ANALYSIS OF THE POTENTIAL APPLICATION OF RECYCLED THERMOFIX INDUSTRIAL POLYURETHANE RESIDUE IN SCHOOL DESKS

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ABSTRACT

The objective of this work is to compare the composite developed by Baldan (2015) with materials such as MDF (Medium Density Particleboard) and MDP (Medium Density Particleboard) for its application in the production of school furniture. In order to do so, we present the stages of preparation of the material developed by Baldan (2015) and the comparative tests developed (physical, mechanical and durability properties). The results showed that the recycled thermoset polyurethane composite presents satisfactory results when compared to MDF and MDP, and can be applied in the construction of school furniture. Also, the possibility of the developed material being recycled at the end of its useful life, guarantees the reverse logistics of the developed product and safeguards the sustainability of the process.
Key words: composite, recycled thermofix polyurethane, school furniture

1. INTRODUCTION

According to NBR 14006 (ABNT, 2008), which deals with school portfolios, school furniture is a seat and table for a group of students from educational institutions, and recommends the use of solid or plywood for their manufacture. of agglomerate panels. Among its advantages, according to Oliveira (2010), are its homogeneous structure, elimination of reducing factors of resistance and possibility of raw material with smaller restrictions on form and dimensions.
Regarding to its composition, the Technical Information Book (FNDE, 2017) establishes that school furniture should be composed of a table topped with MDP (formed by three layers of wood particles, one thicker in the middle and two thin on surfaces) or MDF (made from wood fiber bonding with synthetic resin), coated on the upper face of high pressure melamine laminate and on the underside with a balancing sheet, mounted on a steel tubular frame, containing book-holders in injected plastic and a stackable chair with seat and back in injected polypropylene or molded anatomical plywood, mounted on steel tubular structure.
Oliveira (2010) also points out disadvantages about the material, such as surface and rough edges, poor machining quality, unsuitability to nail fixing, crumbling with inadequate use of hinges and screws, and poor resistance to moisture.
Also, it is possible to point out that today the serious problems in the school portfolios, mainly in public institutions, caused by vandalism, the inadequate use or even the wear of the materials, besides the lack of ergonomic studies capable of adapting the equipment to the user. The danger to students exposed as rivets of the show and rusted nails and tips of chipped laminate, as exemplified in Figures 1 and 2, is therefore clearly noted. In such cases, high costs to the government or private institutions.

[Figure 01] *Deteriorated laminated material used in school portfolio (Source: http://ecoeducar.com.br)*

[Figure 02] *Deteriorated laminated material used in school portfolio (Source: http://ecoeducar.com.br)*

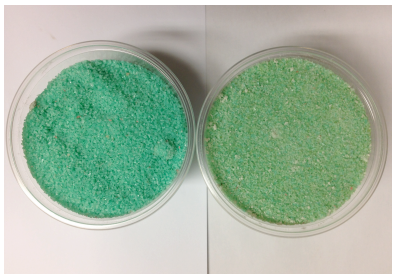
Therefore, one of the alternatives to minimize this type of problem is the replacement of the MDF or MDP with another component that has as main characteristics, strength and durability.
The substitution of MDF and MDP for composites - materials formed from the joining of other materials of different natures, which in turn generate complementary properties and that can be obtained from the

incorporation of residues in their composition - becomes a feasible alternative in view of its possibilities of application, which range from the aeronautical to the civil construction sectors.
On the other hand, companies from Vale do Rio Sinos, in the state of Rio Grande do Sul, Brazil, a major national leather-footwear producer, generates, on average, one million tons of thermo-fixed polyurethane industrial waste from its post- production, which has as final destination the landfill of solid waste (BALDAN, 2015).
Polyurethane deserves special attention because it presents several technical characteristics, such as lightness and resistance to abrasion and flexion, and can be widely used in the manufacture of soles for footwear and furniture, which allows its application on a high industrial scale (SILVA, 2003).
However due it is a thermoset polymer - material that, from the first molding, can not be melted or molded again - the polyurethane used in the leather-footwear production of Vale do Rio Sinos presents difficulties in its reuse and / or recycling .
However, Baldan (2015) promoted the recycling of thermofixed polyurethane industrial waste and the development of a composite from the incorporation of the recycled residue to the polyurethane resin and glass fiber mats and, therefore, can analyze its application potential by the civil construction sector in the substitution of materials such as cement board and gypsum board. The results obtained demonstrated that the thermofixed polyurethane industrial waste can be 100% incorporated into the composite development process. In addition, the composite when analyzed as a component of civil construction, demonstrated applicability by the sector.
The objective of this work is to present the feasibility of replacing materials such as MDF and MDP by the composite developed from recycled thermofix polyurethane industrial waste in the production of school furniture

2. DEVELOPMENT AND CHARACTERIZATION OF POLYURETHANE COMPOUND RECYCLED THERMOFIX

Aiming to recycle the thermofixed polyurethane industrial waste from the post-production processes of the Vale do Rio Sinos, Baldan (2015) developed a methodology in which the thermo-fixed polyurethane industrial waste (Figure 03) is transformed into a recycled aggregate (Figure 04), from cutting and milling processes.

