INFLUENCE OF ADDITION OF WOOD FROM CONTAINERS AND PALLETS AND SELECTED TECHNOLOGICAL PARAMETERS ON THE PROPERTIES OF MDF

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ABSTRACT

The subject of the paper was examining the influence of the addition of the pulp (recovered from wood of pallets and containers) and glue content on the properties of medium density fibreboard (MDF). Wood from used pallets and containers, disintegrated to the form of chips in a wood chipper, were submitted to a hydrothermal treatment and then defibrated in a laboratory defibrator. Pulp obtained from recovered wood was added to standard pulp and MDF were produced from the mixture. The obtained results justify a conclusion that a 25% addition of recovered wood to industrial pulp allows to produce MDF exhibiting properties satisfying the requirements of the standard EN 622-5 (2006). The glue content increase from 10 to 12 % had no significant effect.

KEYWORDS: Recovered wood, containers, pallets, MDF.

INTRODUCTION

In Poland, in the sector of wood-based panels, the production of MDF grows the most dynamically. In 2010, Poland was the second producer of MDF in Europe, with the production of 1.8 million m$^3$ per year (FAOSTAT 2011).

The basic factor which can hamper a further development of the wood-based panels industry is deficiency of wood which in 2010 reached ca. 0.6 million m$^3$ in the MDF industry in Poland.

The main raw material for the production of fibreboards is forest wood in the forms of pulpwood and small pole wood. A significant share in the raw material (about 40 %) is made by wood wastes, both in-house and coming from other sectors of wood industry, mainly sawmills and plywood industry. These wastes are utilized by industrial plants in almost 100 %. Recently, there have been made attempts to utilize in the production of fibreboards other fibrous raw materials, like annual plants, scrap paper and recovered wood (Borysiuk et al. 2006, Danecki et al. 2008, Dukarska et al. 2006, Ergolu and Istek 2000, Han 2001, Han and Kawai 2001, Klimczewski et al. 2009, Nicewicz et al. 2006).
Recovered wood occurs in forms of different assortments: roundwood (utilized in construction industry, water engineering, mining), sawn timber (also utilized in construction industry and mining as well as in packaging and furniture) and wood based materials (applied in construction industry, transportation, packaging, interior fitment and furniture). In Poland, the resources of recovered wood coming from industrial and communal sectors are estimated at about 5.5 million m\(^3\) (2.8 million Mg) yearly. This raw material is classified with regard to its form, material and chemical composition (Daian and Ozarska 2009, Ratajczak et al. 2003). In the production of fibrous boards, used containers and pallets seem to be the most convenient alternative material, because it contains neither bark nor chemical substances. The researches on utilization of recovered wood started with studies on the application of wood from pallets and containers to the production of pulp. Within these studies, pulps for hardboards, insulation boards and MDF, including high density fibreboard (HDF), were characterized in details. As a result of these studies, it was found that pulp obtained from recovered wood from containers can be applied without limitations in the production of fibreboards by the wet method (hardboards and insulation boards) while in the dry method (MDF and HDF) it can be used only in limited amounts (Klimczewski et al. 2009). The present study aimed at determination (whether/ in what quantities), wood from containers and pallets can be used in the production of MDF boards. Additionally, tests determining the influence of content of pulp from recovered wood, glue rate on the properties of resultant boards were performed.

MATERIAL AND METHODS

In the production of MDF, standard pulp from pine wood, obtained in industrial conditions and recovered wood pulp (RW) – from containers and pallets was applied. RW pulp was composed of softwood (34 %), hardwood (33 %) and exotic wood (33 %). Any fasteners were removed from pallets and containers and they were divided into components which subsequently were disintegrated in a wood chipper to the form of chips. Chips were defibrated in a laboratory defibrator. In this operation the humidity of chips must be above the fibre saturation point, but the optimum of moisture of chips is about 50 – 60 % in industrial conditions. For conducted experiment, chips from recovered wood were immersed in water of temperature 30°C for 4 h which allowed to reaching humidity level close to 50 %.

Parameters of the defibration:
- time of heating of chips – 4 min,
- defibration time – 2 min,
- temperature 150°C.

Obtained pulp was refined in a laboratory refiner R\(_1\). The distance between refined disks was 0.1 mm. Fractional composition of this pulp was examined in a Morfi apparatus (Robertson et al. 1999). For both type of pulps a sample of 1 g (of dry fibres) were tested. The shives were calculated by testing a sample for 60 s. Then further analysis was carried to test min. 4 000 fibres.

