NATURAL FIBER COMPOSITES- TECHNOLOGY & APPLICATIONS

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Abstract

Composites bestowed with unique advantages like lightweight, high strength-to-weight ratio, drew attention towards novel applications and as substitutes for the conventional materials like metals, woods etc. Composites are emerging as the leading building materials to replace timber, steel, aluminum, concrete etc. Composites are being used for the manufacture of prefabricated, portable and modular buildings as well as for exterior cladding panels, which can simulate masonry or stone. In interior applications, composites are used in the manufacture of shower enclosures and trays, baths, sinks, troughs and spas. Indian efforts centre around developing cost effective building materials as well as for catering to the housing needs of urban & rural poor. In this context, certain developments concerning natural fiber composites and industrial waste based composites have assumed importance. The key restricting factors in the application of composites are initial costs due to raw materials and also inefficient conventional molding processes. Industry & design experts are of the view that with the adoption of advanced technologies and some extent of standardization, these problems could be easily taken care of.

Natural fiber composites have gained interest in the last decade, especially in the housing sector. Fibers like jute, coir, flax, hemp etc. are cheap, have better stiffness per unit weight and have lower impact on the environment. Natural fibers due to their adequate tensile strength and good specific modulus enjoy the right potential for usage in composites thus ensuring a value-added application avenue. Apart from much lower cost and renewable nature of natural fiber, much lower energy requirement for the production of natural fibers like jute (only 2% of that for glass) makes it attractive as a reinforcing fiber in composites.

India with an excellent knowledge-base in various resins, catalysts & curing systems coupled with an adequate availability of various raw materials can certainly carve out a niche in the emerging technology of natural fiber composites. The presentation would discuss in detail the development activities in various academic Institutions/R&D laboratories in India in partnership with industries on natural fiber composites.

Key words: composites, fiber, Polymers, FRP, jute

I INTRODUCTION

The composite technology of a polymeric matrix reinforced with man-made fibers such as glass, Kevlar, carbon etc. has come of age especially with the advances in aerospace applications since 1950s. The developments in composite material after meeting the challenges of aerospace sector have cascaded down for catering to domestic and industrial applications. Composites, the wonder material with light-weight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, woods etc. The material scientists all over the world focused their attention on natural composites reinforced with jute, sisal, coir,

pineapple etc. primarily to cut down the cost of raw materials.

II TECHNOLOGY INCUBATION TOWARDS COMMERCIALIZATION

High performance FRP can now be found in such diverse applications as composite armoring designed to resist explosive impacts, fuel cylinders for natural gas vehicles, windmill blades, industrial drive shafts, support beams of highway bridges and even paper making rollers. Technology incubation [1] has been an international experience in developing and promoting the novel technology applications. The relevance of technology incubation specially assumes importance in the context of a developing economy and industry as typified by India. From its inception, the Advanced Composites Mission had explored different ways so as to evolve the single most effective mechanism for technology development for faster & wider applications. At the initial stage, the approach had been to locate the incubation activities within the premises of a national level publicly funded R&D lab or an academic institution with the outside support of an industry partner.

III AEROSPACE APPLICATIONS

One of the primary requirements of aerospace structural materials is that they should have low density and, at the same time, should be very stiff and strong.

Early biplanes used wood for structural frameworks and fabrics for wing surfaces. The fuselage of World War I biplane fighter named Vieux Charles was built with wire braced wood framework.

The monoplane had an unusually smooth aerodynamic design. Its fuselage was made with laminated tulip wood, where one layer was placed along the length of the fuselage, the second in a right-hand spiral and the third in a left hand spiral around the fuselage. This laminated single shell wood construction provided highly polished, smooth surfaces. There was a significant reduction in the drag, and the plane could achieve a high speed of 108 mph. It won the Gordon Bennett speed race in Chicago in 1912. Almost all biplanes and monoplanes, with very few exceptions, were built of wood during the first quarter of the twentieth century.

