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Thermal and mechanical analysis of coconut leaf sheath composite

Makhsim Lgor*, Anastasia Ivan

Belarusian State Technological University, Sverdlova street, 13A, Minsk, 220006, Belarus

*Corresponding Author: makkhsim.lgor123@gmail.com

Abstract

In order to manufacture low-density thermal insulating particle boards, castor oil-based polyurethane glue is used to join coconut husk particles, which are subsequently strengthened on the exterior with coconut leaf sheaths, a textile widely available in tropical areas. Hand layup followed by compression moulding was used to construct the untreated (raw) and coconut sheath fibre (CSF) reinforced epoxy composites. A universal testing machine and an izod impact tester assess the tensile, flexibility, and impact strengths of the specimens that have been cut in accordance with ASTM Standards. The top and bottom halves of the leaf sheath were added to one outside side, and the other two exterior sides received the same treatment. It is possible to use coconut fiber-reinforced husk particle boards for thermal insulation based on the thermal, physical, and mechanical findings.

Keywords: coconut leaf, Thermal insulating particle, Mechanical

Introduction

Climate change and human activity's harmful environmental effects have been more clear in recent decades, and efforts to reduce these impacts have become increasingly urgent. The construction industry contributes to global warming by emitting greenhouse gases. The use of thermal insulating materials might be one answer to this serious issue, given the high energy consumption of heating and cooling systems. Heating and cooling systems benefit greatly from the use of thermal insulators [2]. You may save money and enhance your quality of life by installing thermal insulation in your home [3-4]. Materials like mineral wool and plastic foam are used to make commercial thermal insulators. Despite their low moisture content and poor heat conductivity, certain particles may cause respiratory and skin irritation when breathed or inhaled through skin contact [5–7]. Synthetic and toxic products must be replaced on the market for the purpose of both health and environmental well-being to create thermal insulating particle boards, researchers are becoming more interested in the use of lignocellulosic fibres. Construction materials that are ecologically friendly, renewable, and affordable may be made from agricultural waste and natural raw resources. Ecological and cost-effective alternative commodities have been used in the past to make low-density panels with great thermal insulation qualities [8-12]. Researchers have discovered that lignocellulosic materials, such as kenaf core, pineapple leaves, corncob, sugar cane bagasse, coconut coir, flax, jute, hemp, cotton stalk, durian peel and date palm wood can be used to make particle boards with low thermal conductivity that are on par with conventional insulation building products. Although these novel sustainable particulate composites may have a worse bendability due to the absence of sufficient contact between the particles, [13-14]. Particle board is often made using urea and phenol-formaldehyde binders, both of which are hazardous to human health if discharged into the environment. As a consequence, several research have investigated innovative adhesives, such as polyurethane resin based on castor oil. For manufacturing of castor oil polyurethane, isocyanate and polyol from Ricinus communis seed oil are used. [15-17] With regards to their compatibility with wood fibres, polyurethane resins might be used as a substitute for chemical binders. In order to make this happen, the polyurethane's isocyanate groups combine with the fiber's hydroxyl groups [18]. Coconut leaf sheaths and low-density polyurethane particle boards containing coir and castor oil-based polyester reinforcing were the focus of this work. The physical, It is determined the mechanical and thermal characteristics of multilayer panel kinds. To identify natural isothermal insulating boards made from coconut textiles, one or two externally reinforced surfaces and the position of the leaf sheath (top or bottom) employed as a reinforcement may be utilised.

Materials and methods

Materials

Using mesocarp of Cocos nucifera L., the coir fibres were extracted from the mesocarp (Figures 1 The density was calculated with a helium pycnometer to be 185617 kg/m3. Palm trees (Cocos nucifera) on Guadeloupe campus of Indian university offered raw materials needed to harvest coconut textiles (France). Coconut leaf sheaths completely round the tree's stem in the petiole of its leaves. The bottom component is attached to the coconut tree trunk by a brownish, well-structured textile (Figure 1(d)), and the pattern of the fibre mesh varies from the centre to the periphery. Both the upper (UP) and lower (BP) parts of the brain were the focus of this study. The helium pycnometer calculated their density to be 1568 8 kg/m3.

