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Hygroscopic properties of thermally treated MFP

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Abstract: *Hygroscopic properties of thermally treated MFP*. The paper presents the results of studies on improving the hygroscopic properties of MFP by its thermal modification. The effect of temperature and heating time on water absorption and thickness swelling were determined. It was found out that hygroscopic properties first of all depend on heating temperature, and they are the better, the higher the temperature is. By subjecting the panel to thermal modification for 4 hours at a temperature of 200°C it is possible to reduce its water absorption by almost 50 %, and its thickness swelling even by 75%.

Keywords: MFP, thermal modification, thermally treated board, water absorption, thickness swelling

INTRODUCTION

One of the disadvantages of wood-based panels is their high hygroscopicity. It results from the properties of wood particles used for their production, which are characterized by the significant absorption of water from the air. To reduce the absorption of water by wood various methods are employed, including subjecting it to heating at a temperature of 180-220°C. Such modified wood is known as Thermally Modified Timber (TMT). This modification process is well known and described in the literature (Scheiding 2012). TMT has a reduced strength and is more brittle, however, its water absorption and thickness swelling is lower by half. Therefore, it can be used in places with high humidity.

Reduction of water absorption by wood subjected to thermal modification resulted in that wood-based panels began to treated that way too. For instance Paul et al. (2006) studied oriented strand boards (OSB) produced from chips that were earlier modified thermally at 220 – 240°C. The researchers found out that subjecting such a board to heating causes a decrease in the equilibrium moisture content of the board by about 20 % and the reduction of thickness swelling almost by half. The effect of the thermal modification of the board on its water absorption was not so clear. Only for boards bonded with PMDI a 20 % decrease in water absorption was found out, whereas for boards bonded with MUPF and PF thermal modification did not affect this property. Bonigut et al. (2014) and Bonigut and Krug (2013) confirmed that subjecting the typical OSB to thermal modification also affects its hygroscopic properties. They found that subjecting the board to heating at a temperature of 160 to 190°C significantly reduces the thickness swelling of the board and also its equilibrium moisture content.

Similar studies have not been conducted to date with regard to Multi-Function Panel (MFP), which is an alternative material for OSB. The selected hygroscopic properties of MFP were studied by Kociszewski and Sikora (2014), who determined among other things the sorption curve of the board in the range from 40 to 95% RH. Given that MFP is gaining more and more recognition among consumers, we decided to carry out studies to determine the effect of temperature and time of heating on the hygroscopic properties of this panel.

MATERIALS AND METHODS

MFP studied was 18 mm thick and characterized by the following physical and mechanical properties: density – 760 kg/m^3, moisture content – 8.5%, water absorption 24h – 26%, thickness swelling after 24h – 9%, MOE – 4700 MPa, MOR – 22.5 MPa, internal bond – 0.82 MPa.

To determine the effect of temperature and heating time on the properties of the panel, four levels of each of the investigated factors were assumed:

– heating temperature: 140, 160, 180 i 200°C,
– heating time: 1, 2, 3 i 4 hours.

A full test plan (16 test systems) was assumed as well as an additional test system for comparing the results with the properties of the panel that was not subjected to heating.

170 50 x 50 mm specimens were cut from a sheet of the panel, and they were next seasoned in the laboratory for a month at a temperature of about 22°C and a relative air humidity of about 60%. Afterwards, the specimens were measured and weighed, and then they were divided into 17 groups of 10 specimens. One group of specimens was left in the laboratory, and the remaining ones were thermally modified using the Binder 300 drying chamber. 40 specimens were at a time placed in the chamber, and next dried at a temperature of 100°C for 18 hours, and afterwards the temperature was increased to the assumed values of 140, 160, 180 or 200°C. After the temperature had been reached, the heating time was started to be measured. After an hour 10 specimens were taken out of the drying chamber and placed in the laboratory to cool. The same was made after 2, 3, and 5 hours of heating. The exemplary set of specimens containing one specimen from each of the test systems was shown in Figure 1.

Afterwards the specimens were conditioned for 4 weeks at a temperature of 20°C and a relative air humidity of about 65%. After the specimens had reached the constant mass, their water absorption and thickness swelling after 24 hours soaking in water were determined.