Lighter woods like balsa, poplar, spruce, tulip, etc. were more popular. The five-seater Lockheed Vega (first flight in 1927) also had highly polished, smooth, streamlined fuselage made of strips of spruce wood bonded together with resin.

IV APPLICATIONS OF NATURAL FIBRE COMPOSITES

The key industrial sectors covered are mentioned below

1. Composites for Railways

   Composite materials are increasingly being used in the Railway industry [2] where the resulting performance improvements are significant. Weight saving of upto 50% for structural & 75% for non-structural applications bring in associated benefits of high-speed, reduced power consumption, lower inertial, less track wear and the ability to carry greater pay-loads.
2. FRP Gear-Case for Railway Locomotive
3. Jute-Coir Composite Boards for Coach Interiors
4. FRP Pultruded Profiles
5. Jute-Glass Composites for Coaches
6. FRP Sleepers for Railway Girder Bridges
7. FRP Modular Toilet Units for Railway
8. Coaches Composite Main Door for Passenger & EMU Coaches
9. Radiator Cooling FRP Fan for Diesel Locomotive
10. Composite for Automobiles
11. Composite CNG Cylinders for Automobiles
12. Jute-Coir Composite Boards for Bus Interiors
13. Composites for Bio-Medical Applications
14. Carbon Fiber External Ring Fixators for Orthopedics
15. Endoskeleton Type Composite Artificial Limbs for Physically Handicapped
16. Energy Efficient Axial Flow FRP Fans for various Applications
17. Vacuum Forming Press for Composite Fabrication
18. FRP Armored Optical Fiber Cables
19. FRP Pultruded Profiles
20. Double-Walled FRP Vessels for Chemical Storage
21. Composites for Building &Construction
22. Jute-Coir Composite Boards for wardrobes

23. FRP Doors & Windows
24. FRP Pultruded Profiles

V COMPOSITES IN CIVIL ENGINEERING

Fig 1: Composites in civil engineering

Fig 2: Coir-Bamboo Composites

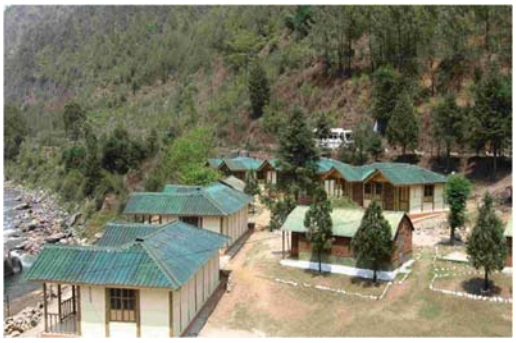

Fig 3: Bamboo Composites Huts

Fig 4: Bamboo Composites Products

Jute Composite Door Jute Composites Corrugated Sheets

Fig 5: Coir Bamboo Composites Door Shutters

Fig 6: Garden Furniture

Fig 7: Office Furniture

Fig 8: Composite House – Mockup Flat For Marketing Office in Bangalore

Fig 9: Composites Police House Constructed In Bangalore

FRP-GEAR CASE RAILWAY LOCOMOTIVES

The project was done at M/s. Permali Wallace Ltd., Bhopal with technology support from the Regional Research Laboratory, Bhopal.

Fig 10: Gear Case Railway Locomotives

FRP SLEEPERS FOR RAILWAY GIRDER BRIDGES

This project aimed at fabricating composite sleepers to replace conventional wooden sleepers on girder bridges and offer good rail holding, bearing toughness and vibration absorption characteristics.

Fig 11: FRP Sleepers for Railway Girder Bridges

JUTE-COIR COMPOSITES BOARDS

Jute-coir composite boards with oriented jute face veneer & coir/rubber wood inside were developed with Natural Fibretech Pvt. Ltd., Bangalore

Fig 12: Jute-Coir Composites Boards

ENERGY EFFICIENCY FRP AXIAL FLOW FANS

The project was launched in partnership with M/s. Parag Fans & Cooling Systems Ltd., Dewas [4]. The technology Support in terms of aerodynamic design of axial flow fan impellers.

