APPLICATION OF JUTE FIBER ON AUTO VEHICLES INSTRUMENTS PANEL FRAME

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ABSTRACT
The automobile industry is growing more due to new model releases. Significant changes are taking place on technology innovation processes which search for lighter and smaller models with sustainable alternatives for market development. One of the approaches currently employed by manufacturer is to replace plastics for natural fiber composites (for example Jute Fiber) ensuring the performance of its products. This study is focused to compare the performance of conventional plastic materials with natural fiber composites, measuring properties, weight and functional behaviors of each material

Keywords: Automobile, market, plastics and composites.

INTRODUCTION
With increasing competition among automakers and greater governmental demand for cleaner energy solutions in the automotive sector, it has been noticed significant changes in the segment aiming to offer to its customers quality products at low cost and less harmful to the environment. Currently, automakers seek to differ from each other by producing environmentally friendly cars (Marsh, 2003; Alves et al 2010). These requirements force the industry to invest in the research of materials that are partially or completely renewable.

Within the various developed researches, it has been highlighted the study to add the natural Jute fiber to polypropylene (PP), in components used in the vehicle (Holbery; Houston, 2006). Due to its low production cost, the PP is present in part of the internal passenger compartment of vehicles produced in Brazil. The polypropylene is derived from oil, a natural non-renewable fossil resource and polluting agent to the environment. Therefore, a partial substitution for a renewable and clean natural resource has become important. The Jute fiber is derived from the jute plant (Corchorus Capsularis), a plant fiber from the Tilioideae family. The plant grows in tropical and humid climates, it is renewable and non-polluting, consisting of about 60% cellulose. In Brazil, is grown mainly by river populations of the Amazon. Four months after being sown, the plant height reached three to four meters with stem twenty millimeters thick.

The useful Jute fiber is contained between the shell and the inner stem and extraction is made by the maceration process. The leaves of the plant, after being cleaned, are dipped in bundles into the water for a few days and then the beams are removed, the fiber is separated from the stem and placed to dry on clotheslines (Fig. 1). After drying, the fibers are subjected to beating in machines for removing dust and fibers of short length, resulting in a clean product. The fibers are selected, brushed and sorted, and then be packed in bales for transport to the industry. (Fig. 2). (ISO, 178: 2010). Natural fibers, when incorporated into polymers, can be
processed by conventional processing methods (extrusion, injection, calendering and pressing) and have lower density than inorganic fibers such as glass fibers (Mohanty; Misra; Drzal, 2005).

The polymeric composites reinforced with continuous fibers constitute a configuration that provides better results for specific mechanical properties, i.e., the ratio between mechanical properties and specific weight (Tsai; Hoa; Gay, 2003). The continuous unidirectional fibers can be aligned in specific directions, or in the form of webs or tissues. The making of quilts consists of grinding and mixing the fibers of jute and polypropylene and subsequently the preparation of blanks for needling (Fig. 3).

For molding the final product, first, the blanket are first pre-heated in a furnace with controlled temperature and time, along with vinyl (aesthetics of the product), soon after being shaped. Fig. 4 shows a product molded with natural fiber product and Fig. 5 highlights examples of application components in the automotive industry using composites reinforced with natural fibers. Observing these advantages, it is possible to envision the potential demand of Jute fiber from automakers for renewable energy solutions. However, for this change to be implemented, it is necessary that the component manufactured with fiber base and PP pass several tests to ensure its full functionality. For this purpose, tensile tests were carried out, bending, heat resistance, light behavior and odor test to characterize the materials.
EXPERIMENTAL PROCEDURE

To verify the feasibility of the application of jute fiber component used in the automotive industry, it was compared the mechanical behavior of the composite (50% PP + 50% fiber jute) with polypropylene added with 20% talc and, therefore, Traction and Flexion tests were performed as well as Heat and light behavior and Odor Evaluation.

The evaluation of product performance was made from the manufacture of test specimens (CP) obtained by injection and thermoforming of the raw materials constituents of the product. (Ferracini et al., 2009).

A 250 ton. injection machine, Cincinnati Milacron, was used to manufacture the specimens for tensile tests (ASTM D638-10), impact (ASTM D256-10) and bending (ISO, 178: 2010).