The pulp obtained from RW was added to standard pulp in relations: 0; 25; 50; 75 and 100 %, after mixing, resin (UF – 10 % or 12 %) and paraffin (1 %) were spread on fibres and boards were produced.

Target boards density: 700 kg.m\(^{-3}\) (±5 %), thickness of 12 mm (±0.1 mm). Technological parameters during production: temperature of press platens 170°C, pressure 2.5 MPa, time 3 minutes. Properties of obtained boards (30 in each series) were tested according to the obligatory standards EN 622-5 (2006). Significance of results was examined by means of the Student’s criterion.

For most effective course of the research, an experimental design was implemented: 8 runs-
two factors: glue content and addition of pulp from recovered wood (Montgomery 2001) (Tab. 1).

**Tab. 1: Experimental design for the production of MDF boards.**

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Glue content UF (%)</th>
<th>Addition of RW pulp (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>75</td>
</tr>
</tbody>
</table>

**RESULTS AND DISCUSSION**

The results of dimensional analysis of fibre conducted in Morfi LB 01 apparatus are shown in Tab. 2.

**Tab. 2: Dimensional analysis of fibres in wood from containers and pallets and in standard wood chips.**

<table>
<thead>
<tr>
<th>Fibre dimension</th>
<th>From pallets</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average length of fibres (µm)</td>
<td>563</td>
<td>857</td>
</tr>
<tr>
<td>Average width (µm)</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>Quantity of shives (pieces)</td>
<td>192</td>
<td>106</td>
</tr>
<tr>
<td>Quantity of fines (% of surface)</td>
<td>13</td>
<td>10</td>
</tr>
</tbody>
</table>

As it results from the analysis of fibre dimensions, pulps differed not only in length of fibres but also in contents of shives. In the standard pulp, fibres were on average by 1/3 longer in comparison with fibres obtained from pallet wood. There can be at least two reasons for this fact. The first one is a species composition of wood pulps that were obtained. In the pallet wood, there was about 33 % of wood of exotic species and about 33 % of hardwood from local species. Industrial pulp was produced from pine wood. Thus the anatomic structure of wood had an influence on the length of pulp fibres. Fibres from exotic and hardwood are shorter than pine fibres but their width was similar. The second important parameter was susceptibility of chips to defibration. Chips from RW (of initial humidity about 15 %) were plasticized in the heater of defibrator to a lesser extent and were more shortened during defibration compared to the industrial pulp. Their lower plasticization was additionally proven by much higher (ca. 45 %) quantity of shives in the tested sample. On the other hand, the proportions of fines were at similar levels in the analyzed pulps.

The length of pine fibres determined by Roffael et al. 2009 (1.64 mm) was greater than that of standard pulp fibres applied in the present study (0.86 mm). It can testify to different
defibration parameters applied in both studies. However, it is noteworthy that regardless the kind of recovered wood (particleboards, MDF, wood from containers and pallets) fibres obtained from it are shorter than standard ones. In each case, fibres from recovered wood were shorter by about 25 – 35 %.

In Tab. 3, there are presented properties of MDF boards obtained with different shares of RW pulp and glue content.

**Tab. 3: Properties of MDF boards produced with different shares of pulp from recovered wood and standard pulp.**

<table>
<thead>
<tr>
<th>Proportion of RW/UF content (%</th>
<th>MOR (N.mm⁻²)</th>
<th>Standard deviation (N.mm⁻²)</th>
<th>IB (N.mm⁻²)</th>
<th>Standard deviation (N.mm⁻²)</th>
<th>MOE (N.mm⁻²)</th>
<th>Standard deviation (N.mm⁻²)</th>
<th>Thickness swelling after 24 h (%)</th>
<th>Standard deviation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0/ 10</td>
<td>42</td>
<td>2.9</td>
<td>0.70</td>
<td>0.06</td>
<td>3950</td>
<td>127</td>
<td>12</td>
<td>1.2</td>
</tr>
<tr>
<td>0.0/ 12</td>
<td>43</td>
<td>2.6</td>
<td>0.65</td>
<td>0.07</td>
<td>3150</td>
<td>194</td>
<td>11</td>
<td>2.2</td>
</tr>
<tr>
<td>25 / 10</td>
<td>31</td>
<td>2.7</td>
<td>0.61</td>
<td>0.07</td>
<td>2550</td>
<td>236</td>
<td>12</td>
<td>1.3</td>
</tr>
<tr>
<td>25 / 12</td>
<td>37</td>
<td>1.9</td>
<td>0.57</td>
<td>0.08</td>
<td>3150</td>
<td>67</td>
<td>12</td>
<td>1.6</td>
</tr>
<tr>
<td>50 / 10</td>
<td>32</td>
<td>2.6</td>
<td>0.50</td>
<td>0.08</td>
<td>2650</td>
<td>135</td>
<td>20</td>
<td>1.6</td>
</tr>
<tr>
<td>50 / 12</td>
<td>29</td>
<td>3.3</td>
<td>0.52</td>
<td>0.05</td>
<td>2650</td>
<td>159</td>
<td>23</td>
<td>2.5</td>
</tr>
<tr>
<td>75 / 10</td>
<td>33</td>
<td>2.1</td>
<td>0.68</td>
<td>0.07</td>
<td>2800</td>
<td>52</td>
<td>21</td>
<td>1.7</td>
</tr>
<tr>
<td>75 / 12</td>
<td>36</td>
<td>2.3</td>
<td>0.61</td>
<td>0.08</td>
<td>2700</td>
<td>399</td>
<td>22</td>
<td>1.4</td>
</tr>
</tbody>
</table>

