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Natural Fibers Polymeric Composites with Particulate Fillers – A review report

Rajendra Kumar[1*], Tejeet Singh[2] and Harwinder Singh[3]

[1]Lecturer, Mechanical Engineering Department, Government Polytechnic, Firozabad, Uttar Pradesh, INDIA
*E-mail: *radaur_rudra@yahoo.co.in*

[2]Professor, Mechanical Engineering Department, SBS State Technical Campus, Ferozapur, Punjab, INDIA
E-mail: *tejeetsingh@rediffmail.com*

[3]Professor, Mechanical Engineering Department, GND Engineering College, Ludhiana, Punjab, INDIA
E-mail: *harwin75@rediffmail.com*

*Abstract***:** This paper present the state-of-the-art literature review and explore the research guidelines on natural fibres polymeric composites. Due to the environmental issues, cost reduction and high performance of engineering applications, the demand of natural fibre is increasing day by day. Reinforcement with natural fiber in composites has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of separation, enhanced energy recovery, bio-degradability and recyclable in nature. To safeguard the environment, efforts are being made for recycling different wastes and utilise them in value added applications.

Keywords: Natural Fibers; Solid Waste; Polymers Composite; Environment

I. INTRODUCTION

In earlier days, builders used to reinforce mud with twigs to make structures. In nature wood and human body are the examples of composite. Over the past few decades composites, plastics, ceramics, have been the dominant engineering materials. The areas of applications of the composite materials have grown rapidly and have even found new markets. In the recent years, the concept of eco- materials has gained key importance due to the need to safe our environment. The use of eco-materials are depend on the factors such as working life, lifetime requirements complexity of product shape, number of items to produced, saving cost and weight. New resin matrix materials and high performance natural fibers which have been introduced recently have resulted in steady expansion in uses and volume of composites [1, 21].

Composite materials are commonly classified at following two distinct levels. The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite is generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites [1, 2, 20].

The second level of classification refers to the reinforcement form - fiber reinforced composites, laminar composites and particulate composites. Fiber Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibers.

- Fiber Reinforced Composites are composed of fibers embedded in matrix material. Such a composite is considered to be a discontinuous fiber or short fiber composite if its properties vary with fiber length.

- Laminar Composites are composed of layers of materials held together by matrix. Sandwich structures fall under this category.

- Particulate Composites are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category [1].

This article discusses the literature on the make use of and properties of natural fibers. Due to the consciousness of environment we reviewed the solid waste materials, their recycling process and uses.

II. PLASTICS

The ability of plastics materials to replace steel, concrete and wood in transportation, building, construction and other infrastructure, engineering, marine and in chemical industries [2] Thermoplastics have one- or two-dimensional molecular structure and they tend to at an elevated temperature. Some resins are shown in figure1.

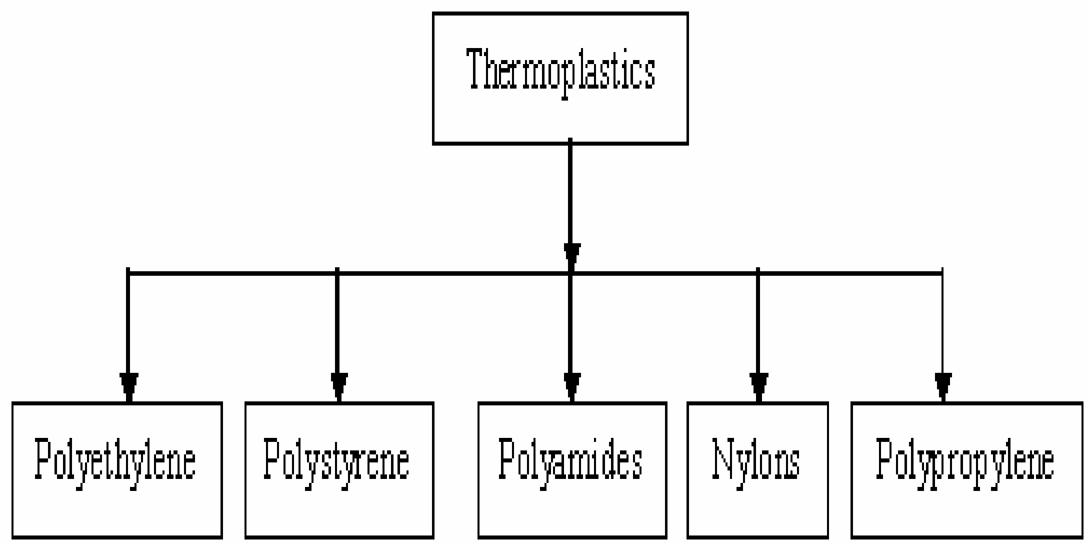

Figure 1: Different thermoplastics [20, 21]

Thermosets are the most popular of the fiber composite matrices without which, research and development in structural engineering field could get truncated. Aerospace components, automobile parts, defense systems etc., use a great deal of this type of fiber composites. Epoxy matrix materials are used in printed circuit boards and similar areas. Figure 2 shows some kinds of thermosets.

