By-Products

MAGNESITE-BONDED BAGASSE PARTICLEBOARDS

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ABSTRACT

In the paper, the technical feasibility of using bagasse to produce particleboards with calcined magnesite as binder is presented. Good results employing bagasse: magnesite relation 1:2, water:magnesite relation 0.4:1 and magnesium sulfate as addition salt has been obtained. Boards without salt were also tested. Achieved properties were acceptable. The use of calcined magnesite as binder to produce bagasse particleboards for the building industry may represent a good option for sugarcane producing countries.

Key words: Particleboard, mineral-bonded composite, inorganic binder, bagasse, calcined magnesite.

INTRODUCTION

Wood cement particleboards and more recently wood-gypsum particleboards are the most widely known mineral-bonded boards. The possibility of using sugarcane bagasse for these purposes has been reported previously. These technologies produce a high quality building panels but high initial investment cost is required.

Magnesium cement is another inorganic binder that can be employed. It was the first mineral used to manufacture agglomerated inorganic-bonded materials. As early as in the 19th Century, flooring tiles of magnesia cement (Sorel cement) and sawdust were produced. Later, during the 1920s the production of magnesium bonded wood-wool panels, known as Heraklith, was performed. At that time the introduction of Portland cement for this purpose displaced the magnesium cement, due to the better water resistance of Portland cement.

In the middle of the 1970s, when the production of magnesite particleboards by hot pressing appeared, a new era in the use of this mineral as binder began.

This technology is still in the development stage although a plant in Finland (Metsä–Serla Company) was established in 1980 with good results. Some productions in Germany (Pyroverth–Olok) and Austria (Homogen–M) are also reported.
Magnesite particleboard process has some advantages, it allows to utilize conventional particleboard technology with only slight modifications (and for this reason the investment cost is lower); the product is fire and fungi resistant, and panels cannot emit formaldehyde (one of the most important problems for particleboard industry nowadays). Regarding its use, it is a light-weight building material with large surface so that it can improve the construction productivity.

In this paper, the possibility of using bagasse to produce magnesite particleboards and the properties achieved at laboratory scale are presented.

Some Theoretical Considerations

The basic product of magnesium cement is magnesite (MgCO₃) which is calcined at temperatures between 800°C to 900°C to form calcined magnesite (MgO). Calcined magnesite in the presence of magnesium salts solutions such as carbonate, chloride, nitrate, phosphate or sulfate forms a plastic mass setting at room temperature between 1 to 6 h.

The general formula is:

\[ x\text{ Mg(OH)}_2 \cdot y\text{ Mg} \cdot z\text{ H}_2\text{O} \]

where, \( x, y, z \) are integer number.

AR is acid radical of salt which can be calcium, magnesium, etc...

Generally, magnesia cement is prepared by mixing caustic calcined magnesite and magnesium chloride or sulfate. To produce wood magnesite particleboards, magnesium oxysulfate is more recommendable than oxichloride. The latter is a more corrosive material, more hygroscopic and has lower decomposition temperature. These results agree with our experiences in bagasse-magnesite boards manufactured at laboratory scale. Simatupang reported that it is possible to produce boards without magnesium sulfate. The bending strength was acceptable, but the swelling in water was poor.

Regarding the compatibility of lignocellulosic materials with magnesium cement it has been reported that free carbohydrates and phenolic compounds showed no negative effect in the setting time. More recently, reports from the same authors have shown that the setting time of magnesium cement made with magnesium sulfate is slightly retarded by phenolic compounds, but not by carbohydrates. For this reason, magnesia-boards have been prepared successfully from the wood of limba, abachi and bagasse. These results are in accordance with our researches.
The objective of this paper is to present the results from the investigations carried out at laboratory scale in the production of bagasse-magnesite cement boards and the possibility of not using salt addition, taking into account, that we do not have these resources in our country.

MATERIALS AND METHODS

Raw materials

- Depithed and predried storage bagasse (from Camilo Particleboard Plant in Havana).
- Calcined magnesite (Jaruco Factory-Havana).
- Magnesium sulfate (reactive quality).