Tensile Tests

The tensile test was performed in a universal machine servo-hydraulic testing, model 4467, Instron make, as ISO 527-1: 2005 The test speed was 100 mm / min. Simultaneous observations of the variation of the base measure of the specimen were made at room temperature and relative humidity of 30%. The true stress and strain were calculated for each load. Equations (1) and (2) (Callister, 2000).

\[ \varepsilon_v = \ln(1 + e) \]  
\[ \sigma_v = S \times (1 + e) \]

where: \( \sigma_v \) is the true stress; \( \varepsilon_v \) is the true strain, dimensionless; \( e \) is the engineering strain, dimensionless;

Bending test

The method used for the bending test of the specimens with rectangular cross section (3x50x160) mm was the three points. (ISO, 178: 2010). The test speed was 50 mm / min. The deformation was determined by the Equations (3) and the maximum stress on the surface opposite to the loading at the midpoint between the supports was determined by Equation (4). From the values of stress and deflection in the elastic field, the elastic modulus was obtained.
where: $\varepsilon_1$ is the deformation of the specimen, in mm; $D_1$ is maximum deflection at the midpoint between the supports, $L$ is the distance between the supports;

$$\sigma = \frac{3F_{\text{max}}L}{2bh^2}$$

where: $\sigma$ is bending stress in MPa; $F_{\text{max}}$ is the maximum load applied during the test, in N; $L$ is the distance between supports, in mm; $b$ is the width of the specimen, in mm; $h$ is the thickness of the specimen, in mm.

**Heat Behavior**

Aging of the samples was carried out in a climatic chamber for 24 hours at 90 °C. Evaluation after at least 2 h at 23 °C, followed by further aging for 6 h at 100 °C. It was subsequently certified the areas with greater sun exposure as standard Fiat (Source: FIAT Cars). The components were evaluated freely and mounted on the panel.

**Light Behavior**

Samples cut with circles of 200 mm diameter were exposed to artificial sunlight with light source of carbon arc (FADE-OMETER) for a period of time of 300 hours at 60 °C and 55% humidity.

**Odor Analysis**

For Odor analysis three samples of the material with dimensions of 50x50mm, were taken and placed in a glass container and then 3 drops of catalyst were applied in the central area of the sample surface, being the container sealed and placed in a chamber climate for 48 hours at 65 °C. The final evaluation took place at room temperature one hour after opening the containers.

**RESULTS AND DISCUSSION**

**Experimental Results Analysis**

**Tensile test**

In the tests carried out there was a higher deformation capacity of the composite (50% PP + 50% jute fibers) and higher yield stress at 23 °C. The composite (50% PP + 50% jute fiber) had a maximum stress of 11.93 MPA and for PP 20% with talc the value found was 9.7 MPa, however, in the initial deflection range, PP demanded a higher stress. Fig. 6 shows the stress-strain curves obtained in the tension test of polypropylene and the composite (50% PP + 50% fiber jute).

The best performance of the composite (50% PP + 50% fiber jute) in tensile testing, is related to the grain direction. Composites reinforced with continuous fibers have high strength and stiffness in the direction of the fibers. Unlike the composite reinforced by discontinuous fibers or particles, which have an isotropic behavior in a macroscopic scale, continuous fiber reinforced composites have orthotropic properties, i.e., different behaviors in the orthogonal directions, leading to specific failure mechanisms. Have high strength and stiffness in the direction of the fibers, however, a poor performance in the transverse direction to them. It is
observed that the Jute fiber contributes to composite material strength with high deformation break, increasing the fracture work. In this sense, the composite reinforced with Jute fiber becomes an economical and ecological alternative for use in engineering materials.

![Stress-strain curve](image)

**Fig. 6 - Stress-strain curves (polypropylene and the composite (50% PP + 50% fiber jute)).**

**Bending test**

In the bending tests polypropylene with 20% talc presented better performance at different temperatures (23 °C, 40 °C, 80 °C) and after immersion in water when compared to the composite (50% PP + 50% jute fiber). Another issue is that by increasing the temperature, there was a decrease in the mechanical strength, reducing the stress values. Advantageously the composite (50% PP + 50% jute fiber) showed greater deformation capacity. Fig. 7 shows the stress-strain curve in bending test for the composite (50% + 50% PP fiber, jute), and Fig. 8 shows the stress versus deformation curve in bending test for PP with 20% talc.