The water absorption of the specimen was calculated as the increase in its weight during soaking in water as compared to the mass of the specimen before soaking, i.e.

$$WA = \frac{m_2 - m_1}{m_1} \times 100\% \qquad (1)$$

where: m_1, m_2 – a specimen's weight before and after soaking, respectively

Thickness swelling, in accordance with PN-EN 317, was calculated as an increase in thickness of the specimen during soaking in water as compared to its thickness before soaking, i.e.

$$TS = \frac{t_2 - t_1}{t_1} \times 100\% \qquad (2)$$

where: t_1, t_2 – a specimen's thickness before and after soaking in water, respectively.

RESULTS AND DISCUSSION

Figures 1 and 2 show the relationship between the water absorption and the thickness swelling of the panel and the temperature and time of heating it, respectively. Each column in the chart and whiskers assigned to it are the mean value of water absorption and standard deviation from 10 specimens, respectively.

As expected, the thermal modification of MFP substantially alters its hygroscopic properties. Regardless of the time of the modification of the panel, its water absorption and thickness swelling significantly depend on heating time. A significant decrease in water absorption and thickness swelling is noticed only when the panel is heated at a temperature of at least 180°C for at least 2 hours.

The heating of the panel at a temperature of 160°C does not improve these properties, and for the temperature below 160°C it significantly makes them worse.

Extending the heating time up to 4 hours at a temperature of 180 and 200°C causes an decrease in water absorption as compared to the panel untreated by 31,6 and 57,9 % respectively, and in thickness swelling by 52,5 and 73,8 % respectively.

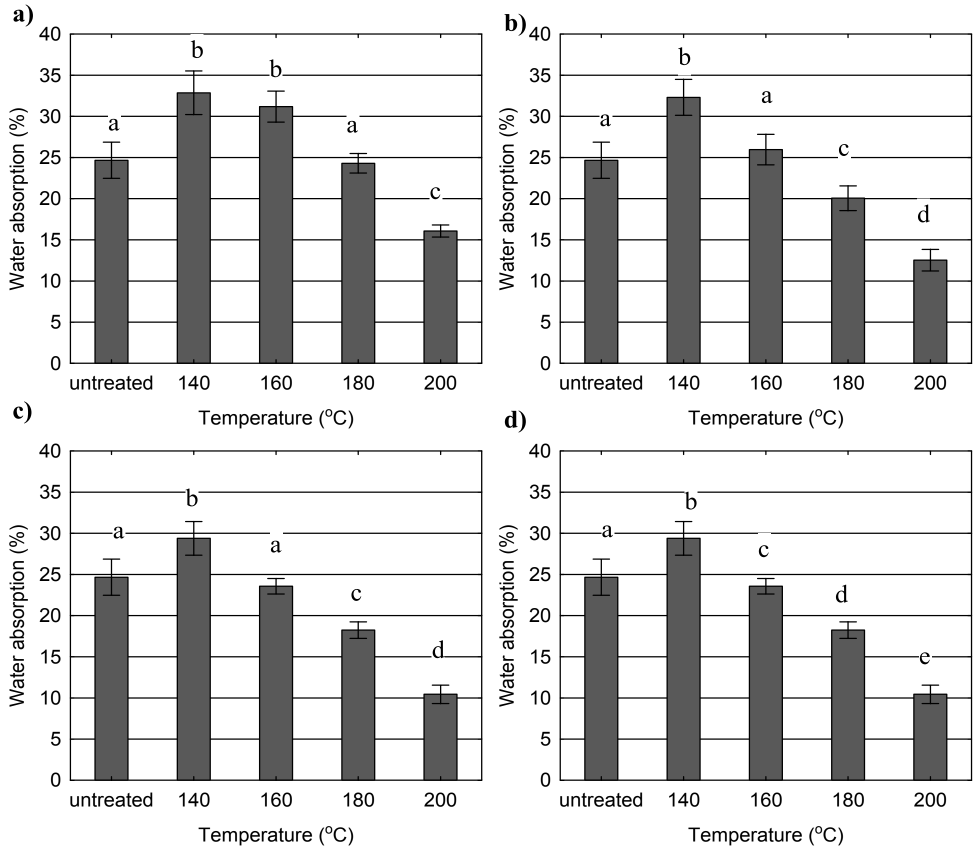

Fig. 1 Relationship between water absorption of MFP and its heating time for a) 1 hour, b) 2 hours, c) 3 hours and d) 4 hours
Mean values marked with the same letter are not statistically different at the 5% significance level

Using the highest analyzed temperature (200°C) and time (4 hours) one can reduce the water absorption of the panel from 25 to 11 %, and its thickness swelling from 8 to 2 %. It is worthwhile noticing that for heating times over 1 hour the change of temperature from 140 to 200°C causes the linear decrease in the water absorption of the panel.