Bagasse was processed at ICIDCA pilot plant to obtain surface and core materials by hammermilling.

The properties of main raw materials are presented in Tables 1 and 2.

Experimental plan

One experiment was made by using one of the best conditions obtained previously in our research work, utilizing magnesium sulfate as salt addition\textsuperscript{6}. Another one was made without salt addition in order to evaluate its behavior.

The main process parameters were:

- Size of boards = 25 x 28 x 1 cm.
- Density = 1,200 kg/m\textsuperscript{3} (Theoretical).
- Bagasse : magnesite relation = 1:2.
- Water:magnesite relation = 0.4:1 (effective water).
- Magnesium sulfate addition = 10\% by weight of the binder.
- Board composition = 40\% surface material, 60\% core material.
- Mixing time = 2 min (for each component).
- Pressing conditions = 130\textdegree C, 8 min.
- Conditioning: 7 days, environment conditions (30 \pm 2\textdegree C, 80 \pm 5\% R.H.).

The sequence followed for the boards elaboration are shown in Figure 1.
TABLE 1. Granulometric composition of bagasse (medium values).

<table>
<thead>
<tr>
<th>Material</th>
<th>6.3 mm</th>
<th>4.0 mm</th>
<th>2.0 mm</th>
<th>1.0 mm</th>
<th>0.5 mm</th>
<th>0.2 mm</th>
<th>0.0 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface layers</td>
<td>-</td>
<td>-</td>
<td>2.2</td>
<td>20.1</td>
<td>40.5</td>
<td>27.2</td>
<td>10</td>
</tr>
<tr>
<td>Core layers</td>
<td>2.3</td>
<td>7.6</td>
<td>42.3</td>
<td>32.0</td>
<td>13.3</td>
<td>2.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

FIGURE 1. Flow diagram for panels manufacture.
TABLE 2. Calcined magnesite specifications.

<table>
<thead>
<tr>
<th>Chemical composition:</th>
<th>% MgO</th>
<th>% CaO</th>
<th>% Fe₂O₃</th>
<th>% Al₂O₃</th>
<th>% SiO₂</th>
<th>% MgCO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.72</td>
<td>5.08</td>
<td>2.93</td>
<td>1.65</td>
<td>25.33</td>
<td>31.72</td>
<td></td>
</tr>
</tbody>
</table>

- Granulometric composition: (Sieve analyzed)

<table>
<thead>
<tr>
<th>% Screen retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 mm</td>
</tr>
<tr>
<td>20.6</td>
</tr>
</tbody>
</table>

- Setting time (vica technique): initial setting time = 120 min, final setting time = 130 min.

Three boards for each experiment and two samples per board were evaluated. Physical and mechanical properties were: thickness, density, moisture content, bending strength (MOR) and thickness swelling 24 h in water. The evaluation of the physico-mechanical properties was developed according to the Particleboard Cuban Standards NC 4308/1987.

RESULTS AND DISCUSSION

The results obtained were shown in Table 3.

The properties obtained in the first experiment (with MgSO₄ addition) showed good bagasse behavior to produce magnesite boards. Medium figures for density and bending strength can be comparable with wood-magnesite particleboards. Thickness swelling is a little higher. The results for the second experiment (without salt addition) were satisfactory.

A comparison of two experiments medium values, by using the t-test and F-test (P =0.05) was made. Physical and mechanical properties were considered.

For the density, non-significant difference exists. This means that no interference in the analysis of the rest of the properties will appear due to density variation.