III. NATURAL FIBER

Recently, in the research and industrial development explores a new way to create greener and eco-materials for environment consciousness for a variety of applications. Composites made of natural fibres and biopolymers are completely biodegradable and are called ‘‘green composites” because of their environmentally beneficial properties. Natural fibres as reinforcement for petrochemical polymers like PP (polypropylene) have added a great value in the automotive industries [3].

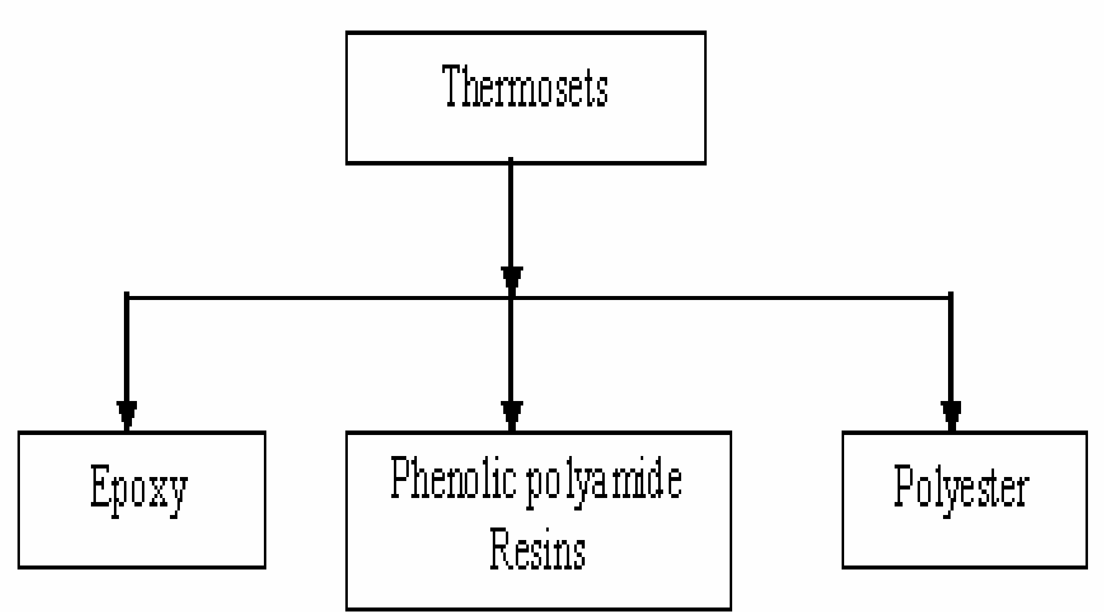

Figure 2: Different thermoset plastics [20, 21]

Natural fibers present many advantages compare to synthetic fibers, such as low tool wear, low density, cheaper cost availability, and biodegradability [4]. Some other important advantages of natural fibers are low specific weight, environmental friendly, carbon dioxide sequestration, producible low investment, good thermal and acoustic insulating properties, and no skin irritation, thermal recycling is possible [5]. Nowadays, the world faces unprecedented challenges in social, environmental and economical dimensions, in which the industrial design has showed an important contribution with solutions that provide positive answers regarding these problems. The use of natural fiber composites, produced in developing countries, have presented several social, environmental and economical advantages to design "green" automotive components [6]. The natural fibers found in all life cycles are shown in figure 3 [7].

