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THE CHARACTERISTICS OF THERMALLY TREATED MDF PANELS

Aurel LUNGULEASA[1] Cosmin SPÎRCHEZ[1]

Abstract: *The paper aims to study the characteristics of medium-density fiberboards (MDF), resulted upon a thermal treatment at temperatures of 180°C and 200°C, during 3 and 5 hours. These characteristics are compared to those of untreated, duplicate samples. Research method and material elements are succinctly presented in order to determine the water absorption and thickness swelling, but also the bending strength and Brinell hardness, as well as the materials and equipment being used. The results of the research emphasize that thermally treated panels present a lower level of water absorption and thickness swelling, but along these advantages we also have certain disadvantages, such as the decrease of the static bending strength and of the Brinell hardness. In general, the thermal treatment brings undisputable benefits to the MDF panels when they are used within highly humid environments.*

Key words: *medium-density fiberboards (MDF), water absorption, thickness swelling, bending strength, Brinell hardness.*

1. Introduction

The biomass is the renewable energy resource of the future [2], [9-10]. Any ligno-cellulosic material obtained from biomass can be thermally treated in dry environment in the presence of oxygen and nitrogen (thermal treatment) [12] in order to improve its hydrophobicity and other features [6], [7], [11]. The thermal treatment is generally performed on the raw material used to obtain the composites and less on the final products [3, 4]. Thus, a chipboard made of thermally treated chips or a plywood made of thermally treated veneers will have a lower higroscopicity than the composite made of not thermally treated components. This occurs as a result of the fact that during the thermal treatment, an important part of hemicelluloses existing in such products become damaged at temperatures of 180-200°C, these having a special affinity towards water [13], [18-20].

Particleboards are semi-finished wood-based composites obtained by particle agglomeration with adhesive under the influence of pressure and temperature. If the particles are wooden chips then panels are called chipboard and if fiber is used then panels are called fibreboards. The panels of wood fibers (fibreboards) are

[1] Wood Processing and Design of Wooden Products, *Transilvania* University of Brasov, Colina Universităţii no. 1, Brasov 500063, Romania;
Correspondence: Aurel Lunguleasa; email: lunga@unitbv.ro.

obtained by agglomeration of the fibrous elements, in the presence of adhesive, the temperature and pressure, with or without the presence of water. Classification of fibreboards on the basis of density can be: soft fibreboards (LDF) with density of 0.3-0.4 g/cm^3; medium density fibreboards (MDF) with 0.7 g/cm^3; hard fibreboards (HDF), with a density of approx. 1 g/cm^3. MDF (medium density fibreboard) are made especially dry. The density of these boards is around 750-800 kg/m^3, variations around these values depending on wood species, specification and technological conditions. MDF is very stable dimensionally and can be used especially for kitchen furniture. MDF doors are very dimensionally stable, do not bend and do not absorb a lot of moisture in wet/moist environments where the panels are used (kitchens, bathrooms, cellars, basements etc.).

MDF has a lot of advantages compared to lumber, chipboard [6], and high density fibreboard (HDF). Large and flat surface as main advantage is due to the fact that MDF is a reconstituted board, composed of fine and uniforme dimensional fibres. Therefore cutting of these panels is smooth, with a low roughness, milling without pulling fibers is smooth and can be finished directly with lacquers and varnishes. Finishing these areas is attractive, as it does not happen in case of other wood-based boards. It must not forget the reaction to water and moisture, low in comparison with solid wood and other wood based composites.

Uses of MDF are multiple. For example their use is welcome in the furniture, decorations and door moldings have a highly decorative aspect, much nicer than that obtained from timber. MDF is a good insulator against sound and heat. Also, MDF can be fit with cylindrical dowels, screws, and adhesion may be done with natural or synthetic adhesive. Usually, cutting tools used to process MDF (circular disks, cutters, drills etc.) can use carbide as the composite cause more wear on tools. It can be noticed that the processing of MDF generates an amount of dust, which is why all machines must be equipped with the Vacuum system. The level of formaldehyde emission from MDF must be reduced, especially because formaldehyde is carcinogenic. The thermal treatment can be performed for ligno-cellulosic products such as briquettes and pellets as well; however, positive results occur in case of surface treatment, respectively in order to maintain their superficial integrity a longer period of time [15-17], [22]. The more compact the products are, the longer the thermal treatment lasts and the poorer the in-depth penetration of treatment is. This is the reason why the gradient of thermal treatment penetration across the whole thickness of the wooden products was analysed [22]. The duration of the thermal treatment in case of sawdust is of several minutes, while for massive wood it takes several hours [1], [21-28].

