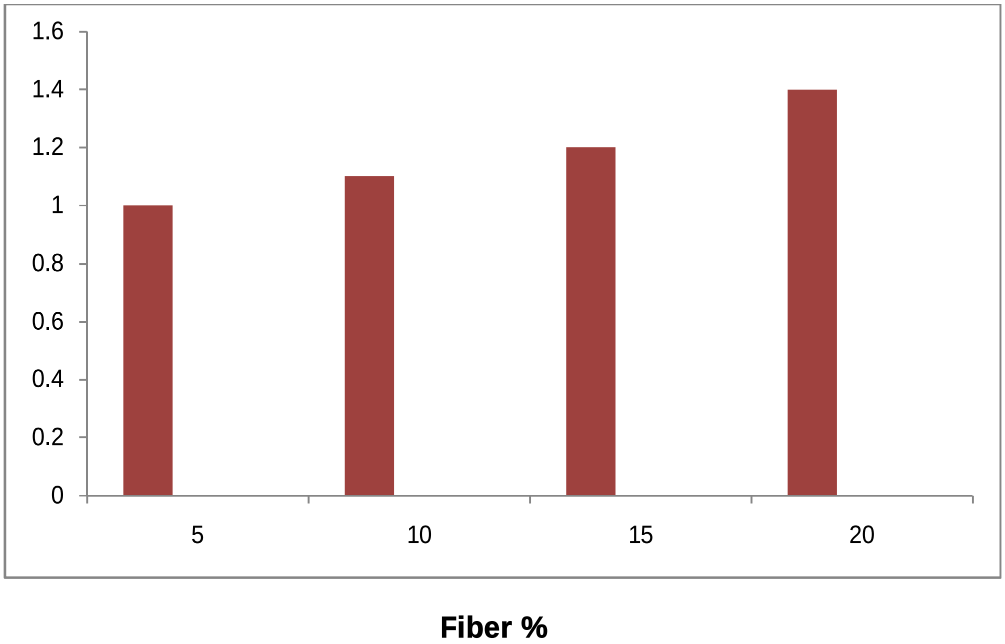


Fig. 4.4 Variation of flexural modulus at different fiber content.

4.1.3 Impact Strength

Variation of the Charpy impact strength with fiber loading for coir and jute fiber reinforced hybrid composite is shown in “Fig. 4.5”. Impact strength increased with fiber loading [10] [15] [17] [19]. Impact strength of a material provides information regarding the energy required to break a specimen of given dimension, the magnitude of which reflects the materials ability to resist a sudden impact. The impact strength of the fiber reinforced polymeric composites depends on the nature of the fiber, polymer and fiber–matrix interfacial bonding [20] . As presented in the figure, impact strength of all composites increased with fiber loading. This result suggests that the fiber was capable of absorbing energy because of favourable entanglement of fiber and matrix. Fiber pull out is found to be an important energy dissipation mechanism in fiber reinforced composites [21] . One of the factors of impact failure of a composite is fiber pull out. With the increase in fiber loading , stronger force is required to pull out the fiber . This in turn increased the impact strength.

Composite	Impact Strength (J/m)
PPJCF-1	450
PPJCF-2	700
PPJCF-3	800
PPJCF-4	1100

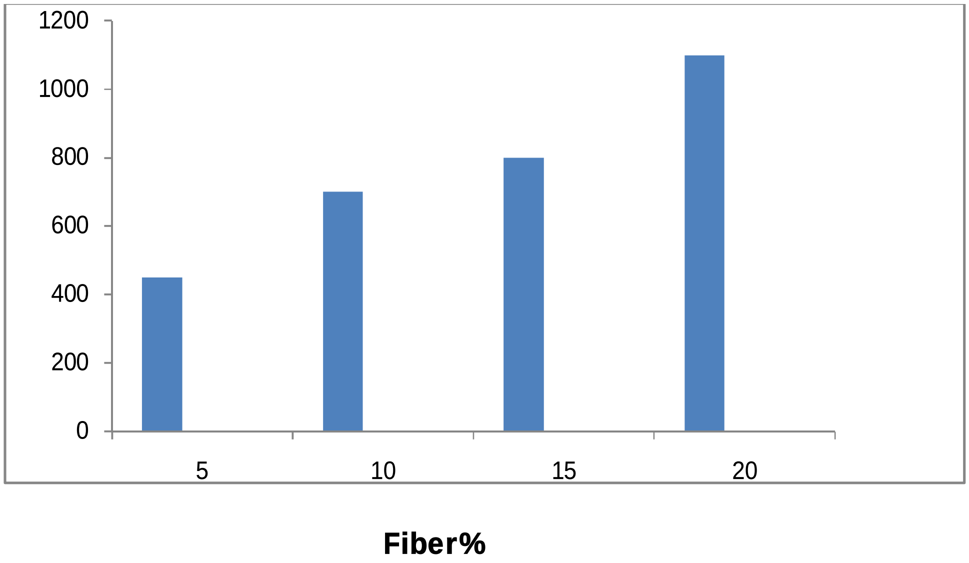


Fig. 4.5 Represents Variation of different fiber content.

