DEVELOPMENT OF NATURAL FIBRE COMPOSITES IN PAPUA NEW GUINEA (PNG)

Ales Steve K., Sumanasiri K.E.D
Graduate Research Assistant, Department of Mechanical Engineering, PNG University of Technology, Private Mail Bag Lae 411 Papua New Guinea. Tel: +675 473 4851/+675 71524109,
skorokan@mech.unitech.ac.pg

1 INTRODUCTION

In the current research we are mainly focusing on the utilization of agricultural by-products both from industries at larger scale like sugar cane fibers (Bagasse), corn, oil palm fruit shells and coconut coir from copra industries while domestic wastes such banana fiber, bamboo, pandanus and betel nut fibres can be used to produce NFRP composites. The potential applications of these products can be both for industries and domestic uses. The industrial applications include Medium Density Fiber (MDF) boards, insulations, particle boards and hard boards while natural fiber sandwiches of bamboo and foam cores as roofing panels as a substitute for both vegetable and corrugated iron roofing constructions as the traditional vegetable roofing does not last longer while the corrugated iron corrodes easily posing health risk to those who depend on rainwater collected from tanks for drinking and cooking. The different production techniques can be applicable in producing the NFRP composites. Some of these compounding processes and techniques including synthetic resin transfer injection, extrusion, hand lay-up molding and hot press compounding processes are being utilized and the mechanical properties are being evaluated. The investigations also include the economic viability and sustainability of the fibre supply in the manufacture of NFRP composites. The fiber surfaces can be chemically modified to have enhanced and improved mechanical properties. The important mechanical properties such as stiffness and flexural strength while utilizing the vast amount of natural fibres such as bagasse from sugar industry, coconut coir, banana fibres, sawdust, and corn stalks etc.

Composites are made from two or more distinct materials that when combined create a better, stronger and more durable material. Most composites consist of a reinforcing material embedded in a matrix and these reinforcing materials are generally fibres. The matrix can be any type of material that bonds to the reinforcement and holds the material together

2 AVAILABILITY OF DIFFERENT NATURAL FIBERS

Several Natural fibres are found in Papua New Guinea both from plants and animals. These fibres have been considered wastes as they have not been utilized in any resourceful ways as from our observations.

The supply of fibers from agricultural waste products is consistent with the annual crop productions especially sugar cane, oil palm and copra industries. We also have many other types of fibres found in the localities of Papua New Guinea which are being considered as wastes as seen both from industries and domestic such as corn, rice, pineapple, banana, sisal, bamboo, betel nut husk etc. However, the current literature reveals that these by-products have high potentials in the production of NFRP composites.

TABLE 1 **Classification of fibers**

NATURAL FIBRES					
PLANT /Lignocellulosic Fibers					**Animal Fibers**
Wood	Stem/Bast	Leaf	Seed/Fruit	Grass	Silk Wool Feathers
Softwood Hardwood	Sugar Cane Hibiscus	Sisal Pineapple Banana Pandanus	Cotton Coconut Oil palm Betel nut	Bamboo Rice Wheat Corn	

3 METHODS OF FIBER EXTRACTION

Fibre extraction is an integral part of NFRP composites production. There are several methods of extracting fibers from both plants and animals. The process is named according to the nature of separating fibers from the bulk materials. Fibres can be extracted manually by traditional means, biological action or with the aid of fibre extraction machinery such as coir fibre extraction machinery units. Some of these simple fibre extraction methods are discussed here. Retting is a treatment process to release the fibres from the rest of the plant. The following are some basic fibre separating processes involved in the separation of fibres from the plant.

3.1. Dew Retting

A type of retting process in which the stems of fibre plants are spread out in moist meadows, and the pectin decomposition is accomplished by molds and aerobic bacteria with the formation of CO_2 and H_2.

3.2 Water Retting

A type of retting process in which the stalks of fiber plants are immersed in cold or warm, slowly renewed water, for 4 days to several weeks. The active organism is Clostridium felsineum and related types, which break down the pectin to a mixture of organic acids (chiefly acetic and butyric), alcohols (butanol, ethanol, and methanol), carbon dioxide (CO_2), and hydrogen (H_2).

3.3 Decortications

Decortication is disaggregating of the stalks, loosening of the adhesion between fibres and wood or husks and the extraction of the fibres. Simultaneously, the fibre bundles should be opened to get thinner bundles or elementary fibres, as far as possible. For this purpose the wooden elements or husks have to be bruised many times without altering the natural fibre structure. The process of decortication is carried out manually by beating of husks or with an aid of fibre extraction machines such as coconut coir and banana fibre extraction machinery.

