APPLICATION OF CHIPS DESIGNED FOR PARTICLEBOARD CORE IN OSB AS SUBSTITUTE FOR FLAKES

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The aim of the study was to assess the applicability of flake substitution in the core of OSB with chips designed for the core in particleboards. OSB panels were manufactured under laboratory conditions, containing small chips in the core from 0% to 100% of mass fraction (0%, 25%, 50%, 75% 100%) resinated with two types of commonly used binding agents, i.e. MUPF and pMDI resins. It was found that the applied modification of the core structure significantly diminished bending strength and modulus of elasticity; however, even at a 100% fraction of small chips in the core the application of pMDI made it possible to manufacture boards meeting the requirements imposed on OSB/3.

Key words: OSB, core layer, flakes, chips, mechanical properties

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INTRODUCTION

At present oriented strand boards (OSB) are leading products on the market of wood based materials used in the construction industry both as sheathing and structural materials. They owe their rank to their high mechanical properties as well as good resistance to variable environmental conditions. A significant characteristic of OSB, making this board exceptional among other wood based materials, is their purposeful anisotropy, a feature that is often considered undesirable, even in non-wood materials. Variation in mechanical properties for the two identified axes, i.e. the longer axis (direction of the board surface, in which bending strength takes higher values in accordance with EN 300) and the shorter axis (perpendicular to the longer axis) is provided thanks to the fact that they are produced from flakes of more than 70 mm in length and approx. 20 mm in width (Keiser 1987; Chen et al. 2008), facilitating their mechanical or electrostatic orientation. The effect of flake orientation and their geometry on physico-mechanical properties, including dimensional stability (linear expansion) of particleboards, was presented as early as 1976 by Geimer (1976). In his studies he used relatively large chips, of 0.1-0.5 in. (2.5-12 mm) in width and 1-3 in. (25-75 mm) in length, for which he showed a dependence of bending strength and modulus of elasticity on the alignment angle. In turn, the importance of chips geometry and the degree of their orientation on mechanical properties of OSB was shown in their studies by Barnes (2000; 2001) and Nishimura et al. (2004). They confirmed a significant effect, first of all of chip length, on bending strength and modulus of elasticity at bending. However, the evaluation of these properties through the determination of chip quality and their position on the surface of finished boards on the basis of digital image analysis did not yield satisfactory results (Nishimura et al. 2001). In turn, the use of this testing technique made it possible to orient chips in the production process (Nishimura and Ansell 2002a;

2002b), which may facilitate the evaluation of board properties already during production. Chip geometry also has a significant effect on the density profile of boards, causing an increase in density with an increase in chip dimensions (Steiner and Xu 1995; Kruse et al. 2000).

It can be concluded from the presented review of literature that the problem of chip geometry and their position in OSB had been investigated in detail; however, in studies conducted so far generally a homogenous type of chips was used at the cross-section of boards. Fakhir et al. (2006a; 2006b) showed that the presence of small fractions affect the transverse permeability of OSB, however, with no reference to mechanical properties of boards. In turn, it is clear from a study by Jastrząb (2008) that the substitution in the OSB core from 5% to 15% chips designed for the core of particleboards did not influence changes in mechanical properties of these boards, since the observed changes were statistically non-significant.

Therefore, the aim of this study was to determine optimal amounts of chips designed for the core of particleboards as a substitute of flakes in the OSB core.

EXPERIMENTAL

Experimental OSB was manufactured from commercial flakes as well as chips designed for the core of particleboards. In both cases the particles were prepared from pine (*Pinus sylvestris* L.) and were sieved at mesh size of 0.5 x 0.5 mm^2 in order to separate fine and dust fractions. Sieve analysis of chips to be used in particleboard production showed that fines fraction was less than 5% and the share of chips left on 5 and 6.3 mm mesh size sieves was about 30% (fig. 1). The data indicates high quality of these chips.