Raw materials fabricated

Coconut fibres were dried in an oven at 65°C to obtain moisture content of 10–12% by mass. Fibres were crushed and sieved before being employed in the particle boards, which ranged from 1 to 4 mm in diameter. Leaf sheaths were cleaned and dried in the sun for a week using high-pressure tap water and distilled water.

Production of particle boards

This resulted in 300 kg/m3 panels with a resin/particle ratio of 02, which assured particle adherence (by weight). In this investigation, the quantity of resin needed is substantially less than in standard procedures.

Figure 1. (a) coir fibers of coconut tree,

The resin/particle ratio of Khedari et al ranged from 012 to 003, whereas that of Tangjuank7 was between 2 and 4. An equal mass ratio of castor oil and prepolymer resulted in a viscosity range of between 950 and 1500 at 20°C. The polyurethane glue and coconut powder were combined in a planetary mixer to provide a uniform consistency. Binder-impregnated particles were compressed at 5 MPa and 100°C in 10 minutes using a hydraulic press. To provide great adhesion between mat at surface and textiles before they were pressed into place, leaf sheaths coated with resin and dispersed alternately with coir particles were employed on external sides. In the end, four alternative panel compositions were constructed, each measuring 400 mm 400 mm 20 mm. Table 1 (simplified). Before testing, the panels were pre-conditioned at room temperature with a relative humidity of 60% for up to 72 hours to ensure that the resin had enough time to properly cure.

Result and discussion

Thermal properties

The thermal conductivity of particle board was measured using Controlab CT-meter, made in Saint-Ouen, France. Particle board specimens were sandwiched between two 20 mm diameter rings of 346 W resistance. As per BS EN 12664, the samples had to have been dried at 105°C to constant mass before being tested. 26 Each panel composition was tested six times at a temperature of 25°C and a relative humidity of 65 percent.

Mechanical properties

External textile-coated fiberboard UP1S, which has just one reinforced surface, has lower average MOR values than the UP2S and BP2S boards with reinforced coconut leaf sheaths on both external sides, as seen in the bended sample and WT panels.

To make the coir stronger, no leaf sheaths were employed. Leaf sheaths are extremely durable because of their dense network and the overlap of several fibre layers. WT's MOR is 742 times less than that of UP2S. Thus, the MOR values of UP2S and BP2S for low-density panel applications are superior and similar to the 3 MPa standard of ANSI A208, respectively. Figure 2 tensile strength of the specimen. After the testing, specimen no. 4 have optimal tensile strength and density. And modulus of rigidity and elasticity are also calculated. The average MOR values of UP2S and BP2S are extremely acceptable when compared to the MOR obtained in the literature for the same range of non-reinforced board density. Binderless coconut husk insulation boards with densities of 250, 350, and 450 kg/m3 were found to have the highest MOR values of 012, 068, and 194 MPa.