FIGURE 1 **a) Harvesting Sugar Cane, b) Sisal, c) Areca Catechu (Betel Nut)**

a) b) c)


FIGURE 2 **a) Sugar Cane Fibre (Bagasse), b) Extracted Sisal Leaf Fibres, c) Extracted betel nut fibres**

4 FIBER SURFACE TREATMENTS AND MODIFICATIONS

Chemical pre-treatment of fibers before manufacturing of NFRP composites is an integral part of the manufacturing processes to have improved fibre properties. Fibre treatments serve to give a final product chemically and physically improved properties. (Yoldas, 2009) reported that in order to improve the incorporation of natural fibres (NF) into polymers and to promote higher fibber/matrix interfacial adhesion, NF can be modified by different chemical and physical treatments. Organic fibres generally have smooth surfaces and little superficial surface energy, which result in low adherence within the matrix. These fibres usually do not have chemical functional groups to form strong bonds in the fibre–matrix interface. (Grozdanov, 2009) stated that the most common treatment modify the fibres by removing the superficial layer, changing the topography and the chemical nature of the surface. Chemical treatment improves fibre-matrix adhesion largely by introducing polar or excited groups or even a new polymer layer that can form strong covalent bonds between the fibre and the matrix, and sometimes by roughening the surface of fibres to increase mechanical interlocks between the fibre and the matrix**.**

5 MECHANICAL PROPERTIES

Mechanical properties such as the elastic modulus and strength of most reinforcing natural fibres would be considered with those of unreinforced resin systems. Therefore, the mechanical properties of the fibre/resin composites are dominated by the contribution of the fibre in the composites.

The tests are being carried out to evaluate mechanical properties using standard testing methods (ASTM/ASNZ). The mechanical properties such as stiffness, impact strength, and flexural modulus are being determined and investigated for further improvement in NFRP composite properties and production of composites.

6 MANUFACTURING PROCESSES

6.1 Hand Laminating

The fibers, usually, mats are cut and placed in a mould. The resin is applied by rollers as shown in Fig. 1. One option is to cure while using a vacuum bag, excess air is removed and the atmospheric pressure exerts pressure to compact the composite. A possible product is the boat hull shown in Fig. 8. The advantages of this technique are the high flexibility and the simplicity of the process and the low cost of tools needed. The long production time, the labor intensive character and the limited possibilities for automation are considered to be disadvantages as stated (Yoldas S.K.S, 2009)**.**

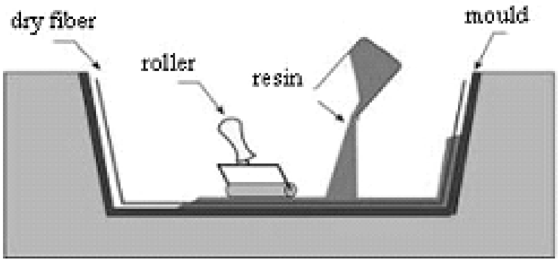

FIGURE 3 **Hand laminating (left); Boat hull (right)**

6.2 Hot Press Method

Grozdanov (2009) reported that in hot pressing, also called pressure sintering, pressure and temperature are applied simultaneously**.** This method makes the molded article denser and stronger by reducing porosity. Protective atmospheres are usually employed, and graphite is a commonly used punch and die material**.**

6.3 Spray-Up (Chopping)

ACMA (2009) states that Spray-up or chopping is an open mold method similar to hand lay-up in its suitability for making boats, tanks, transportation components and tub/shower units in a large variety of shapes and sizes. A chopped laminate has good conformability and is sometimes faster than hand lay-up in molding complex shapes. In the spray-up process the operator controls thickness and consistency, therefore the process is more operator dependent than hand lay-up. Although production volume per mold is low, it is feasible to produce substantial production quantities using multiple molds.

7 PRODUCTS AND APPLICATIONS

The products of NFRP composites can be used in several areas both in industries, constructions and domestic uses.

7.1 Industrial applications

Certain potential applications of core materials are possible. These include: Low-density insulation boards, ceiling tiles, substrate for lightweight furniture, components in manufactured housing, office partitions, core materials for doors and possibly particleboard and MDF (Medium Density Fibre).boards.