Fig 13: Energy Efficiency FRP Axial Flow Fans

FRP MODULAR TOILET UNITSFOR RAILWAY COACHES

The FRP toilet unit developed under the project consists of the flooring trough, one L-shaped side-wall another C-shaped side wall & roof. All the four parts could be fastened together and assembled in a short span inside the coach.

FRP DOORS FOR RAILWAY COACHES

Lightweight, cost effective & corrosion resistant FRP main doors for passenger coaches as replacement of heavy steel doors were designed & developed in partnership with M/s. Urbane

Industries, Chennai & technology support from IIT-Bombay.

Fig 14: FRP Doors for Railway Coaches

FRP PROPELLOR

Fig 15: FRP Propeller

European production of flax and hemp fibers [3] is in competition with the world's major exotic plant fibers such as cotton, jute, ramie, sisal, raffia, etc., and synthetic fibers such as glass or polyamide fiber.

The processing of plant fibers by means of injection and extrusion is today on an upward growth trend, particularly in Europe. These technologies use plant fibers in combination with polypropylene, polyethylene and ABS. They can be used to manufacture objects with complex shapes. This type of material is marketed in the form of pellets that can be used in injection or extrusion processes. The main applications for injection molding include structural parts for the car industry, for example. Extrusion is used to produce profiles, hollow components, etc.

Other potential sectors are also being developed: public works (pipes), furnishings, materials handling (pallets), packaging, electrical and electronic goods, and aerospace, boatbuilding, and consumer products.

Fig 16: FRP for car engine part

Fig 17: Interior parts of the Mercedes A-200 reinforced by natural fibers

Fig 18: Lightweight composite military helmet

Fig 19: Filament winding Composite LPG container vessel

1. Building & construction industry (panels, false ceilings, partition boards etc.),
2. Automotive
3. Railway coach interiors and storage devices.
4. Aerospace
5. Sporting goods
6. Furniture
7. Packaging
8. Biomedical
9. Corrugated sheets etc...
10. Aerospace (brake disc, aircraft interiors, canopies, wings etc),
11. Transportation (bus bodies, coach interiors, metal matrix composites for brake-drums, cylinder-blocks etc),
12. Chemical Industry (storage tanks, scrubbers, ducting, piping, exhaust stacks, pumps, distillation columns, reactors, gratings & structural supports),
13. Electrical & Electronics (switchgear & laminates, insulators, boxes),
14. Marine (boats, trawlers, barges, naval vessels & other ship components),
15. Construction (doors & windows, paneling and other interiors),
16. Consumer & Sports goods (trays, furniture, accessories, hockey sticks, tennis racquets, golf clubs, archery equipment, hand glidersetc)
17. Composite Artificial Limbs for Physically Handicapped
18. Carbon Fiber Composites for Orthopedic Appliances

Some of the other potential applications are:

1. Composite vessels for liquid natural gas for alternative fuel vehicle
2. Racked bottles for fire service, mountain climbing
3. Double-wall FRP vessels with an early warning system for leakage detection
4. Underground storage tanks
5. Casings for electrostatic precipitator
6. Drive shafts
7. Fan blades (for both axial & centrifugal fans)
8. Ducts & Stacks
9. Aerial man-lift device…

CONCLUSIONS

- Hence the suitability of plant fiber composites for various applications are selectively chosen, where lighter weight, less density, low temperature, less corrosion parameters are considered while using natural jute composites.
- From the point of view of wood substitution, Plant fiber composites could be an ideal solution with ever depleting forest reserves and corresponding premium on wood, a composite based on renewable resources such as jute, coir, sisal etc. is poised to penetrate the market.
- There is scope for future work for further studying the better manufacturing process of natural plant composite materials, as there is lack in advanced manufacturing process of composite materials.
- Hence, more research study & work has to be carried out in this field for revolutionize technology development in a continuous pace in natural plant fiber composite materials.

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