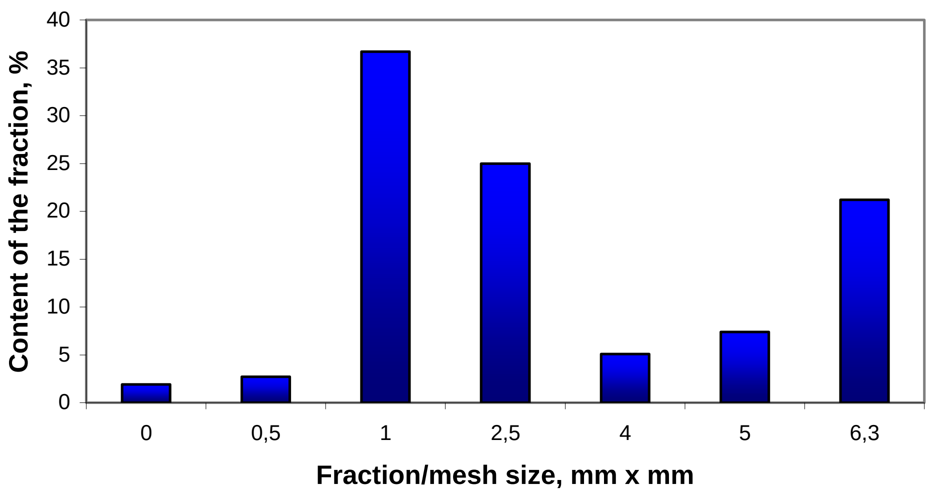

Fig. 1. Sieve fraction of particleboard chips

Previous studies (Jastrząb 2008) showed that the share of chips in the core up to 15% did not have a significant effect on properties of OSB; therefore, the present study considers chips share ranging from 0% to 100%, with a 25% increment in the mass fraction at the standard proportion of the layers of 50:50 (face:core).

From such prepared chips three panels of 750 x 450 mm^2, 15 mm thickness and density of 600 kg·m^{-3} were prepared for each of the experimental variants. In their manufacture standard commercial binding agents were used, i.e. MUPF and pMDI resin. The OSB boards were pressed in a laboratory automatic press at pressing parameters presented in Table 1. No additional agents improving hydrophobicity of produced boards were applied. However, it was assumed that the manufactured boards should meet the requirements of the standard EN 300 binding for OSB/3.

Table 1. **Characteristics of the OSB pressing process**

proportion of small-sized chips	MUPF				pMDI			
	Resin content		Time factor	Temp.	Resin content		Time factor	Temp.
	Face	Core			Face	Core		
%	%		mm ·s^{-1}	°C	%		mm ·s^{-1}	°C
0	6.0	6.00	17	210	3.0	3.00	15	200
25		6.25				3.25		
50		6.60				3.50		
75		6.75				3.75		
100		7.00				4.00		

The manufactured OSBs were tested in accordance with the respective standards as listed in the followings:

- density in accordance with EN 323;
- swelling in thickness (TS) after 24 h in accordance with EN 317;
- formaldehyde content by the perforation test in accordance with EN 120 (only boards resinated with MUPF resin);
- bending strength (MOR - modulus of rigidity) and modulus of elasticity (MOE) in accordance with EN 310;
- internal bond (IB) in accordance with EN 319;
- water resistance as determined by the V-100 test in accordance with EN 1087-1.

In addition, in the case of boards made with small chips at the 0%, 50% and 100% levels, the density profile was recorded.

RESULTS AND DISCUSSION

Properties of manufactured OSB are presented in Table 2 and figs. 2 – 10. As indicated in Table 2, all series of boards are characterized by mean density being very similar to the assumed level.

Moreover, the recorded values, particularly for boards containing 100% flakes or small chips in the core, as well as those resinated with MUPF resin, are characterized by a relatively low standard deviation. The small scatter of density in manufactured OSB resinated with MUPF resin is probably the effect of flakes being covered by small chips, which facilitates manual formation of the mat and prevents chips from falling into its lower parts in the course of formation and charging them to the press. However, what is an advantage at manual forming, may prove to be a disadvantage in commercial scale production, due to the potential difficulties in orientation of small chips.