7.2 Domestic applications

Rjswijk (2003) stated that some of the products made from natural fibre composites like sandwich panels are directly applicable to rural societies of Papua New Guinea in the construction of semi-covenant houses as roofing in place of vegetable roofing and partitions for walling. They can also be manufactured using simple manufacturing processes. The possible products include roofing panels, fluid containers, constructive bridge parts, small boats, floor mats, and table clothes.

8 ECONOMIC SUSTAINABILITY

NZBIO (2009) discovered that a potential large market for ligno-cellulosic materials is found in an increased interest for renewable materials in ecological building and construction applications. For, example, it has been demonstrated that high performance / high quality fibre boards can be manufactured from the whole fibrous coconut husk without the use of any chemical additive The global demand for building materials and timber is ever increasing and with rising prices of wood the market for sustainable timber substitutes seems bright. Coconuts are abundantly available in Papua New Guinea and their husks now often discarded because of lack of economic value. Manufacturing of ecologically and (bio-) economically sustainable materials from this waste could create many jobs and offer new perspective for local industrial development.

The current research on NFRP composites has a great potential in endurance of economic activities in terms of its economic viability as people heavily rely on these plants especially for food. However, turning the waste part into a useful product would enlighten the livelihood especially for the rural communities (NZBIO, 2009) Current innovation on the markets for natural fibre containing (composite) products has widened the scope of its use and that should go parallel with agro-industrial development. Then it has the potential to become a major sustainable bio-economic commodity.

9 COMMERCIALIZATION

For the current research to easily shift into commercialization, there needs some critical technical issues to be considered. In this way commercialization approach would take place efficiently. Some of these areas of critical issues:

- Reliable and consistent raw materials
- Agronomic/harvesting practices and decortications processes to produce clean and undamaged fibres
- Robust and consistent fibre and mat quality/testing methods
- Material forms compatible with existing manufacturing processes
- Properties that are sufficient to replace current reinforcements
- Compatible fibres/resins-polymeric and bio-based
- Development of co-products to ensure economic sustainability

10 CONCLUSION

Agricultural fibers have been successfully utilized in a variety of composite productions such as panels, most notably conventional composite panels and inorganic-bonded composites. Lignocellulosic/thermoplastic composites are a newer area of lignocellulosic utilization. It is anticipated that interest and commercial development will continue in this area. Excessive amounts of agricultural fiber residues are available here in PNG to support composite manufacturing needs, although the agro-based materials may not have a suitable geographical distribution to provide an economically feasible endeavor. Lignocellulosics are attractive material sources for composites because they are lightweight, economical, and require low amounts of energy for processing. In addition, their growth, use, and disposal are generally considered environmentally friendly. As renewable materials, they can be used to replace or extend non-renewable materials such as those based on petroleum as their end products expose environmental hazards.

ACKNOWLEDGEMENTS

The authors wish to gratefully acknowledge the financial support provided by the Office of Higher Education (OHE) under Science and Technology Initiative (STI) research fund.

REFERENCES

Natural Indian Coir Fibre Online (2006). Coir is Green Business
http://coirboard.nic.in/about_process.htm (March 04, 2010).

American Composites Manufacturing Association (ACMA) (2009).*Composites Manufacturing Processes*
http://www.acmanet.org/resources/manufacturing-process.cfm (March 8, 2010).

Grozdanov A 2009. Thermal Stability of Differently Treated Natural Fibre Reinforcements for Composites. *International Conference of the Chemical Societies of the South-East Europian Countries (ICOSECS 5)* (p. 1). Italy: Institute for Chemistry and Technology of Polymers.

Jan E G van Dam 2009. Environmental Benefits of Narural Fibre Production and Use. *Proceedings of the Symposium on Natural Fibres* (p. 3). Wagenigen: Wageningen University Press.

van Rijswijk K W B 2003. Application of Natural Fibre Composites in the Development of Rural Societies. *FAO CORPORATE DOCUMENT REPOSITORY* , p.4,

NZBIO 2009. Innovations and Opportunities in Composite Materials. NZBIO Conference 2009, Manitoba, Canada: Composites Innovation Centre.
http://nzbio2009.Co.nz/files/1041549240.pdf (April 4, 2010).

Encyclopædia Britannica Online 2009.Water retting.
http://www.britannica.com/EBchecked/topic/637243/water-retting (March 15, 2010).

Yoldas Seki K S 2009. The Influence of Oxygen Plasma Treatmaent of Jute Fibers on Mechanical Properties of Jute Fibre reinforced Thermoplastic Composites. *5th International Advanced Technologies Symposium* (p. 1). Karabuk, Turkey: IATS'09 Karabuk University Press.