![Stress-strain curve](image)

**Fig. 7: Stress-strain curves (bending tests for the composite (50% PP + 50% jute fiber)).**
Heat Analyses, Light Exposure and Odor Analysis in Composite and PP with 20% talc

The tests related to thermal resistance are intended to ensure the viability of applying the product to the desired function. The tests related to light behavior is intended to control the color change after exposure to sunlight or artificial light and the test related to odor consists of applying a catalyst for polyurethane dispersed on the surface of the material to be analyzed and verify if after the contact, it develops some different unpleasant odor which differs from the material own odor or the catalyst odor.

In all three tests the evaluated components were vinyl laminate (0.4 mm thick) and the foam (2.4 mm thick), joined by a calendering process. Subsequently, took place the forming with plate "PP + Jute" (PP + 50% Composite 50% jute fibers - 2.3 mm thick). The test specification does not allow contraction, deformation, swelling of the coating, loss of texture or any other visual change.

In the composite thermal validation tests were performed on three samples of laminate in shades (Matte Black, Glossy Black and White), where no changes have occurred. Fig. 9 (a) shows the pictures of the pieces of composite free after heat cycle.

In the polypropylene with 20% of talc were conducted thermal validation tests in eight laminate samples and no changes were found. Fig. 9 (b) shows a picture of the part PP 20% talc mounted on the panel after heat cycle.

![Stress-strain curves](image)

Fig. 8: Stress-strain curves (bending tests PP 20% talc)
In light behavior test the qualitative assessment of products (Matte Black, Gloss Black and White) after exposure for 300 hours showed no discoloration of the surface.

In the odor test the evaluation team consisted of 10 people, based on different criteria, when compared with the criteria used for the selection of a representative of the population. The olfactory assessment of a technical product, such as automobile, requires the following of particular procedures because the team does not need to evaluate a perfume or no smell, but a bad odor emitted by individual components/ materials or components present in the internal cabin.

In the composite test (50% PP + 50% jute fiber) and 20% PP fiber average results were classified as "acceptable limit" and "acceptable" respectively to the piece and the laminate

**Weight Analysis**

With application of the composite (50% PP + 50% jute fiber) a weight reduction of approximately 40% was noticed. This reduction is related to lower density of the composite (50% PP + 50% jute fiber) compared to the PP and the simplest form of the product (inner side) (Fig. 10).

<table>
<thead>
<tr>
<th>Compósito</th>
<th>PP</th>
<th>Redução</th>
<th>Variação</th>
</tr>
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<tbody>
<tr>
<td>275 g</td>
<td>430g</td>
<td>115g</td>
<td>36%</td>
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Fig. 10 Comparison of PP x Composite pesos (50% PP + 50% fiber jute)

**CONCLUSION**

From the tensile strength and flexural strength data of the composite (50% PP + 50% fiber jute) and PP with 20% talc, there is better composite behavior (50% PP + 50% fiber jute) for tests traction and better PP behavior in bending tests. Better performance of the composite (50% PP + 50% fiber jute) in tensile testing is related to the grain direction. Composites reinforced with continuous fibers have high strength and stiffness in the direction of the fibers and a low performance in the transverse direction of same.(Flexion).

The composite (50% PP + 50% jute fiber) has higher yield strength as compared to PP + 20% talc, being the percentage increase in tensile strength of about 20% at temperatures evaluated.

With regard to the bending test, the composite (50% + 50% PP fiber jute) presents a resistance drop, compared to PP + 20% talc, being this resistance reduction of approximately 50% at the evaluated temperatures and approximately 70 % after immersion in water.

Comparing the results of thermal resistance, dimensional stability and odor from the composite (50% PP + 50% jute fiber) and PP + 20% talc, it is observed that the heat and light behaviors are mainly related to the coupling of vinyl laminate and foam. The tested samples
used the same vinyl material and the same foam coupling process, so the materials had similar behaviors.

Evaluation on the dimensional stability indicates greater dimensional stability of the composite (50% PP + 50% fiber jute) since the contraction of the material is lower.

Regarding the evaluation of odor, the materials showed similar performance being within the acceptable range (subjective assessment).

Even with a significant discrepancy in mechanical strength, materials showed similar performance in other tests. As the required application does not demand great effort, the application of the composite (50% PP + 50% jute fiber) becomes feasible. The fiber is composed of 60% cellulose and brings as main advantages the reduced weight and reduction in the use of petrochemical materials.

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REFERENCES