[Figure 03] *Post-production thermo-fixed polyurethane industrial waste (Source: Baldan, 2015)*



[Figure 04] Recycled aggregate (Source: Baldan, 2015)

Then, the recycled aggregate of thermoset polyurethane was added to the polyurethane resin in the ratio 4: 1 (Figure 05). In order to reinforce the composite, two 90 ° oriented fiberglass blankets were also added to the blend (Figure 06).

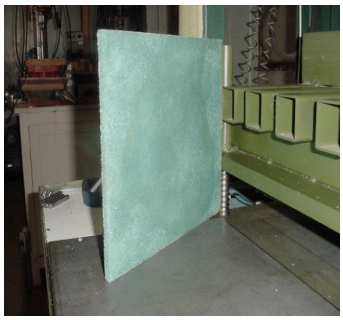
[Figure 05] *Recycled aggregate + polyurethane vegetable resin (Source: Baldan, 2015)*

[Figure 06] *Recycled aggregate blend + polyurethane vegetable resin + glass fibers (Source: Baldan, 2015)*

With the aid of a thermal press (Figure 07) and a metallic shape in the dimensions of 250 x 300 x 9 mm (Figure 08), the blend was compacted for 15 minutes at a constant temperature of 50 ° C and pressing of 5 tons , which generated the material called by Baldan (2015) as polymeric plates (Figure 9).

[Figure 07] *Metal press (Source: Baldan, 2015)*

[Figure 08] *Metal press (Source: Baldan, 2015)*



[Figure 9] *Polymer plate (Source: Baldan, 2015)*

In turn, the developed polymer plates were characterized for their physical properties (density, water absorption, swelling, hardness and impact) and mechanical (tensile strength and parallel and perpendicular screw start) and for the durability potential (abrasion surface and fire resistance). Thus, it was possible to compare the results obtained with the same properties presented by MDF and MDP.

3. ANALYSIS AND DISCUSSION OF RESULTS

To perform the tests, MDF and MDP polymer plates of the same dimensions (25 x 30 x 9 cm) and the same density were used. Table 1 presents the results obtained from the comparison of the physical and mechanical properties of the polymer plate with respect to MDF and MDP.

[Table 1] *Comparison of the physical and mechanical properties of the polymer board with respect to materials commonly applied in the manufacture of school furniture*

Parameters analyzed	polymer plates	MDF	MDP
Density	760,0 kg/m³	760,0 kg/m³	760,0 kg/m³
Absorption in water	Up to 0,5%	Up to 13,0%	Up to 13,0%
Swelling	Up tp 0,5%	Up to 3,5%	Up to 3,5%
Hardness	50,0	45,0	45,0
Impact	4,0 J	2,6 J	3,0 J
Tensile strength	1,6 N/mm²	1,0 N/mm²	1,2 N/mm²
Parallel screw start	1380,0 N	1000,0 N	1200,0 N

Perpendicular Screw Start	1100,0 N	800,0 N	950,0 N

The water absorption and swelling analyzes presented lower results when compared with MDF and MDP, causing the material to not overload, present good structural performance and be light. Further, the polymer plates tested were classified as a ductile material and of elution resistance to impact.
With respect to parallel and perpendicular screw start tests, the results obtained demonstrate that the polymer plates obtained the best results, which guarantees stability to the material.
Table 2 shows the results obtained from the comparison of the physical and mechanical properties of the polymer plate with respect to MDF and MDP.

[Table 2] *Comparison of the durability potential of the polymer board with respect to the materials commonly applied in the manufacture of school furniture*

Parameters analyzed	polymer plates	MDF	MDP
Surface abrasion	PEI-3	PEI-1	PEI-1
Fire resistance	Self-extinguishing	Flammable	Flammable

When subjected to the surface abrasion test, the polymer plates presented characteristics of PEI - 3, which guarantees high resistance to the risk according to NBR 13817 (ABNT, 1997). On the other hand, MDF and MDP, which presented PEI-1, can be classified as low resistance to risk according to the same standard.
With respect to fire resistance, the material presented as extinguishing self, in addition to not releasing smoke during the test. This means that the polymer plates, when subjected to the fire conditions, lose their flames when they are removed from the fire, unlike the MDF and MDP, in which the flames remain constant even when they are far from the fire.
These results are important considering that the polymer plaques present superior results when compared to MDF and MDP, which allows their application in the construction of school furniture.

4. CONCLUSIONS

The data obtained through the tests showed that the plates made by Baldan (2015) presented superior results when compared with the MDF and MDP, which allows the use of the material also developed in the production of school furniture.
In addition, it is important to highlight that, according to Baldan (2015), the boards developed by their research can be recycled again, with the potential to make new boards with the same characteristics and results, guaranteeing the reverse logistics of the product, safeguarding sustainability of the entire production chain.

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