The time of the panel's thermal modification is not so important as its temperature. Generally, for all temperatures analyzed, extending heating time causes a decrease in water absorption, but these decreases are small and in general not statistically significant. Extending the time of heating the panel also causes a decrease in thickness swelling, but a significant effect of this factor was observed only for temperatures higher than 160°C.

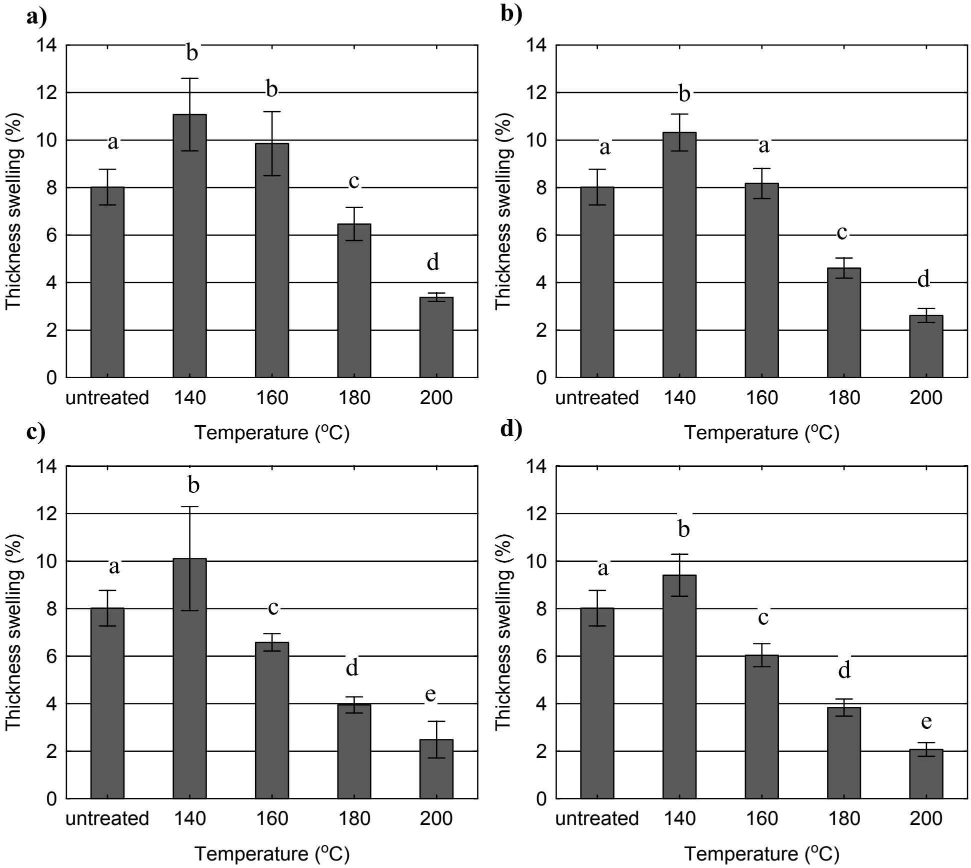

Fig. 2 Relationship between thickness swelling of MFP and heating temperature for a) 1 hour, b) 2 hours, c) 3 hours and d) 4 hours

Mean values marked with the same letter are not statistically different at the 5% significance level

CONCLUSIONS

1. The hygroscopic properties of MFP can be altered by subjecting it to thermal modification
2. To improve the hygroscopic properties of MFP the heating temperature higher than 160°C should be used.
3. Water absorption and thickness swelling significantly depend on temperature and in a lesser degree on heating time.
4. Subjecting the panel to thermal modification for 4 hours at a temperature of 200°C causes that water absorption of the panel decreases by 2,5 times, and its thickness swelling by 4 times.

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Streszczenie: *Właściwości higroskopijne termicznie modyfikowanej płyty MFP*. W pracy zaprezentowano wyniki badań nad możliwością polepszenia właściwości higroskopijnych płyty MFP poprzez poddanie jej modyfikacji termicznej. Określono wpływ temperatury i czasu nagrzewania na nasiąkliwość i spęcznienie na grubość płyty. Stwierdzono, że właściwości higroskopijne zależą głównie od temperatury nagrzewania i są tym lepsze, im wyższa jest wartość tej temperatury. Poprzez poddanie płyty modyfikacji termicznej przez 4 godziny w temperaturze 200°C można obniżyć jej nasiąkliwość o ponad połowę, a spęcznienie na grubość nawet o 75%.

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