It is visible from the data presented in the Tab. 3 and Fig. 1, 2 and 3 that with a growing addition of pulp from wood of containers and pallets strength properties were decreased.

Analysis of the results presented in Tab. 3 shown that the increase of glue content in the production of boards from 10 % to 12 % had no statistically significant effect neither on strength properties nor on thickness swelling of tested boards.

Fig. 1, 2 and 3 shows correlation of strength properties with RW content.

**Fig. 1:** Modulus of rupture (MOR) of MDF panels produced with different content of pulp from recovered wood.

**Fig. 2:** Internal bond (IB) of MDF panels produced with different content of pulp from recovered wood.

Addition of RW fibres caused a decrease of strength properties of boards (in most cases the fall was statistically significant), but values of all strength properties were higher than those required by the relevant EN standard. An RW content increase from 25 % to 50 % and 75 % do not caused further decrease in strength properties of boards. Obtained results for IB doesn’t show statistically significant influence of RW addition.
Results of TS related to RW content presented on Fig. 4 shows that the addition of 25 % fibres from RW had no statistically significant effect. Further addition of RW – 50 % and 75 % resulted in significantly increased thickness swelling of boards exceeding the acceptable values.

Decreased strength properties of boards with an addition of recovered wood and increased swelling may suggest that between fibres from recovered wood less chemical bonds are formed in comparison with standard fibres. Increasing glue content from 10 to 12 % did not significantly improve board properties. As mentioned above, in the production of fibreboards, there is applied wood of moisture level above the fibre saturation point (usually 50 – 60 %). Wood from containers and pallets had the initial humidity of 15 % which was increased by water soaking. Increased humidity of recovered wood facilitated the operation of defibration but did not affect the activity of the fibre surface, which revealed from the properties of the board.

The obtained in the present study values of MOR, MOE and swelling after 24 h for the boards produced with a 25 % addition of RW pulp are comparable with the values obtained by Roffael et al. (2009, 2010), who applied an addition of RW fibres from particleboards and MDF in a proportion of 30 %. The authors produced boards of similar density (700 kg.m⁻³) but of greater thickness (16 mm).

Kearley and Goroyias (2004) have proven that MDF can be produced entirely from recovered MDF and particleboards. However, it is necessary to disintegrate the recovered boards in an autoclave. Boards produced from such raw material have the same properties as boards produced from forest wood (Kearley and Goroyias 2004). This method seems to be difficult to implement in the Polish industry of wood-based materials. Therefore further research on increasing the share of recovered wood in the raw material for MDF boards above the level of 25 % is being carried out.

**CONCLUSIONS**

1. The maximum addition of RW fibres in laboratory made MDF to comply with EN 622-5 (2006) requirements are 25 %. Addition of 50 % or more of RW fibres give MDF panels with properties below values requested by the standard.

2. Strength properties of MDF with RW content of 25, 50 and 75 % were similar and statistically lower than for standard MDF.

3. Addition of 25 % RW resulted with no significant difference in TS compared to standard MDF. Further increase of RW content caused significant increase of TS above values requested by EN standard.
4. Glue content increase from 10 % to 12 % resulted with no statistically significant impact on board properties.
5. To allow for an increase of RW fibres addition, further research should be conducted to improve chips preparation process before defibration.

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REFERENCES


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