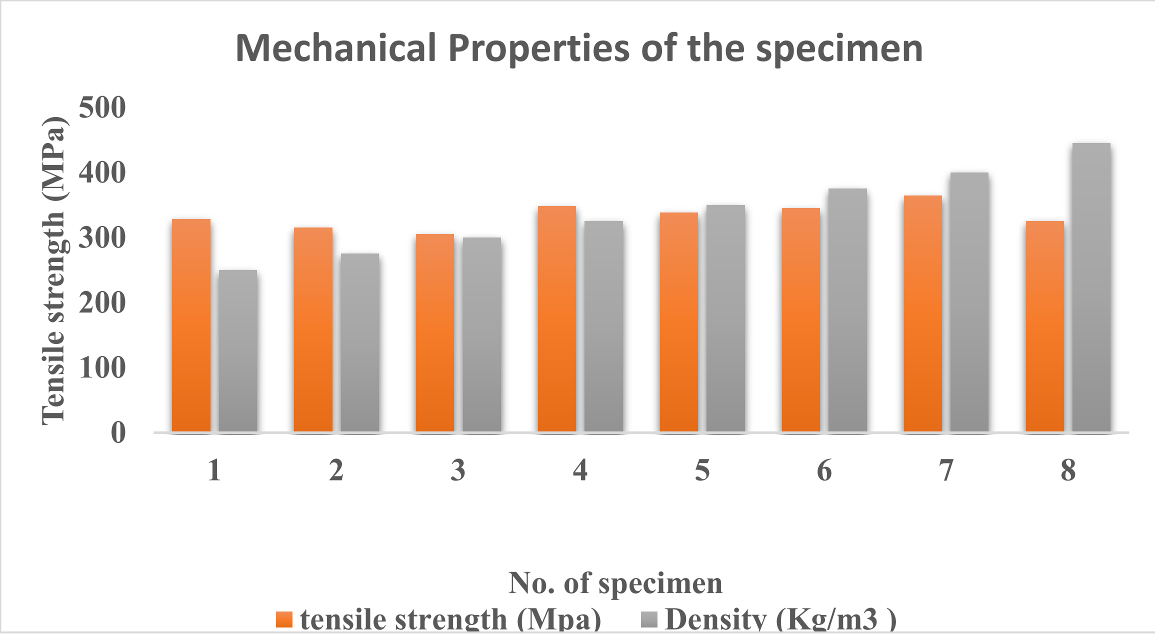

Figure 2 tensile strength of the specimen

Xu et al.13, kenaf core boards with a density of 200 kg/m3 had a mean MOR of 11 MPa. For maximum mechanical efficiency (MOE), the coir panel sandwiched between the coconut leaf sheaths on both outer sides is UP2S. While still above ANSI A208's minimum MOE requirement for low-density panels of 550 MPa, this MOE value of 455±94 MPa falls short of that standard. 27 Low-density particle boards made with vegetable particles have low MOE values, despite this. Binderless coconut husk insulating boards with densities of 350 and 450 kg/m3 had MOE values of 88 and 365 MPa. 350 kg/m3 binderless cotton stalk-based boards were found to have MOE values between 27 and 80 MPa, as reported. In general, the pressure is between 0.050 and 0.060 millipascals. For low-density panels, ANSI A208 requires an IB value of 0-1 MPa, although none of the formulae evaluated reached this number. 27 Poor cross-linking of coir particles may be due to a lack of resin dispersion in the panels. The resin was applied by hand rather than using a spray nozzle, which might account for the uneven distribution of resin. Between 0003 and 008 MPa, fibreglass and rock wool insulation boards are often used. According to our research, four of the insulating boards we tested fell inside this range.

Effect of edge/middle area of the leaf sheaths

Those values may be found for all specimens with leaf sheaths added to the middle and edge. As long as they're reinforced with coconut leaf sheath centres or edges, specimens show equivalent MOR and MOE values. The bending properties of samples of coconut textiles with fibres meshing in the centre and the outside borders that varied in tightness are not significantly different.

Thermal properties

Thermal conductivity is defined as the quantity of heat energy transmitted per unit time and surface area under a temperature gradient of 1 K/m. As an indicator of how easily heat can be transferred, material thermal conductivity serves as an indicator of a material's suitability for insulation. As insulating capacity increases, so does thermal conductivity. The thermal conductivities of the four boards, whose densities range from 415to 445 kg/m3. No matter how many board sides are strengthened (one or both) or how many leaf sheaths are removed, the coir panels' thermal conductivity does not improve appreciably (top or bottom piece). There is no influence on heat conductivity from the coconut textiles reinforcing, while, normally, higher density indicates better thermal conductivity, thus this is a significant benefit. Lighter boards actually have more voids and lower heat conductivity than heavy ones. In comparison to low-density lignocellulose-based boards indicated in Table 4, panels generated in this investigation showed higher thermal conductivities than the best insulating boards. It's conceivable that the more the particle board's density, the kind of vegetal material utilised, and/or the manufacturing method Coconut coir12 and wood are both good insulators, yet their thermal properties are similar.

