

Development, Testing of Flax and Banana Fiber Using Poly Vinyl Alcohol Polymer Matrix Composite by Hand Lay-Up Process

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Abstract

Last few decades have seen composite materials being used predominantly in various applications. Many types of natural fibers have been investigated for their use in plastics including Flax, hemp, jute, straw, wood fiber, rice husks, wheat, barley, oats, cane (sugar and bamboo), grass reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, water pennywort, kapok, paper-mulberry, raphia, banana fiber, pineapple leaf fiber and papyrus. Their volume and number of applications have grown steadily. Natural fibers offer both cost savings and reduction in density when compared to glass fibers. Natural fibers are an alternative resource to synthetic fibers, as reinforcement for polymeric materials for the manufacture is cheap, renewable and environment friendly. This paper discusses in detail about the uses & applications of banana fibre composites.

Keywords: Banana fibers, Properties of fibers, Application of fibers, uses of fibers

1. Introduction

Flax fiber is a bast fiber and they are exerted by retting and scutching operations. Flax fiber is cellulose based fiber and they have low density, good tensile strength, stiffness and high aspect ratio [1]. The position of stem is deciding the mechanical property of flax fiber. The load rate increase from 1.33%/min to 8%/min to increase the interfacial shear strength with equal change in the average tensile strength of the composite. The thermal insulation is suitable for bast fibers like flax and hemp. Under the tensile loading and repeated loading-unloading the test are performed of flax fiber was found that the young's modulus are influenced by the flax diameter and direction [2]. Fine and regular long fibers are usually spun yarn for linen textiles. Linen fabric maintains a strong traditional place all one's own among high quality household textiles, like as bed linen, furnishing fabrics and interior

decoration accessories. And we know that the shorter flax fibers produce stronger yarn and it is suitable for kitchen towels, sails. In near future the flax fiber reinforced composite can be utilized for hybridization of flax fiber with synthetic fibers. [3]

Polyvinyl Alcohol (PVA), also known as PVOH, PVA, is a biodegradable polymer matrix and it is soluble in water. It is useful in film forming, emulsifying, and has an adhesive quality. It has no odour and is not a toxic solvent. PVA is ductile but it is strong, flexible and functions as a high oxygen and aroma barrier. While other polyvinyl alcohol polymer is prepared by polymerization of its corresponding monomers, PVA undergoes either partial or complete hydrolysis of polyvinyl acetate to remove acetate groups. To ensure lubricate and binding action in order to protect the fiber and help with handling, sizing is a processing mechanism applied to roving and yarns. The key raw material to create PVA is the vinyl acetate monomer. The monomer is manufactured through the polymerization of vinyl acetate. Then it goes through partial hydrolysis, which consists of partial replacement of the ester group in vinyl acetate with the hydroxyl group, complete in the presence of the aqueous sodium hydroxide. After the gradual addition of the aqueous saponification agent, the PVA is precipitated, washed and dried. [4]

1.2 History of Polymers

The science of composites is not new to humans. Even in ancient times around 1500BC Egyptians had a view to mix mud with straw in order to improve the strength of the mixture. This material they usually used in making their houses. Even the paper we use is composite, certain mineral fibres are added to the pulp in order to retain ink, maintain glossy finish etc.

It is said that composites are a great boon for the military

equipments but the truth is in 1200 Mongols in the time of throne of Genghis Khan developed their accurate and powerful archery bow using a composite material made of cattle horn, wood, cattle tendons and animal glue. The hierarchal trend of development of synthetic polymers:

Table 1: History of Polymers

1850	Development of plywood was seen in this time period by John Henry Bettler
1907	Phenol – Formaldehyde was produced by Leo Baekeland
1928	Accidental discovery of safety glass was done by Otto Rohm
1933	Development of Melamine Formaldehyde took place
1935	First glass fiber was introduced by Owens Curing
1938	Pierre Castan discovered Epoxy
1942	This stage was a boon period for composites ; thus making up the scarcity of material during the World War II.
1950s	Innovative manufacturing methods like pultrusion, vacuum bagging, filament winding were introduced.
1956	Periods of MMCs marks a beginning from this time.
1964	Kevlar fiber was developed by Stephanie Louise Kwolek
1978	First filament wound aircraft fuselage was developed
1979	Invention of dyneema Fiber took place
1990	Nanocomposites starts gaining popularity
2000	Development of smart materials by mixing organic and inorganic components. [63]

1.2 Classification of Polymer:

Polymers are broadly classified as follows:

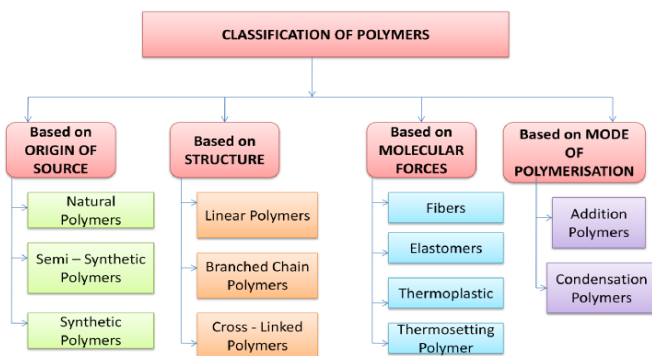


Fig 1: Classification of Polymers

1.2.1 Based on origin of source

- **Natural Polymers:** These polymers which are create from the nature i.e. from plants and animals. Those polymers which directly affect the basic life processes of plant or animal body are also known as Bio Polymer. Some of generally occurring natural polymer is
 - Starch and Cellulose – It is a polymers of Glucose. These are produced by plants during photosynthesis from glucose. Starch is called as reserved food of the plant.
 - Nucleic Acids of Polymers of Nucleotides are nucleic acids. For example RNA and DNA
 - Proteins – These are large molecules and the building

blocks of animal body. They consist of α -amino acids, having an arrangement of around 1000 amino acids.

- **Semi-Synthetic polymers:** A semi synthetic polymer is a polymer made by chemically treatment of a natural polymer. We know that the cellulose is a natural polymer, is chemically treated to from nitrocellulose.

Example- acetate rayon, viscous rayon, Nitrocellulose

- **Synthetic polymers:** Those polymers are human-made polymers formed by the chemical reactions. The father of synthetic polymer science is Wallace Hume Carothers. Synthetic polymers synthesis dates back during World War II period. Both growing demands and scarcity inspired scientists to develop new materials.

Some of common synthetic polymers are –

- Polyethylene
- Polypropylene
- Polystyrene
- Polytetrafluoroethylene(PTFE)
- Polyvinyl chloride(PVC)
- Polycarbonate
- Nomex

1.2.2 Based on Structure

- **Linear Polymer:** A polymer in which monomeric units are straight continuous chain attached side to side.



Fig 2: Linear Polymer

- **Branched Polymers:** In this Branched polymer are having secondary polymer chain linked to primary backbone polymer.

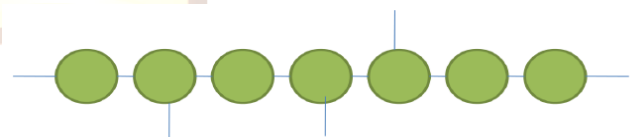


Fig 3: Branched Polymer

- **Cross-linked polymer:** This type of polymer interconnections between chains. It is formed by adding the reagent after the process of polymerization

or it can also be formed by the choice of monomer during polymerization.

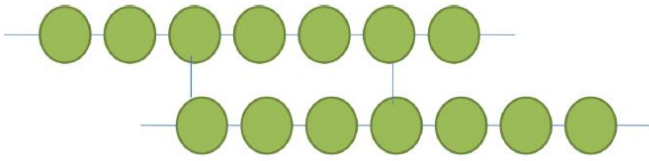


Fig 4: Cross - Linked Polymer

➤ **Based on Molecular Forces**

Depending on the degree of intermolecular forces, two main structures in polymers exist.

- **Crystalline structure:** This is highly ordered and arranged structures. It is very helpful to mechanical properties, i.e. resistance to stress and loads to avoid sudden deformation.

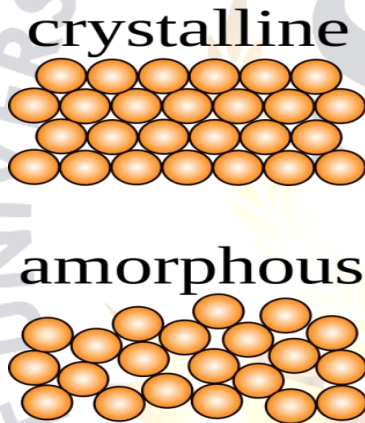


Fig 5: Crystalline Structure and Amorphous Structure

- **Amorphous Structure:** This is a disordered structure, like a tangled roll of thread. It is responsible for the elastic characteristics of the material
- **Elastomers:** Elastomeric polymers have viscoelastic properties and very weak intermolecular forces. It has low young's modulus and high elasticity. Because of they are highly flexible and elastic. Elastomers exist above the glass transition temperature and are amorphous in nature. These polymers are converting him in gaseous state but do not melt. It Have very low creep resistance. The common example of elastomers is Natural Rubber, Polybutadine, Silicone rubber, Neoprene rubber, Buna-s and Buna-n.
- **Thermosetting Polymers:** In this polymers have a cross link structure between covalent bonds between

the units. Gel Point is the governing parameter of thermosetting polymers. In which Gel Point is the stage in curing process when material changes from liquid state to solid state means irreversible change. So in the thermosetting polymer has no physical change but they have chemically change and so no possibility of recycling of such material exists. Thermosetting polymer has high creep resistance. Examples of thermo sets are epoxy resin, polyester resin, melamine formaldehyde, etc.

