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Improving the properties of HDF boards for use in humid conditions

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Abstract: Industrially produced HDFs were subjected to heating or the boards have been covered with a layer of vegetable oil, and then the boards were heated at 150º C for 1.5-2.5 h These operations aimed at increasing the tensile properties and reduce swelling to the extent that these boards may be used in wet conditions outdoors. Properties of produced boards were examined, which concluded that boards thermal treatment leads to a significant improvement of their properties (MOR and MOE increase and decrease of TS) and oil saturation of boards can be useful to reduce the swelling of boards.

Keywords: oil saturation, thermal treatment, properties of HDF

INTRODUCTION

In Poland, the fiberboards produced by the dry method are mainly devoted to applications in the so-called dry conditions. The boards may be used in wet conditions, but then they should have higher, compared to panels intended for the dry conditions, strength properties and a lower swelling. Specific requirements for boards intended for use in both dry and wet conditions are given in the PN-EN 622-5:2010.

Generally as a base is used a rule, that for the production of boards, according to their destination, used are corresponding types of resin for fibers gluing. In the production of boards intended for use in dry conditions UF resins are used, for use in moist conditions, indoors MUF resins, and under moist conditions, outdoors, PF or pMDI resins. Additionally, in order to reduce the swelling of the boards, in production the amount of hydrophobic agents is increased from 0.5 to 1.0% or even 1.5%.

In the literature there are also described other methods to improve the properties of boards: actions on chipped wood (chips or fibers) with high temperature (120-180ºC) (Mohebby et al. 2007, Mohebby et al. 2008,), overheating fiber mats with hot steam, heating the finished boards (Sekino et al. 1998). The most widely used under industrial conditions is the injection of steam.

Heating of boards may not produce the desired results when in their production used are UF resins. At temperatures of 210 -230ºC, not only the adhesive resins may be subject to degradation, but also the connection between the components of wood (Sekino et al. 1998, Stamm, 1964). On the other hand, as a result of properly carried out thermal treatment wood composites can become more hydrophobic due to chemical changes in the components of wood, i.e. the esterification process of hydroxyl groups (-OH) and oxidation and/or partial hydrolysis of hemicelluloses (Ale'n et al 2002, Bekhta and Niemz 2003).

The wood fibers can be coated with chemicals which react with -OH groups of the wood components. The chemical bonds formed between the chemical and the wood can significantly improve the properties of boards - to increase resistance and reduce swelling. The most commonly used material for this purpose is acetic acid anhydride (Rowell 2005).

On an industrial scale, until recently only solid wood was subjected to acetylation. This operation was not carried out in relation to wood chips. Recently, the company Medite

Tricoya carried out in industrial environments the acetylation of fibers and produces MDF with them, and products made of these boards are successfully used in exterior conditions [1].

In the present work vegetable oil (containing unsaturated fatty acids) was applied in a short-term bath to the HDF and subjected to a heat treatment or only subjected to a heat treatment in order to achieve properties to be suitable for use in humid conditions.

MATERIALS AND METHODS

Boards with a density of 880kg/m^3 and thickness of 2.5 mm were produced in industrial conditions. The degree of gluing with MUF resin was 11.5% and with paraffin emulsion with 0.5% paraffin in relation to the dry mass of fibers.

Forms of dimensions 300x300x2,5mm cut out from the boards were subjected to a short bath – approx. 10 s in a container filled with vegetable oil heated to approx. 60ºC. Then the boards and boards containing no oil have been heat treated in a drying oven at a temperature of 150ºC for a varied time: 1.0, 1.5, 2.0 and 2.5 h. Properties of the boards were tested according to PN EN 622-5: 2010 and compared with the properties of boards not subjected to impregnation with oil or heat treatment. Significance of results was evaluated using the Student's t-test.

RESULTS AND DISCUSION

Properties of the thermally treated and infused with oil and subjected to a heat treatment boards are shown in Table 1.