Table 2. Gravity, thickness swelling and perforator value of OSB boards

Property	Testing method	Unit	Proportion of small-sized chips in the core [%]									
			0		25		50		75		100	
MUPF												
ρ	EN 323	kg/m^3	598	12*	604	12	597	19	593	19	604	15
TS	EN 317	%	30.1	1.0	28.8	1.5	27.2	3.5	26.4	3.3	27.7	1.7
Perforator value	EN 120	mg/100g oven dry board	4.13	-	4.50	-	4.89	-	5.03	-	5.29	-
PMDI												
ρ	EN 323	kg/m^3	602	14	600	25	597	26	590	16	612	12
TS	EN 317	%	26.9	1.7	27.9	1.3	29.0	1.8	26.1	2.2	25.7	0.9

*** - standard deviation**

Irrespective of the amount of small chips in the core and the applied binding agents, all boards were characterized by a relatively high swelling in thickness after 24h soaking in water (Tab. 2). However, it seems that recorded values of swelling in thickness are typical of boards manufactured with no hydrophobic compounds added. Geimer and Kwon (1999) showed swelling in thickness amounting to 26% for boards pressed from chips of aspen (*Populus tremuloides*) resinated with pMDI (3% resin content) and pressed at 205°C. In turn, Paul et al. (2006) for boards pressed from pine chips *(Pinus sylvestris)* found swelling in thickness to be slightly lower, approx. 20% and 23%, respectively, for pMDI and MUPF; however, they applied much higher resination rates. The application of small chips in the core did not have a significant effect on the behaviour of boards subjected to soaking. Although a slight reduction is observed in swelling in thickness for boards resinated with MUPF, a similar trend might also be expected in case of boards resinated with pMDI, which does not actually occur. Thus it may be assumed that recorded values fluctuate around a certain mean, irrespective of the proportion of small chips in the core.

The applied level of resination with MUPF resin, although about 2 times higher compared to commercial scale production, made it possible to manufacture OSB meeting the requirements for hygienic class E1 (Tab. 2). Moreover, the share of small chips in the core was found to have no significant effect on bending strength or modulus of elasticity of boards at bending determined for the longer axis (Figs. 2-3).