Nowadays, the thermal treatment of medium-density fibreboard (MDF) is rarely used, especially due to the fact that fibre elements dry at high temperatures. It is well-known the fact that Asplunt-Defibrator technology for obtaining fiberboard through the wet procedure, includes the thermal treatment of fiberboard right after they are taken out from the pressing machine, at temperatures of 180 – 200°C, the boards being placed on racks and introduced into heated enclosures. The strengthening treatment is considered as improving a little the mechanical characteristics of boards, sterilization, i.e. their mycological durability.

The main objective of this paper is the thermal treatment of MDF in order to identify the positive effects. To this end, the purpose was to determine the mass loss, hygroscopicity, dimensional stability, static bending strength and Brinell hardness for the thermally treated boards and the duplicate samples for comparison.

2. Method and materials

There were used standard (not moisture resistant or fire retardant) MDF boards (18 mm thickness) with UF resin, obtained from the market of wooden composites, produced by Kronospan Company. Samples of 320×320 mm were cut of these, and they were packed in film in order to maintain moisture content unchanged. The absolute moisture content (ratio of amount of water and completely dried mass) of the 50×50 mm samples was determined. Samples were treated in a laboratory oven, using two temperatures (T) of 180 and 200 ^{0}C, and time (t) of 3 and 5 hours. The combination of the two treatment parameters were noted with T1/t1, T1/t2, T2/t2 and T2/t1.The mass loss was determined using the ratio between diference of initial and final masses and the initial one.

The thermally treated samples were stored into a dessicator away from the humidity of the laboratory environment. Then, the absorption and thickness swelling (for 2, 4, 6 and 24 hours), as main determinations of the MDF hygroscopicity (EN 317:1993) and dimensional stability were made, using the following formulas:

$$A_i = \frac{m_i - m_{0i}}{m_{0i}} \cdot 100[\%] \quad (1)$$

$$S_i = \frac{g_i - g_{0i}}{g_{0i}} \cdot 100[\%] \quad (2)$$

where:

m_i – sample's mass after immersion into water [g];

m_{0i} – sample's completely dried mass [g];

i – index quantifying the duration of immersion, respectively 2, 4, 6, 24;

g_0 – sample's initial thickness, in completely dried status [mm].

Among the mechanical characteristics of the MDF boards, the static bending strength and Brinell hardness [6, EN 310, EN 1534] were taken into consideration; they were determined using the following formulas:

$$BS = \frac{3 \cdot P_{\max} \cdot l}{2 \cdot b \cdot g^2} \quad [N/mm^2] \quad (3)$$

$$HB = \frac{2 \cdot P}{\pi \cdot D(D - \sqrt{D^2 - d^2}} \quad [N/mm^2] \quad (4)$$

where:

P_{max} – force [N];

l – distance between supports [mm];

b – width of sample [mm];

g – thickness of sample [mm];

D – diameter of punch, habitually10 mm;

d – diameter of stump [mm].

The static bending strength was determined in order to study the general boards' degradation of resistance across the whole board's thickness, and Brinell hardness was used to determine the degradation of surface of treated boards as compared to those not treated.

3. Results and Discussions

The test results for each determination were introduced in centralizing tables and processed in Microsoft Excel. The average moisture content of the MDF boards, determined using the gravimetric method, was of 10+/- 1%, and the density 850+/- 30 kg/m^3. The main characteristics of treatment is the mass loss, visible in Figure 1. It may be noted that increasing the level of thermal treatment leads to the increase of mass loss. It may be noted that increasing the level of thermal treatments leads to the increase of mass loss, up to more than 13% when the temperature is 200°C, and the treatment duration is 5 hours. Similar results were also obtained by other authors [2], [5] for other materials. The main characteristics noticed as being improved after thermal treatment were: the beautiful brown colour, the water absorption and thickness swelling (Fig. 2). It was noted a decrease from 2.8% to 0.7% for S_2, (a decrease by 75%), and a decrease from 9.4% to 3.5% for A_2 (a decrease by 62.7%), for 180/5 treatment.