Bending strength, the main mechanical property, showed significant difference between medium values. As we expected the figures for the first experiment were

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TABLE 3. Properties of bagasse-magnesite particleboards:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Thickness (mm)</th>
<th>Moisture content (%)</th>
<th>Density (kg/m³)</th>
<th>Bending strength (MPa)</th>
<th>Thickness swelling (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>10.90</td>
<td>10.5</td>
<td>1181</td>
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<tr>
<td></td>
<td>11.10</td>
<td>11.2</td>
<td>1201</td>
<td>12.8</td>
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<tr>
<td></td>
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<td></td>
<td>10.85</td>
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<td>12.5</td>
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<td></td>
<td>0.17</td>
<td>0.4</td>
<td>32.1</td>
<td>0.83</td>
<td>1.6</td>
</tr>
<tr>
<td>2.</td>
<td>11.0</td>
<td>13.4</td>
<td>1232</td>
<td>11.6</td>
<td>11.1</td>
</tr>
<tr>
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<tr>
<td></td>
<td>0.17</td>
<td>0.3</td>
<td>26.7</td>
<td>1.46</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Note: Experiment 1: with MgSO₄, Experiment 2: without salt.

- \( \bar{x} \): Average values; SD: Standard deviation.

- Higher. This agrees with other experiences that show proportionality between magnesium sulfate addition and strength properties. It is correct to point out that acceptable result without salt addition was obtained (around 9.4 MPa), indicating the potential of using magnesium sulfate as the additive for improving the properties of bagasse-magnesite panels.

- Thickness swelling did not show difference between experiments. Although magnesium sulfate is not the best additive for swelling properties, the results should have been better compared with the sulfate experiment. Values are in a range between 10 to 12%. The low quality of calcined magnesite employed and bagasse hygroscopicity may have influenced in these results. However, the thickness swelling thus reached did not exclude the possibility of using bagasse-magnesite panels for interior building purposes. (Wood-magnesite thickness swelling is around 7 to 10%). Further researches are needed to improve this property.

- Pressing conditions were adequate and no blow took place during the boards manufacture. The surface quality of boards was acceptable.
We are preparing now the necessary conditions, for an industrial trial production, that will be performed in a near future. The possibility of producing boards without magnesium salt, already tested in this work, allows us to accomplish this objective under our conditions and constraints.

CONCLUSIONS

The possibility of producing bagasse particleboards with magnesite as binder is demonstrated. Good mechanical properties (MOR) by using bagasse:magnesite relation = 1:2 and water: magnesite relation = 0.4:1 are obtained with magnesium salt addition. Bending strength (MOR) is around 12 MPa for these conditions, similar to wood-magnesite particleboards.

Thickness swelling did not show difference. It is important to mention that the magnesite used was not of high quality. This result has a great importance because Cuba does not have any magnesium salt sources.

It is true that magnesite particleboard are not suitable for external building purposes and in some cases magnesite may be a little expensive but it opens a new way in agglomerated mineral-bonded products with many advantages (low investment cost, high construction productivity, etc). For sugarcane producing countries it may represent another promising product in the diversification path.

REFERENCES


PANNEAUX DE BAGASSE UTILISANT LE CARBONATE DE MAGNESIE COMME ADHESIF

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RESUME
On presente une etude de faisabilite technique sur l'emploi de la bagasse pour la production de panneaux particules avec du carbonate de magnesie calcinee comme adhesif. On a obtenu de bons resultats avec de la bagasse et du carbonate de magnesie dans la proportion de 1:2, une proportion eau: magnesie de 0.4:1 et l'addition de sulfate de magnesie comme sel. Des panneaux sans sel ont aussi ete essayes. Les proprietes qui ont ete mesurees etaient acceptables. L'emploi de carbonate de magnesie calcinee comme adhesif dans la production de panneaux de bagasse pour la construction pourrait represente un bon choix pour les pays producteurs de canne a sucre.
En este trabajo se presenta la factibilidad técnica de utilizar bagazo de caña para producir tableros de partículas aglomerados con magnesita calcinada. Se obtuvieron buenos resultados empleando relaciones bagazo:magnesita 1:2, agua:magnesita 0.4:1 y sulfato de magnesio como sal de adición. También fue probada la elaboración de tableros sin sal de adición. Las propiedades alcanzadas fueron aceptables. El uso de la magnesita calcinada como aglutinante para la producción de tableros de partículas de bagazo con destino a la industria constructiva puede representar una buena alternativa para los países productores de azúcar de azúcar de caña.

Palabras claves: Tableros de partículas, composición aglomerada con minerales, aglutinantes inorgánicos, bagazo, magnesita calcinada.