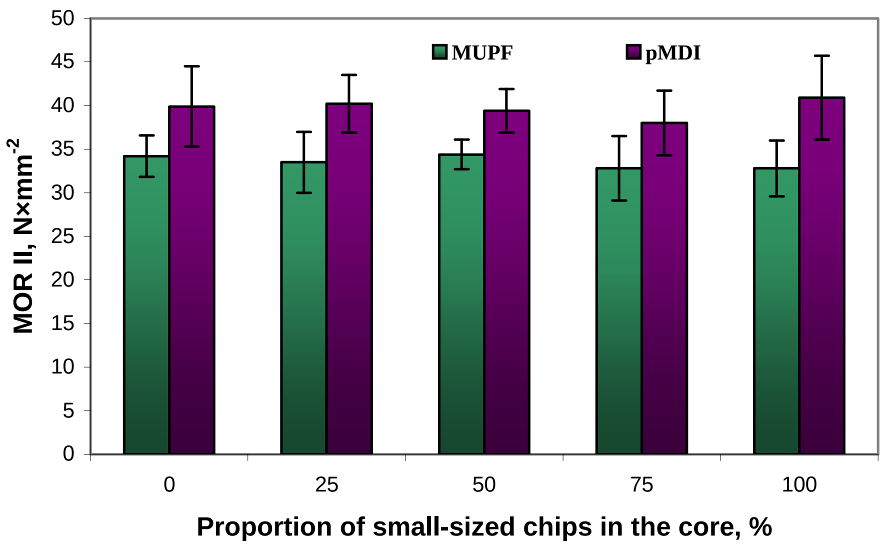

Fig. 2. Bending strength of OSB determined for the longer axis

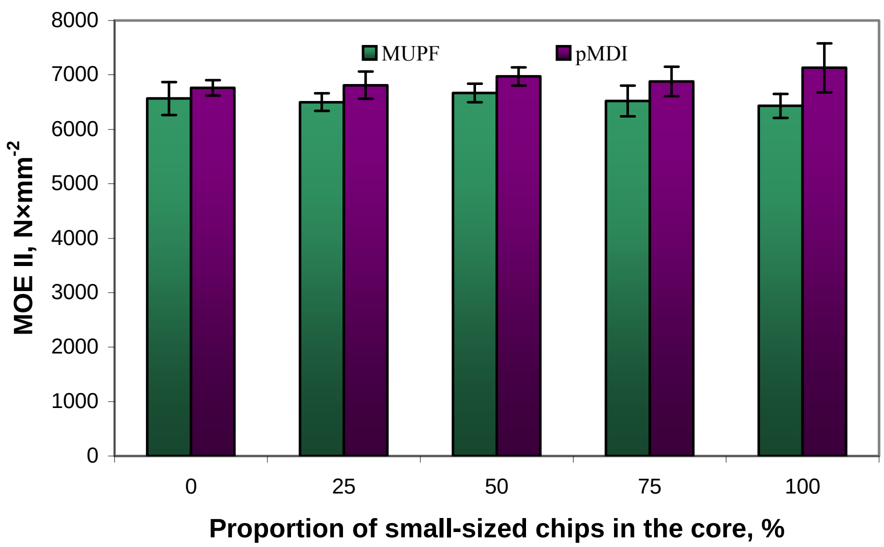

Fig. 3. Modulus of elasticity of manufactured OSB determined for the longer axis

Mean strength of boards resinated with pMDI was around 39.5 N·mm^{-2}, and it was by approx. 6 N·mm^{-2} higher than that of boards resinated with MUPF resin. Modulus of elasticity fluctuated around 6900 N·mm^{-2} for boards resinated with pMDI and approx. 6550 N·mm^{-2} in case of boards resinated with MUPF. Recorded values in both cases were almost 2 times higher than those recommended by the standard EN 300. This is probably a consequence on the one hand of the high quality of applied flakes used for the face, while on the other hand it results from the manual mat forming, as a consequence of which a higher degree of orientation is obtained. Comparable values of MOR and MOE for laboratory-made boards were obtained in their studies by Chen et al. (2008) and Paul et al. (2006).

In turn, a marked effect of the adopted structural modification in the core may be observed when analyzing testing results for bending strength and modulus of elasticity recorded for the smaller axis (Figs. 4-5).