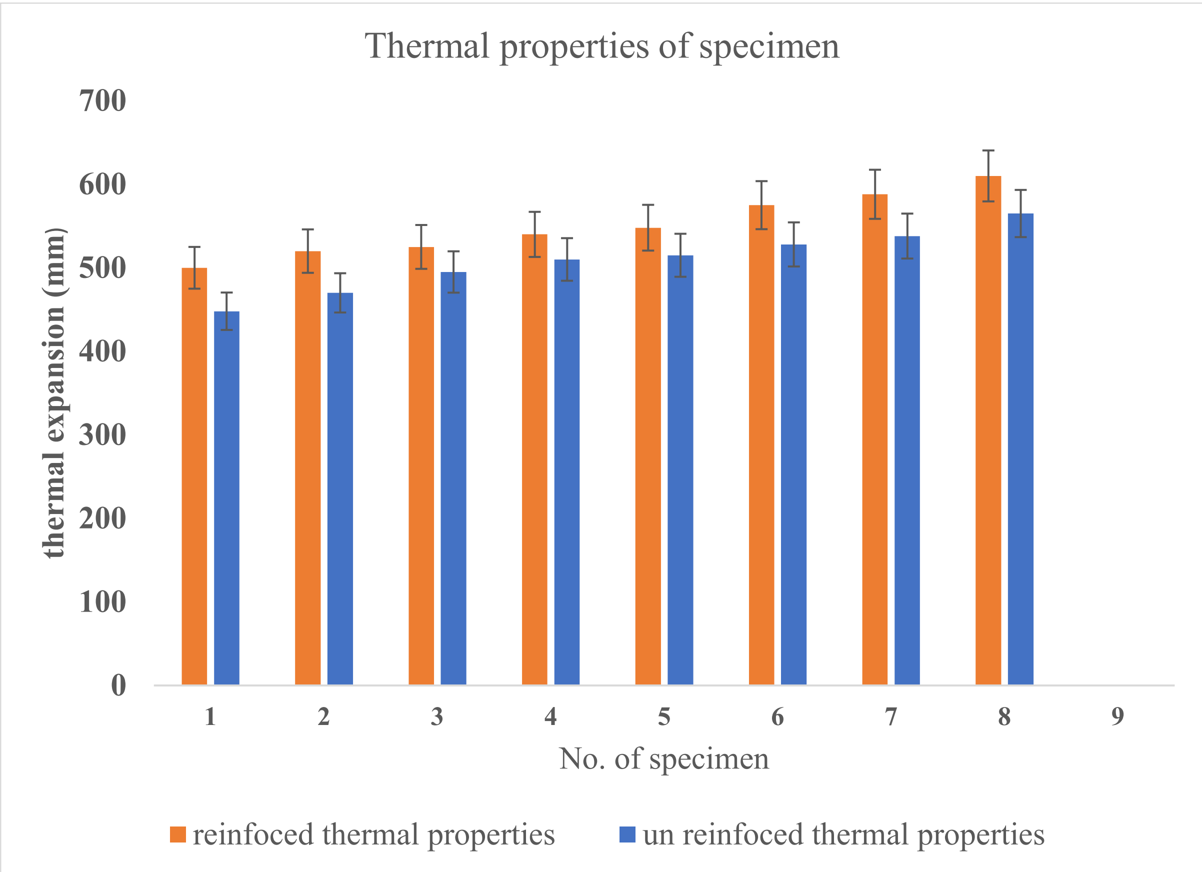

Figure 3: Heat conductivities of unreinforced and reinforced particle boards.

Conclusion

According to this research, castor oil polyurethane resin may be utilised to build low-density particle boards. Coconut leaf sheaths may be used to support the exterior edges of coir particle boards. Regardless of the sheath component (top/bottom) and the number of reinforced outer board faces, the water absorption percentages, IB strengths, and thermal conductivity are almost same to those of WT. While adding coconut tissue to coir particle boards increases density and edoema, bending test results are greatly improved. Low-end devices may benefit from panels with strengthened leaf sheaths that extend from both the exterior and internal sides. Coconut leaf sheaths reinforced with coir particle boards seem to be an appropriate solution for the construction of efficient and safe insulating materials based on their physical properties, mechanical features and thermal conductivity. Panels created from natural and chemical binders are a promising, environmentally friendly, and cost-effective alternative to traditional thermal insulation.

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