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Mechanical properties of Natural Fiber Reinforced hybrid composites with effect of natural rubber – A Review

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Abstract **-** There is abundance of natural fibers and minerals are available in the environment which are eco-friendly in nature, low cost, bio degradable and renewable. By using these naturally available fibers, a composite material is prepared which has comparatively more advantages than that of synthetic fibers and this article presents the overview of the mechanical properties of natural reinforced hybrid composites which is composited by natural fibers like ramie ,sisal along with the mineral fiber basalt and effects of natural rubber as a natural filler on its mechanical properties with epoxy LY556 as a resin and fabrication using the laminate sequence method with the help of vaccumbagging.

***Index Terms* – natural fibers, ramie, sisal, basalt natural rubber, vaccum bagging and mechanical properties.**

INTRODUCTION

Materialselectionindesignandmanufacturingofaquality product plays a vital role in the field of engineeringdesign and production. The materials are used to explore their physical properties along with their mechanical properties to make the product a sustainable one. The natural fiber reinforced composite materials are one of such materials which provide the ease of processing, productivity, and cost reduction (Faruk et al., 2012; Al-Oqla and Sapuan, 2014; Sanjay and Suchart, 2019). These composites are most reliable materials which have a unique quality where the properties can be altered by varying the different reinforcement and matrix phase (Bledzki and Gassan, 1999;Yogesha,2017).Comparedwiththesyntheticfibers, the natural fibers have many advantages due to their abundance, availability, bio degradable and low cost (Arpitha et al., 2017; Madhu et al., 2019b). The natural fibersareintroducedinsteadofsyntheticfiberstomakethe compositeslighter.

Thedensityofnaturalfibers(1.2–1.6g/cm^3)islowerthan most of the other fibers, which leads to the making of the light-weightcomposites.Asaresult,thereisanincreasein the demand for the commercial use of natural fiber-based composites in various industrial sectors. Natural fibers (such as kenaf, jute sisal ramie) reinforced polymer compositereflectsoutstandingandcomparablemechanical and dynamic properties to steel and aluminum, leading to extend its applications for special engineering materials such as automotive, aerospace industry and construction structures.

In the past, natural fibers were used in structural applications. More recently, some cellulosic products and wastes have been used as fillers in polymers to achieve cost savings and to impart some desirable properties (Chawla and Bastos, 1979; Kokta, 1988; Lubin, 1982 Maldas and Kokta, 1995; Piggot, 1980; Prasad et al., 1983). Already explored industrial applications include window and door frames, furniture, railroad sleepers, automotive panels and upholstery, gardening items, packaging, shelvesetc., application in aerospace, leisure, constructions, and sports, industries and, in general applications that do not require very high mechanical resistance, but, instead, reduce the purchasing and maintenance costs (Faris et al., 2014; Ku et al., 2011; Manti and Morreale, 2011). Recent work on natural fiber composites reveals that the specific mechanical propertiesofnaturalfibercompositesarecomparable to used to those of synthetic fibercomposites.

The natural fiber-based composites have been used in automotive interior linings (roof, rear wall, side panel lining), furniture, construction, packaging, and shipping pallets, etc. (Oksman, 2001; Lau et al., 2018; Sood and Dwivedi,2018; Santhosh Kumar and Hiremath, 2019). Natural fibers are extracted from different plants and animals (chicken feather, hair, etc.) (Aziz and Ansell, 2004; Huda et al., 2006; Kicinska- Jakubowska et al.

2012). The plant fibers are made up of constituents like cellulose, lignin, hemicellulose, pectin, waxes, and water-soluble substances, the presence of cellulose which is hydrophilic in nature affects the interfacial bonding between the polymer matrix and the fibers because the matrix is hydrophobic. The study of natural fibers is very essential to develop eco-friendly composites.

