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The influence of moisture of fiber mats on the properties of MDF boards

NICEWICZ DANUTA, SŁAWOMIR MONDER
Faculty of Wood Technology, Warsaw University of Life Sciences – SGGW

Abstract: The study investigated the extent to which the properties of MDF boards change with changes in the moisture of fibers forming mats from 4.5 to 10.5%. MDF panels were produced in the laboratory with an assumed density of 660kg/m3 and a thickness of 12 mm. It has been found that it is possible to produce boards without their delamination in the whole range of humidity of fibers. The increased amount of water vapor in the mats when they are pressed is likely to influence better plasticization of the fibers, which translates to improved properties of the boards. Increasing moisture content from 6.5 to 10.5% increases the modulus of rapture by approx. 9%, the modulus of elasticity by approx. 7%, internal bonds by approx.30% and reduces swelling by approx. 22%.

Keywords: moisture of fiber mats, MDF properties

INTRODUCTION

Properties of wood-based panels, including MDF, depend on the properties of wood raw material, the type and amount of chemicals added during the production process and extent of the technological parameters. One of the technological parameters, to which is paid relatively little space in the literature is the moisture content of fibers forming a fiber mat. A suitable amount of water, transformed into steam during the pressing operation is necessary to transfer heat from the outer layers to the middle layer of mats. Provided heat warms the mats to a temperature at which the curing of the adhesive resin takes place (typically about 105ºC). Water vapor is not only the heat transfer medium in the mats, but also causes the plasticization of wood fibers, making them easy to connect. In industrial practice it is known that moisture of mats is typically 6,5 - 8.5%. Too low moisture content poses a risk of improper curing of resins, adversely affects the compensating properties of the mats, and thus the properties of the boards. An increased amount of water in the fibers can shorten the mat pressing operation, but it may cause delamination of boards, as a result of stresses generated within the boards (Ayrilmis 2007, Thoemen , Humphrey 2006). Cai et al. (2006) found that delamination of boards occurs when the internal pressure of steam in the mat exceeds 100 kPa (15 psi). These studies show, that in order to avoid delamination of boards, mats humidity should be determined according to their density : for the lower density mats (approx. 670 kg/m^3) humidity can be higher, while for higher it (770-840 kg/m^3) can be lower.

The purpose of this study was to clarify how the properties of MDF with an assumed density change due to the increase in moisture of fibers in the mat.

MATERIALS AND METHODS

The boards with a target density of 660 kg/m^3 and thickness of 12 mm were produced in laboratory conditions from pulp obtained in industrial conditions. The variable parameter was humidity of the fibers in the mat, which was: 4,5, 6,5, 8,5 or 10,5%. Urea-formaldehyde resin was sprayed onto fibers in the amount of 10,0% in relation to absolutely dry fibers. The blended fibers were manually formed into mats using a wooden frame. The mats were pre-pressed in the platens press at room temperature, and then in hot- press at 180^{o}C, at a pressure 2,5 MPa for 216s. Physical and mechanical properties of boards were tested according to the PN-EN 622-5/2010 standard. Significance of results was evaluated using the Student's t-test.

RESULTS AND DISCUSION

Board properties are presented in Table 1.

Table 1. Properties of MDF

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 [%]
I/4,5	**25,4**	3,6	**2630**	400	**0,38**	0,1	**9,0**	1,0
II/6,5	**26,6**	3,9	**2620**	353	**0,40**	0,1	**10**	1,0
III/8,5	**26,8**	2,7	**2760**	242	**0,44**	0,1	**8,0**	1,0
IV/10,5	**27,6**	2,6	**2810**	199	**0,49**	0,1	**7,0**	1,0