IV. POLYMER COMPOSITES FROM NATURAL FIBERS

A. *Effect of Fiber Length on Mechanical Properties of Polymer Composites*

Evaluated of mechanical properties such as tensile strength, flexural strength and impact strength for different fibre length and fibre volume fraction Specimen1 [3mm] Sisal (25%) - coir (15%), Specimen 2 [3mm] Sisal (20%) - coir (20%), Specimen 3[5mm] Sisal (20%) - coir (20%). Sisal and coir fibers used as reinforcement materials with matrix of Epoxy resin to manufacturing of composite. It was observed that mechanical properties depend on fiber length and volume fraction [8]. The coir fiber was added in various lengths for prepared polyester composite. The effects of coconut shell powder content and coir fiber on the mechanical properties of the composites were investigated. It was found that the value of tensile modulus and tensile strength values increases with the increase of fiber length, while the impact strength slightly decreased, compared to pure polyester resin [9]. The effects of the fiber length distribution and the fiber orientation distribution on the strength have been studied in detail for short-fiber-reinforced polymers (SFRP). The results shown that the strength of SFRP increases rapidly with the increase of the mean fiber length at small mean fiber lengths and approaches a plateau level as the mean fiber length increases for the cases of large mean fiber lengths. It observed that composite strength increases with the decrease of critical fiber length and hence with the increase of interfacial adhesion strength and slightly with the decrease of the mode fiber length [10].

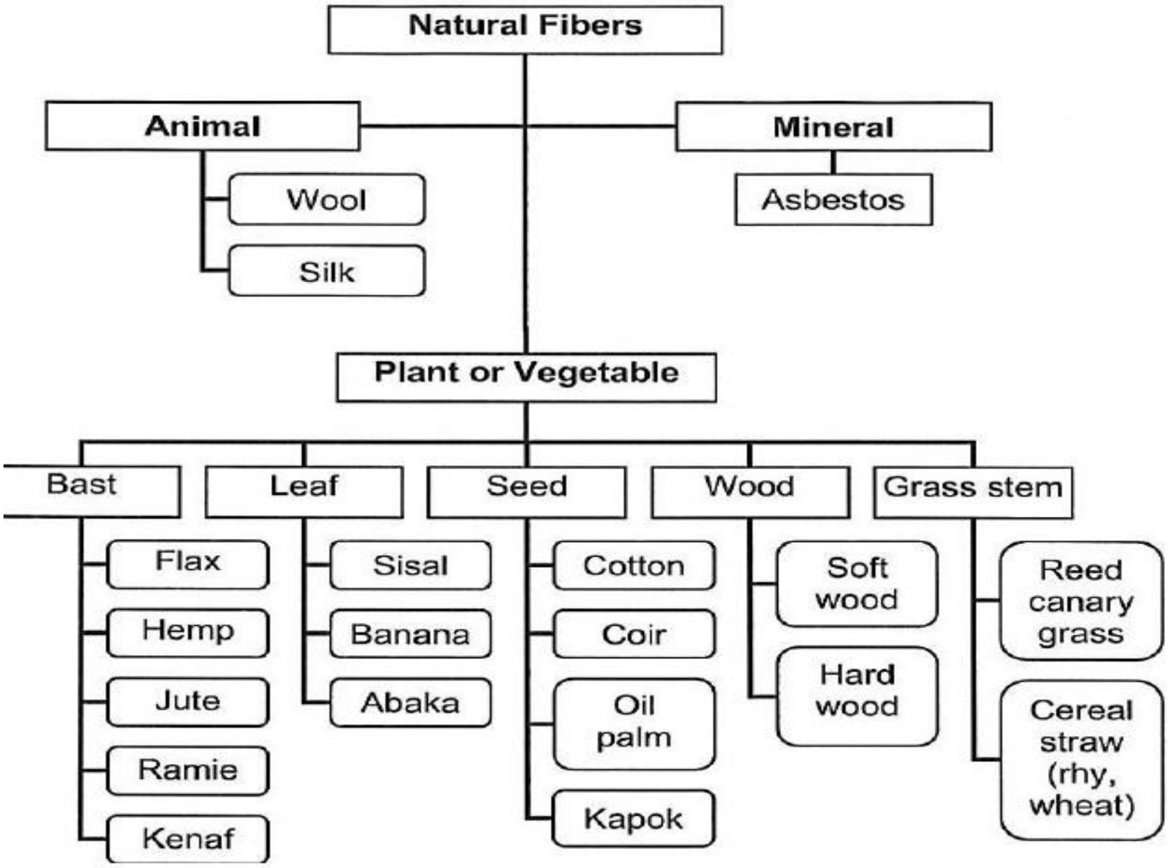

Figure 3: Natural fibers found in all life cycles [20, 21]