SOURCE, PROPERTIES, AND APPLICATION OF NATURAL FIBERS

Ramie (Boehmeria Nivea)

Ramie is one of the herbaceous perennial plants cultivated extensively in the region native to China, Japan, and Malaysia where it has been used for over a century as one ofthetextilefabrics(NamandNetravali,2006;Rehmanet al.,2019;Yanetal.,2019).Ramieisanon-branching,fast-growing plant which grows up to 1–2m height. The fibers extractedfromthestemarethestrongestandlongestofthe natural bast fibers. In addition to this attempt has been made for developing bio-based products by utilizing them in the field of automotive, furniture, construction, etc. The ramie fibers are extensively used for the production of a wide range of textiles, pulp, and paper, agrochemicals, composites, etc. The processing of the ramie fibers is similar to linen from flax (Angelini and Tavarini, 2013; Bunsell,2018).

Sisal (Agave sisalana)

The sisal is one of the most used natural fibers and Brazil is one of the largest producers of this fiber. It is a species native to south Mexico consists of the rosette of leaves grows up to 1.5–2m tall (Naveen et.al 2018; Sanjay et al., 2018; Senthilkumar et al., 2018; Devaraju and Harikumar, 2019). The sisal produces about 200–250 commercially usable leaves in the life span of 6–7 years. These sisal fibers have good range of mechanical properties and are used in the automotive industry, shipping industry (for mooring small craft and handling cargo), civil constructions, used as fiber core of the steel wire cables of elevators, agricultural twine or baler twine, etc. (Mihai, 2013;Rameshetal.,2013;Nirmaletal.,2015;Aslanetal., 2018).

Basalt fiber

It is the material made from the extremely fine fibersof basalt which is composed of the minerals plagioclase, pyroxene, and olivine. The technology of production of BF (Basalt Fiber) is a one-stage process which includes melting, homogenization of basalt and extraction of fibers. Basalt is heated only once. Further processing of BF into materials is carried out using "cold technologies" with low energy costs. The manufactureof basalt fibers requires the meltingofthecrushedandwashed basalt rock at about 1,500 °C (2,730 °F). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. They also have a highelasticmodulus,andhighspecificstrength.Thinfiber is usually used for textile applications mainly for production of wovenfabric.(Wikipedia)

NATURAL FIBERS ASREINFORCEMENT FOR COMPOSITESMATERIALS

Over the past few years, attempts have been made in developing the materials which replace the existing materials to have better mechanical properties for various applications (Arpitha and Yogesha, 2017; Abdellaoui et al., 2019). In view of this the monolithic materials are replaced by the fibers and materials such as carbon, glass, aramid fibers which are extensively used in aerospace, automotive, construction, and sporting industries, etc. (Balakrishnanetal.,2016;Pickeringetal.,2016;Asimetal., 2018). However, these materials have some disadvantages like non-biodegradability, non-renewability, high-energy requirement for production, and also harmful to the environment as the production of these materials releases enormous amounts of carbon dioxide into the atmosphere. Therefore, to overcome all these drawbacks researchers hasmadeanattempttostudyonthedifferentnaturalfiber-reinforced composites which have better properties so that they can replace synthetic fibers in various applications (Wambua et al., 2003; Li et al., 2007; Sanjay et al., 2015; Mochane et al., 2019). As the demand for the newer materials which have better properties than the existing one's upsurges, the researchers have tried different types of natural materials with different natural fibers obtained fromfruits,seeds,leaves,stem,animals,etc.(Sanjayetal., 2019a).

Natural rubber

Natural rubber is basically present in the form of latex, which is obtained by the bark of rubber trees and various othertrees.Latexisamilkywhiteliquidwhichiscollected by trees through vessels. This method of obtaining latex is called as 'tapping'.Then this latex is hardened by the method of vulcanization (the process of hardening natural rubber with Sulphur and synthetic rubber with other metallic oxides is called asvulcanization).

Natural rubber used for the composite material is the rubber obtained without vulcanization, the latex obtained is kept for some days/ to make it hard naturally, then it is crushed to get in powder form and further it is mixed with resins in the desired proportions. Latex obtained is the polymercis-1,4-polyisoprenewhichhasdrymassupto5% of other materials, such as resins, inorganic materials(salts), fatty acids andproteins.