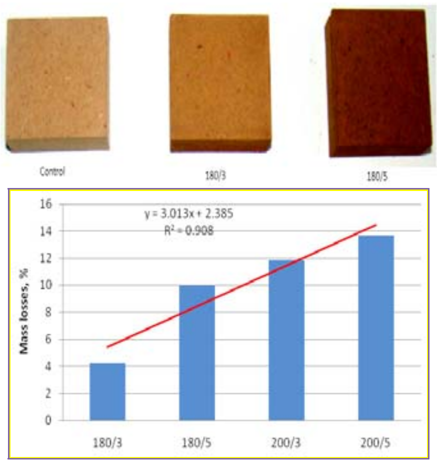

Fig.1. *Mass losses of treated MDF*

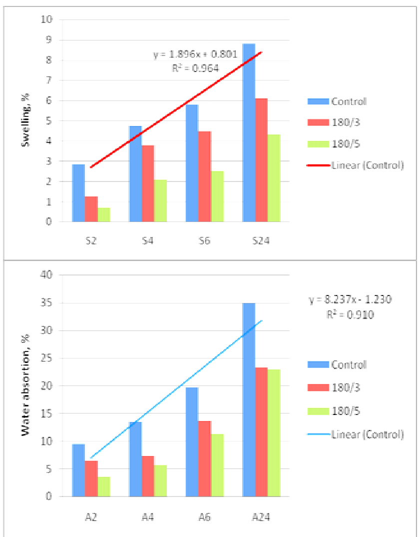

Fig.2. *Thickness swelling and water absorption of treated MDF*

MDF strengths decrease as the level of thermal treatment increases, even if certain authors [1] believe that one could obtain a small increase in case of treated massive wood. The static bending strength decreased from 80 N/mm^2 for the control sample to 35 N/mm^2 for the 180/5 treatment (temperature 180°C and time 5 houres). At the same time, Brinell hardness decreases as the level of treatment increases, from a value of about 30 N/mm^2 for control samples to 20 N/mm^2 for the 180/5 treatment.

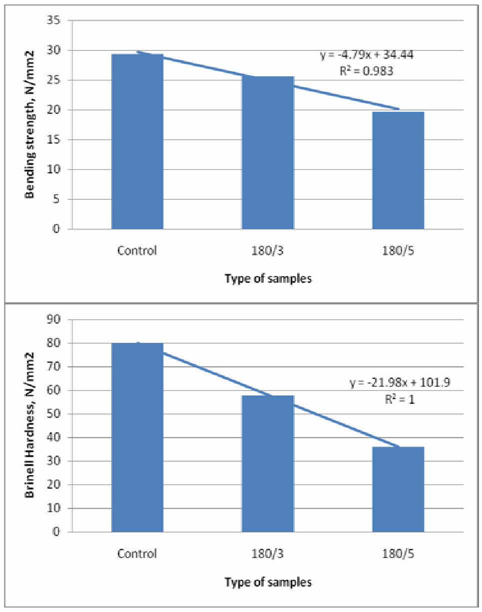

Fig.3. *Static bending strength and Brinell hardness of treated MDF*

4. Conclusions

The thermal treatment of MDF (temperature of 180 and 200 ^{0}C and time of 3 and 5 hours) brings the improvement of hygroscopicity and dimensional stability (water absorption and thickness swelling). Significant decreases of sweling with 60-70% is observed for 180/5 treatment. Moreover, the mass losses show a decrease in density of treated MDF, of up to 15% for 200/5 treatment. The decreases of bending strength up to 10 N/mm^2 for 180/5 treatment show that the thermal treatment affects product's internal cohesion, i.e. the bonds between the adhesive and the wooden fibres are damaged.

The decrease of Brinell hardness by more than 40 N/mm^2 for 180/5 degree of treatment shows a significant degradation of board surface, due to the direct contact with the heat. The use of these boards is recommended for wet environments, based on the good results of water absorbtion and thickness swelling. In addition, if the issue of extremely high costs of thermal treatment is to be considered, we should naturally think twice whether it is convenient to thermally treat the MDF.

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