4.1.4 Hardness test

Hardness of the composite depends on distribution of of the filler into matrix [2] [15]. Usually presence of a more flexible matrix causes the resultant composite to exhibit lower hardness. As shown in fig. 4.6 , incorporation of fiber into the PP matrix has reduced the flexibility of the matrix resulting in more rigid composite. Due to the increase of stiffness of respective composite the hardness of jute , coir hybrid PP composite showed a Slight increasing trend with an increasing in the fiber content [2]. Better dispersion of the filler into the matrix with minimization of void between the matrix and the filler also enhance hardness[22].

Composite	Hardness
PPJCF-1	93
PPJCF-2	95
PPJCF-3	98
PPJCF-4	99

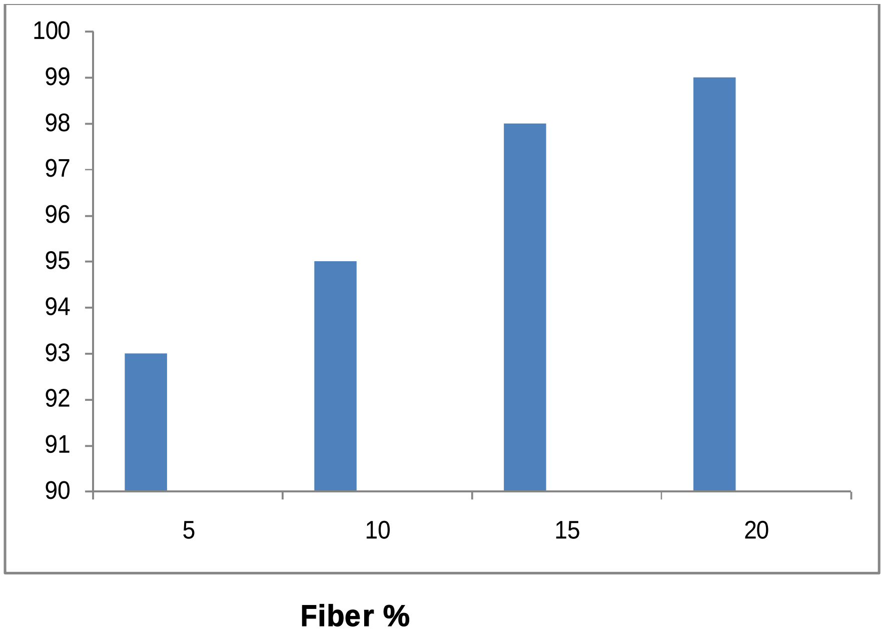


Fig. 4.6 Represents Variation of hardness at different fiber content.

CHAPTER -5

CONCLUSION

CONCLUSION

In the present work, jute and coir hybrid fiber reinforced PP composites were manufactured using hot press machine. The level of fiber loading was varied at 5, 10, 15 and 20 wt% with jute coir ratio of 1:1. The tensile strength of raw coir and jute fiber reinforced hybrid polypropylene composite at different fiber loading. The tensile strength of the composites decreased with an increase in fiber loading. Where as, the Young’s modulus increased with fiber loading. This is because with an increase in fiber content, the brittleness of the composite increased and stress/strain curves becomes steeper. The flexural strength of raw coir and jute fiber reinforced hybrid polypropylene composites at different fiber loading. The flexural strength increased with an increase in fiber loading which was in agreement with the findings by other reseaecher. The flexural modulus increased with an increase in fiber loading. Since both coir and jute are high modulus material, higher fiber concentration demands higher stress for the same deformation. . The impact strength of the fiber reinforced polymeric composites depends on the nature of the fiber, polymer and fiber–matrix interfacial bonding . Impact strength of all composites increased with fiber loading. This result suggests that the fiber was capable of absorbing energy because of favourable entanglement of fiber and matrix. charpy impact strength values increased with an increase in fiber loading. The hardness values increase with an increase in fiber loading. As a result 20% fiber composite yielded the best set of mechanical properties compared to other composites. Basically these composite can be further modified by treatment of the fiber and improving fiber matrix inter bonding

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