COMBINATIONS

Compositelaminatesof4mmthicknessarepreparedusingbasalt, sisal, ramie, epoxy resin, and natural filler. Natural rubber is used as filler material. Composite laminates are prepared by vaccum bagging technique, and cooled at 8 degrees Celsius. The laminates are of a dimension 250mm X250mmX4mm. Hybrid natural composites are prepared by using basalt as mineral fiber and sisal, ramie as natural fibers. Resin LY556 and hardener HY951 is used. The fibers and resin are mixed in the ratio of 50:50 by weight. Theresinandhardeneraremixedintheproportion10:1by weight. In the laminates approximately 8-9 layers of the fiberwovenmatrixlayersareused.Thecombinationswith differentpercentagesoffilleri.e.naturalrubbertostudyits effects is asfollow:

0% NATURAL RUBBER;

1. Basalt (50%) + Resin (45%) + hardener(5%)
2. Sisal (50%) + Resin (45%) + hardener(5%)
3. Ramie (50%) + Resin (45%) + hardener(5%)
4. Basalt (25%) + Sisal (25 %) + Resin (45%)+ hardener (5%)
5. Basalt (25%) +Ramie (25 %) + Resin (45%)+ hardener (5%)
6. Ramie (25%) + Sisal (25 %) + Resin (45%)+ hardener (5%)

5% NATURAL RUBBER;

1. Basalt (22.5%) + Sisal (22.5%) + Naturalrubber (5%) + Resin (45%) + hardener(5%)
2. Basalt (22.5%) + Ramie (22.5%) + Naturalrubber (5%) + Resin (45%) + hardener(5%)
3. Ramie (22.5%) + Sisal (22.5%) + Naturalrubber (5%) + Resin (45%) + hardener (5%)

10% NATURALRUBBER;

1. Basalt (20%) + Sisal (20%) + Natural rubber (10%)+ Resin (45%) + hardener(5%)
2. Basalt (20%) + Ramie (20%) + Natural rubber(10%) + Resin (45%) + hardener (5%)
3. Ramie (20%) + Sisal (20%) + Natural rubber(10%) + Resin (45%) + hardener (5%)

EFFECT OF NATURAL FILLER ON COMPOSITE LAMINATES

Fiber reinforced plastics have replaced many of the materials in many of the areas, mainly in household application and automobile industry. According to the study, natural fillers such as natural rubber, rice husk, wheat husk, coconut coir, sea-shell powder, etc. provide better result for glass fiber reinforced plastics rather than the natural fiber reinforced composites. In the above mentioned natural fillers coconut coir exhibits the better mechanical properties when compared to others.

Composite laminates of 4mm thickness are preparedusing basalt,sisalandramiefibers.Andnaturalrubberisusedas a natural filler. Composite laminates are prepared by vacuum bagging technique, at cooling temperature of 8 degrees Celsius. Epoxy resin LY556 and hardener HY951 is used. The resin and hardener are mixed and stirred mechanically in the ratio 10:1 by weight. The natural rubber is used in a proportion of 5% - 10% of the weight of the fibers used. When the natural rubber is used there were little variation in the mechanical properties of the composite laminates. As the filler percentage goes on increasing the variation in the mechanical properties goes on increasing and vice-versa. Some of the properties were studied and are mentionedbelow

Mechanical properties	**Effect of natural fillers**
Tensile strength	Tensile property decreases on increase in filler percentage
Compressive strength	Compressive property decreases on increase in filler percentage
Cross breaking strength	Cross breaking strength decreases on increase in filler percentage
Impact strength	Impact strength increases on increase in filler percentage
Hardness	Hardness of the laminate decreases on increase in filler percentage
Specific gravtiy	It doesn’t show much variation with respect to filler percentage

CONCLUSION

Increased environmental awareness has resulted in the utilization of natural fiber as an effective reinforcement material in polymer matrix composites. Natural fibers are proficient materials which can replace the existing synthetic fibers. The fibers are usually extracted from plants and animals often offer poor resistance to moisture and incompatible nature of fibers become the main disadvantage and addition of natural filler like natural rubberhavemadethetotalexpenditurelittlelessandmade thefiberconcentrationlessincompositematerialbutasper many research, addition of natural fillers only increases impact strength, but it often fails in enhancing other properties, it may not affect the other mechanical properties in higher magnitude, but small variations is inevitable

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