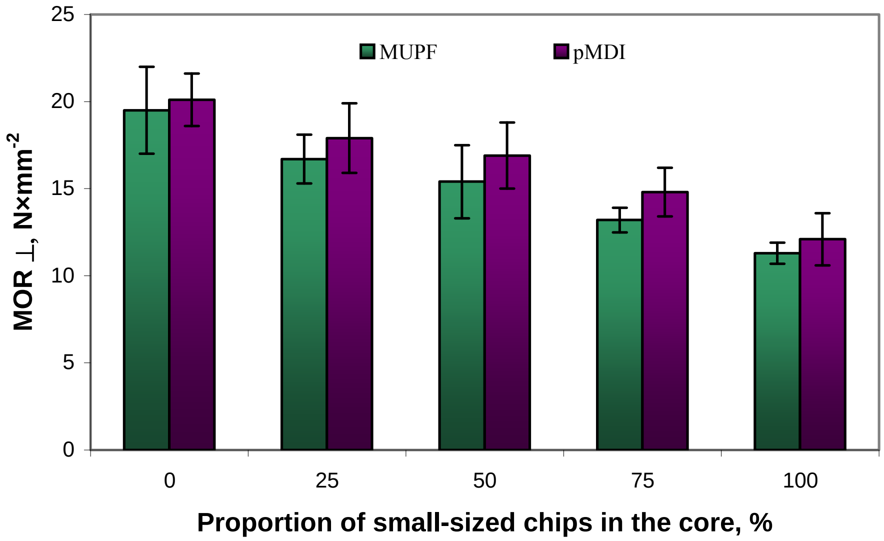

Fig. 4. Bending strength of OSB determined for the smaller axis

In such a case a significant reduction in bending strength and modulus of elasticity was observed with an increase in the share of small chips in the core. Thus, the replacement of 25% mass fraction of flakes with chips designed for the core of particleboards results in a deterioration of MOR by over 14% in case of boards resinated with MUPF and approx. 11% in case of boards resinated with pMDI, while for MOE it is approx. 5% for both types of boards. Complete substitution causes a decrease in bending strength by approx. 40% and that of modulus of elasticity by 20% and 27%, for boards resinated with MUPF and pMDI, respectively. Despite such a considerable reduction of bending strength and modulus of elasticity, the recorded values for both types of boards, even at a complete substitution, are still higher than the limits recommended by the standard EN 300.

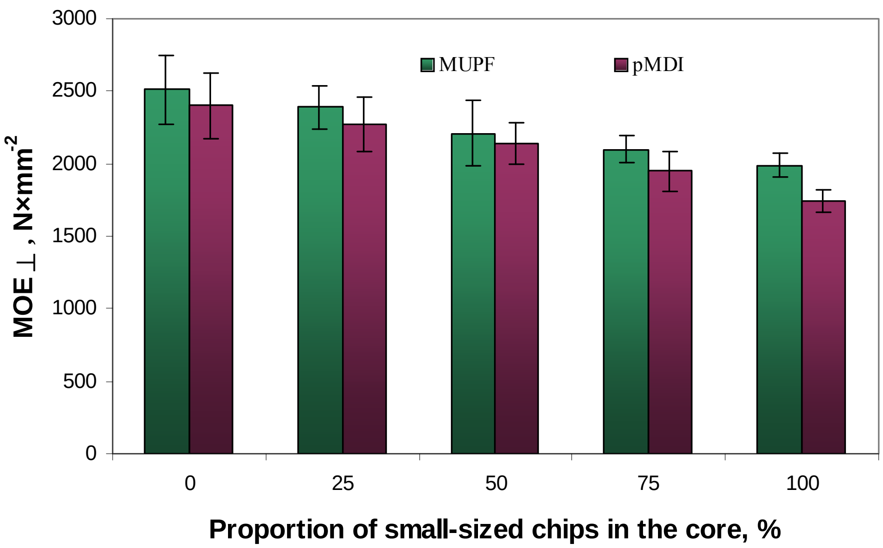

Fig. 5. Modulus of elasticity of manufactured OSB determined for the smaller axis

The internal bond values of boards are given in Fig. 6. As shown by the presented data, the strength of control boards (100% flakes) was around 0.45N·mm^{-2} for boards resinated with MUPF and 0.65N·mm^{-2} in case of boards resinated with pMDI.