B. The Effects of Processing Conditions on the Mechanical Properties of Polymer Composites

The effect of compatibilizing agents on mechanical properties and morphology of a lignocellulosic material- thermoplastic polymer composite were examined. Autors prepared the four levels of samples by filler loading (10, 20, 30 and 40 wt %) and three levels of compatibilizing agent content (1, 3 and 5 wt %). In tensile testing, six temperature (-30, 0, 20, 50, 80, and 110^{0}C$^)$ and five crosshead speeds (2, 10, 100, 500, 1500 mm/min) were used. Tensile strengths of the composites decreased with filler loading, but these properties were significantly improved by addition of compatibilizing agent [11, 22]. Four levels of filler loading (10, 20, 30 and 40 wt %) was prepared. In tensile testing, six levels of test temperature (-30, 0, 20, 50, 80 and 1108C) and five levels of crosshead speed (2, 10, 100, 500 and 1500 mm/min) were performed. It was found that the tensile strengths of composites slightly decreased with increases in filler loading, whereas tensile modulus improved with the higher filler loading [12, 22].

Rice husk is one of the natural plant fiber used as reinforcement in Polymer Matrix composites (PMC). When, rice husk burnt in the open air outside the rice mill yields two types of fillers i.e. white rice husk ash (WRHA) and black rice husk ash (BRHA). WRHA have about 96% silica content, while BRHA has lower silica content, about 54% and remaining carbon content, i.e. about 44%. These ashes filled into epoxidized natural rubber, ENR (50 mol. % epoxidation grade). It prepared on laboratory size two roll mixing mill. The effect of coupling agent and tensile, tear, and hardness properties was studied and found WHRA exhibits the best overall properties as compared to BHRA. Silane coupling agent was used, the present of the silane coupling agent has enhanced improved the performance [13]. Effects of coupling agents, titanate (LICA 38), zirconate (NZ 44) and silanes (PROSIL 2020 and PROSIL 9234) on RHA in polypropylene composites were studied and determined. RHA consists predominantly of silica. Polypropylene composites of 10-40 wt% filler loadings were compounded using a Brabender twin screw extruder. it was determined that the melt flow index decreased with increased filler content. For most of the composites, the flexural modulus increased with filler content while tensile strength, elongation at break and Izod impact strength showed a decrease. PROSIL 2020 coupling agent improved the tensile strength of the composites while the impact properties were enhanced by the LICA 38 and the PROSIL 9234 coupling agents. None of the coupling agents increased the stiffness of the composites excepts for NZ 44 at maximum filler loading. The mechanical properties of RHA composites were compared to PP composites filled with commercial fumed silca and talc [14].

C. Effects of particulate filled on mechanical properties of polymer composites

Generally fillers are used in polymers due to more reasons such as cost reduction, improve processing, density control, optical effects, thermal conductivity, control of thermal expansion, electrical, properties, magnetic properties, flame retardancy, improve hardness, and wear resistance. Filler materials are used to reduce the material costs, to improve mechanical properties to some extent and in some case to improve ability. Besides also increases properties like abrasion resistance, hardness, reduce shrinkage.

Moisture absorption resistant and flexural strength improved in Jute epoxy resin and red mud as filler material composite [15]. Mechanical properties such tensile strength, flexural strength and modulus thermal deformation temperature increase, whereas the impact strength decreased with increasing red mud content. Maximum tensile strength was observed with 15 wt% red mud [16].

A series of bamboo- fiber reinforced epoxy composites was fabricated by using red mud and copper slag particles as filler materials. In study found, the tensile strength of the composites increased where the flexural strength and impact strength decreased with increase of these contents [17]. Sisal fiber and banana fiber was reinforced in unsaturated polyester (USP) with addition of red mud and revealed Mechanical strength increase [18]. Red mud filled coir fiber reinforced polymer composites fabricated and leads to determined of mechanical properties at various percentage of red mud as filler materials [19, 20 -22].

V. CONCLUSION

The extensive use of natural fibers because of their properties such as low density, relative high strength, modulus, high level of filler loadings, biodegradability and safe working environment. Composites enhanced mechanical strength and acoustic performance, light in weight, fuel saving, lower cost of production, shatterproof performance. Composites thus prepared have applications in the construction of building (laminated, door, roofing, beam, sheet, etc.), improving biodegradability for, automobile (interior parts, cabin lining, exterior parts, etc), and electrical (electrical connector, microwave containers etc.). Natural fiber lengths play an important role on the effect of mechanical properties. Industrial wastes as particulate filled composite are very popular to make polymer composites. Due to environment consciousness solid waste recycling solve the environmental problems. To effectively utilize these wastes as a raw material, filler, binder and additive in developing alternative building materials, detailed physical-chemical, engineering, thermal, mineralogical and morphological properties of these wastes are to be evaluated and accurate data made available.

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