- **Thermoplastic:** Thermoplastic has either linear structure or branched structure. They have weak intermolecular forces but strong intermolecular forces. These polymers can be melting on heating and can be reshaped. So there is a feasible of recycling and reuse. Thermoplastics have a good creep resistance. If the thermoplastic has greater concentration of amorphous structure then the material will possess good elasticity with a less resistance to load. But conversely, if the material is rich in crystalline structure then will have good resistance to stress with very less elastic characteristics, making material fragile.

1.2.2 Based on Mode of Polymerisation

- **Addition Polymerisation:** In a broad way joining of monomers one next to other generate a long chain is addition polymerization. In this addition polymerization, reaction starts with double bond monomer. This double bond of monomer is broken under pressure and catalyst resulting vacancies to accommodate side groups and then forming a long polymeric chain. Example of Addition Polymerisation is Polyethene, neoprene, rubbers, polyvinyl acetate etc.

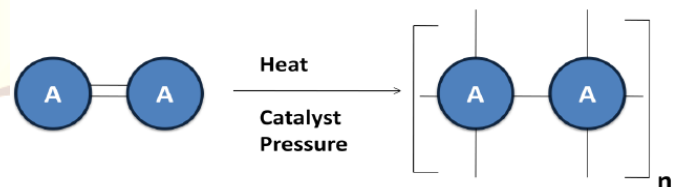


Fig 6: Addition Polymerisation

- **Condensation Polymers :** These polymers are formed by chemical reaction in which molecules join together to form long chain compounds with simultaneous

release of condensed molecules(usually of lower hydrogen

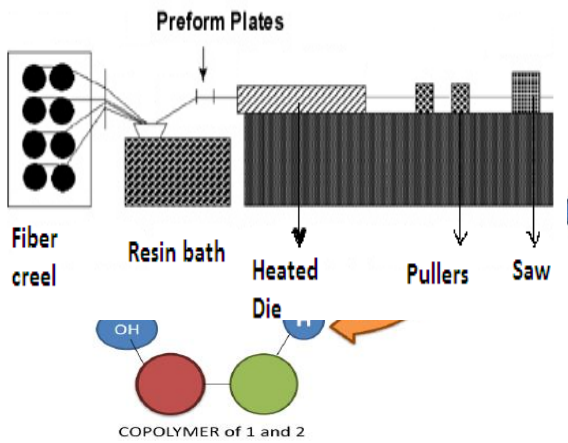


Fig 7: Condensation Polymer

3. Compression Moulding:

Compression Moulding is a method of moulding in which closed mould with pressure are used. In this process, fiber mixed with matrix resin is kept on the lower plate of the mould and then downward progressive pressure is applied to the upper pate of the desired shape.

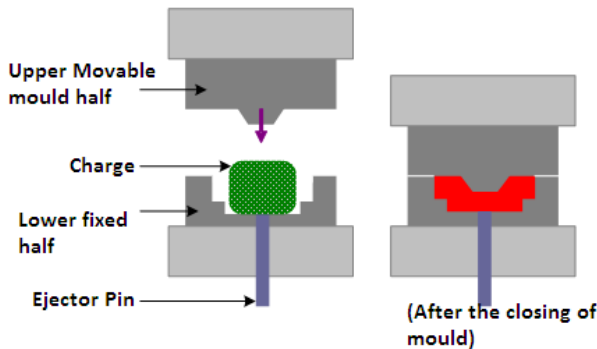


Fig 8: Schematic of Compression Moulding Process

And sometimes heat is also given depending upon the requirement. Pressure, temperature and heat are the three parameters which are critical and plays important role in the properties of the part produced. At last process curing is done either at room temperature or at desired temperature.

4. Autoclave Processing:

Autoclave processing is more time consuming but they produce good quality products. Usually autoclave processed parts application in aerospace industry. Main steps involved in autoclave processing are as follows:

- Firstly preparation of semi finished part known as prepegs.