Table 1. Properties of HDF

Variable/ moisture [%]	MOR [N/mm^2]	SD [N/mm^2]	MOE [N/mm^2]	SD [N/mm^2]	IB [N/mm^2]	SD [N/mm^2]	TS [%]	SD [%]
No oil, no annealing	**45**	2	**4100**	400	**0.4**	0.2	**43**	5
No oil, annealing for 1.5h	**52**	4	**4900**	520	**0.3**	0.1	**38**	7
Oil and annealing for 1.5h	**50**	3	**5000**	510	**0.4**	0.1	**25**	6
No oil, annealing for 2,0h	**50**	3	**5200**	400	**0.3**	0.1	**32**	4
Oil and annealing for 2,0h	**49**	2	**4900**	470	**0.4**	0.1	**21**	3
No oil, annealing for 2,5h	**51**	4	**4800**	410	**0.4**	0.1	**19**	3
Oil and annealing for 2,5h	**53**	3	**5200**	470	**0.4**	0.1	**17**	2

Based on the data presented in the table it can be concluded that the thermal treatment influenced significantly the increase of MOR and MOE of boards and had no effect on IB. After 1.5 h of board heating MOR increased by approximately 16% and MOE by about 20%. Increasing the treatment time to 2.0 h resulted in an increase of only MOE values by about 7% more. Further increasing the heating time of boards did not lead to changes in these properties.

Impregnation of boards with oil did not cause significant changes in the values of MOR and MOE of boards in comparison to the properties of boards subjected to only heat treatment.

Not only the thermal treatment of boards, but applying of oil had no effect on the value of IB of boards. Both of these operations in the most significant and beneficial way affected the TS of boards. By heating the boards for 1.5 h swelling decreased by about 12% relative to the swelling of boards not subjected to the operation, but this decrease was not statistically significant. When the boards were saturated with oil and subjected to a heat treatment for 1.5 h the swelling of them was 25%, which means it decreased compared to swelling of boards not subjected to any treatment by as much as 42%. The lowest swelling (17%) was for boards impregnated with oil and processed for 2.5 hours, but with respect to the boards only subjected to heat treatment for the same time it was a negligible decrease. Boards without oil, only heated for 2.5 h showed swelling of 19%. In this case, swelling decreased by 56% relative to the boards not subjected to any treatment.

In conclusion, especially the heat treatment of boards leads to an improvement of their properties; these boards are suitable for use in humid conditions. Impregnation of boards with oil may be useful to reduce the swelling of boards, but without significant effect on the strength properties.

CONCLUSIONS

1. Thermal treatment of HDF (at 150^0 C for 1.5 to 2.0 h) leads to an increase of MOR by about 20% , MOE by about 27%, does not affect the value of the IB and causes a decrease in TS by about 60%.
2. Application of vegetable oil to HDF and their subsequent annealing does not lead to an increase in strength properties of boards compared with properties of boards only subjected to heat treatment, but tends to influence a reduction of swelling of boards by about 30%.

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[1] http://www.meyertimber.com/Products/Medite-Tricoya-Extreme-Durable-MDF.aspx

Streszczenie: *Poprawa właściwości płyt HDF do zastosowań w warunkach wilgotnych.* Płyty HDF wyprodukowane w warunkach przemysłowych zostały poddane wygrzewaniu lub na płyty została naniesiona warstwa oleju roślinnego, a następnie płyty były wygrzewane w temperaturze 150^0 C w czasie 1,5÷2,5h. Operacje te miały na celu podwyższenie właściwości wytrzymałościowych i obniżenie spęcznienia w takim stopniu, aby płyty te mogły być stosowane w warunkach wilgotnych na zewnątrz. Właściwości wyprodukowanych płyt zostały zbadane, w wyniku których stwierdzono, że obróbka termiczna płyt prowadzi do istotnej poprawy ich właściwości (podwyższenia MOR i MOE i spadku TS), a nasycanie płyt olejem może być przydatne do obniżenia spęcznienia płyt.

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