As mentioned, in an industrial fiber moisture increases mainly in order to accelerate heat transfer within the carpet, thereby shorten the pressing time, that is, to increase the efficiency of the process. In the present study the parameters of mat pressing were left constant. Differentiated was the mat fibers moisture content from 4.5% to 10.5%. 4.5% moisture content was lowered as compared to the commonly used moisture of 6.5 - 8.5%, and 10.5% moisture content was the increased moisture content.
The data given in Table 1 shows that all boards produced meet the requirements of PN-EN622-5. The tested board strength properties increased with increasing humidity of the fibers in the mat, and swelling was decreasing. Static bending strength of boards in the tested range of humidities increased by approx. 9%, modulus of elasticity increased by approximately 7%, the internal bonds by approx. 30%, and swelling decreased by approx. 22%. Evaluating the results using Student's t test, it was found that the increase in bending strength and elastic modulus were statistically insignificant, but the increase in internal bonds and reduction of swelling were statistically significant.
These studies also show that reducing the moisture content of the fibers from 6.5 to 4.5% does not significantly influence the properties of boards, but it is not justified in view of the additional amount of thermal energy required for drying of fibers in the pipe dryers. In turn, fiber moisture increased to 10.5% had a positive impact on changing of all the properties of the boards. Probably, if it the time of pressing the mats has been cut down, too little steam would have been removed from them and it would lead to delamination of boards. Time used in the study proved to be sufficient to discharge a sufficient amount of steam and delamination did not take place. However, the increased amount of steam led to a better plasticization of fibers, which has resulted in improved properties of boards.
The results should be considered interesting.
On their basis it has been shown that the properties of boards can be improved only by

a proper selection and compliance with a technological parameter, which is the moisture content of wood fibers. On the one hand, it can be concluded that the maintenance of parameters in narrow ranges can be difficult under industrial conditions, on the other hand, it seems that compliance with technological parameters is often not appreciated. It should also be noted that without introducing significant changes in the technological process may be obtained a double benefit i.e. improved properties of boards, but probably also saving of thermal energy needed for drying the fibers to a low level, which is 6.5%. Research of thermal energy saving in laboratory conditions were not carried out.

CONCLUSIONS

1. Moisture content of the fibers in mats lowered to 4.5% does not affect the properties of produced boards, but because of the additional heat demand it is unjustified.
2. Increasing humidity of fibers forming mats from 6.5 to 10.5%, in the manufacture of MDF, does not cause delamination of plates. Then takes place an increase in bending strength of boards by approximately 9.0%, the modulus of elasticity by approximately 7.0%, internal bonds to the boards by approximately 30% and decrease swelling by approximately 22%.

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Streszczenie: *Wpływ wilgotności kobierców włóknistych na właściwości płyt MDF*. W pracy zbadano w jakim stopniu zmieniają się właściwości płyt MDF przy zmiennym parametrze technologicznym tj. wilgotności włókien stanowiących kobierce. W tym celu wyprodukowano, w warunkach laboratoryjnych, płyty MDF o założonej gęstości 660kg/m^3 i grubości 12 mm z włókien drzewnych o wilgotności: 4,5; 6,5; 8,5 i 10,5% uzyskanych w zakładzie przemysłowym. Stwierdzono, że istnieje możliwość zwiększenia wilgotności włókien z 6,5 do 10,5% , co nie powoduje ich rozwarstwiania. Zwiększona ilość pary wodnej w kobiercach podczas ich prasowania prawdopodobnie wpływa na lepsze uplastycznienie włókien, co przekłada się na poprawę właściwości płyt. Zwiększenie wilgotności włókien, w badanym zakresie, powoduje wzrost wytrzymałości na zginanie o ok.9%, modułu sprężystości o ok. 7%, rozciągania prostopadłego do płaszczyzn o ok.30% i obniżenie spęcznienia o ok.22%. W pracy zwrócono uwagę na ważny aspekt w produkcji płyt MDF, jakim jest właściwy dobór i przestrzeganie parametrów technologicznych.

Corresponding authors:

Danuta Nicewicz, Sławomir Monder
Faculty of Wood Technology, Warsaw University of Life Sciences– SGGW
02-776 Warsaw, Nowoursynowska str. 159
Poland
e-mail: danuta_nicewicz@sggw.pl
e-mail: slawomir_monder@sggw.pl