- Tool preparation
- Layers of prepegs to the desired thickness.
- Curing in autoclave
- Removal of part from tool
- And finally step Trimming and finishing

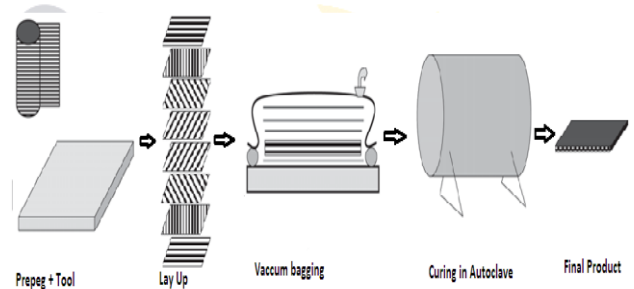


Fig 9: Main steps in the autoclave manufacturing process

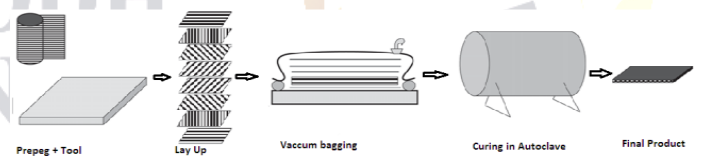


Fig 10: Cylinders for compressed natural gas and drive shafts to be used in automobiles are also made by this process.

5. Filament Winding:

Filament winding is fabrication technique, generally used to make convex spherical structures such as pressure vessels, storage tanks, tubes and piping of varied thickness.

- In this process ravings of fibers are pulled from the creels and separated and kept aligned using combs.
- Then they are made to pass through resin bath, where these fibers get fully dipped in the resin bath covering each and every fiber length with resin.
- After this fibers are placed onto the rotating mandrel which is driven by the motor in the desired angle of wrap. Fiber feed and rotation of mandrel goes simultaneously in order to get a uniform thickness along the entire length of the structure.
- This angle of wrap of fiber can be very well controlled by the ratio of carriage speed to the rotational speed.
- Widely used in making commercial items where strength to weight ratio is an important criteria to be kept in mind.

Common usage of this method is found in the manufacturing of oxygen cylinders carried by mountaineers because of its less weight and high strength. Also, being corrosion resistant it is used in

6. Pultrusion Process:

Pultrusion is very similar to the extrusion process and only one difference of instead of applying force and pressure the material out of die for shaping process and here pulling force is applied to draw out fibers from die. Pultrusion capable the manufacturing of constant cross section parts only.

These procedures are following:

- Firstly the fibers are drawn out from the fiber creels, and passed through creels cards in order to avoid knotting and twisting of the reinforcement fiber.
- Then after this these roving are impregnated with catalysed resin by dipping in the resin bath. Comb is employed at entrance and exit of bath for maintain a proper alignment of the fibers.
- Then further it is passed through perform plates to perform the desired shape and size. Here, excess resin is removed and also avoids excessive hydrostatic pressure.
- These impregnated fibers are then passed to heated die where rate of reaction and degree of curing is controlled.
- And these fibers are pulled through the die and cut by carbide or diamond edged blade saws.

7. Liquid Composite Molding:

In liquid composite moulding (LCM), firstly perform of made of fiber having same or constant dimensions parts are prepared. And then placed in the mould, made of high strength metal (which is usually in two halves) and then mould is closed tightly. The further step is of resin infusion resin and catalyst is mixed in a suitable ratio and the injected in the mould. This process of infusion depends on process to process such as

- It can be injected under high pressure in SRIM
- Moderate pressure of RTM
- Suction created by vacuum in case of VARTM or SCRIMP

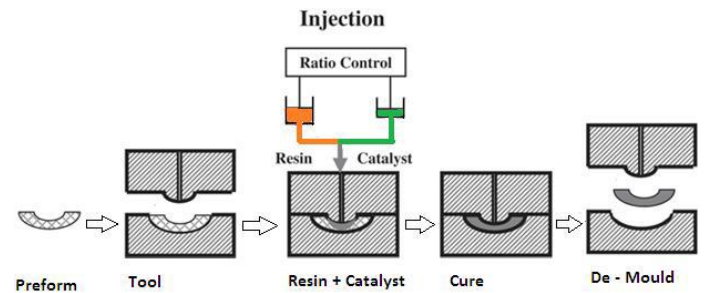


Fig 11: Schematic of the LCM process.

After the resin fills in the mould then it is left for curing in suitable or desired time period. And complete the curing process than the part is removed from the mould.

8. Conclusion

This paper presents the fabrication of different composite such as PVA+Banaan fiber composite, PVA+Flaxfiber composite and PVA+Banana+Flaxfiber hybrid composite by using hand layup method. The following conclusions are below:

- Proper dispersion of PVA particles in water is done by magnetic stirring at suitable rpm.
- When the increase the filler concentration upto 20 gm of the fiber the mechanical properties also increases but on further increases the weight i.e. 25 gm the properties are decreases.
- The tensile strength of hybrid composite 23.515 Mpa is higher compare to the PVA+Bananafiber composite is 18.76 Mpa and PVA+Flaxfiber composite is 21.405 Mpa. Hence, hybrid composite has good tensile properties.

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