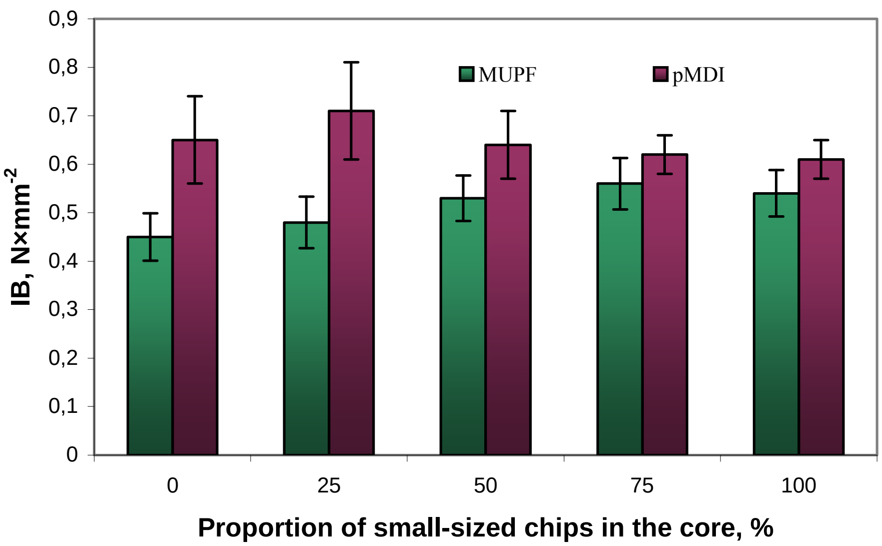

Fig. 6. Internal bond of manufactured OSB

Recorded values for boards resinated with MUPF are comparable with values reported by Paul et al. (2006), while for boards resinated with pMDI they are by 40% lower; however, in both cases recorded values considerably exceeded requirements of the applicable standard. Substitution of flakes with small chips results in an improvement of internal bond. Thus, in case of boards resinated with pMDI the highest IB value was found at a 25% substitution, while for boards resinated with MUPF it was at 75%. In both cases a further increase in the share of small chips causes a reduction of strength, but even at a 100% substitution it was still higher than the requirements of the standard, whereas in case of boards resinated with MUPF it was even higher than that recorded for control boards. However, it needs to be remembered that with an increase in the share of small chips in the core the degree of resination of this layer was proportionally increased. The results of testing for OSB after the boiling test were different (Fig. 7). Internal bond of boards after the V100 test in case of boards resinated with pMDI decreased systematically with an increase in the share of small chips in the core, while in case of boards resinated with MUPF resin this strength increased. However, even if at a 100% substitution boards resinated with pMDI still met the requirements of the standard, for boards resinated with MUPF the recorded results were as low as 40% required values. A similar trend was also observed by Paul et al. (2006).

Generally the density profile for all boards assumes the classical U shape. There are no significant differences either between profiles containing different amounts of small chips or resinated with different binding agents. Migration of small chips resinated with pMDI, observed during mat forming, was not seen in selected samples, since for both types of resination and a 50% share of small chips the density profiles take almost identical shapes. Only slight differences may be observed for boards resinated with pMDI, containing in the core 100% flakes (control board). In this case the equal humidity the outer and the middle layers of board causes smaller differences in its density, which leads to the density profile flattening.

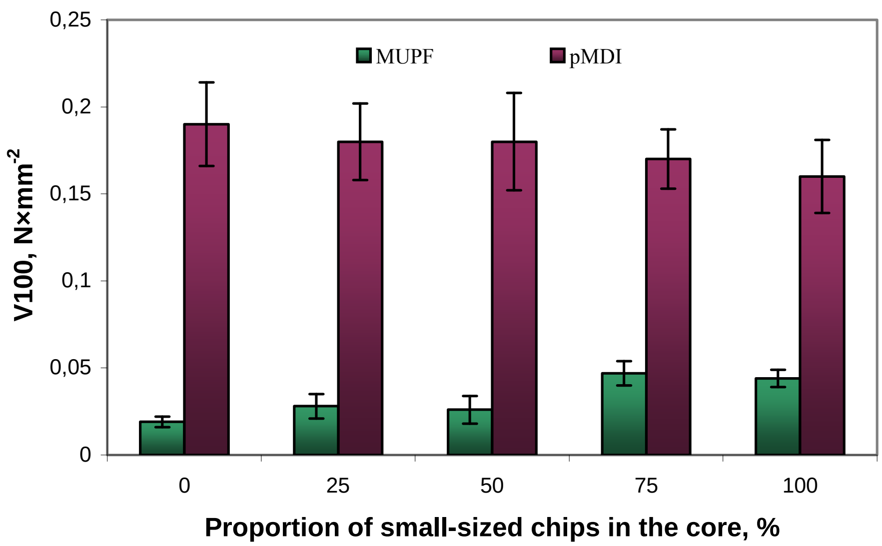

Fig. 7. Internal bond of manufactured OSB after the boiling test

Figures 8 and 9 present density profiles of manufactured OSB containing in their core 0%, 50% and 100% small chips.

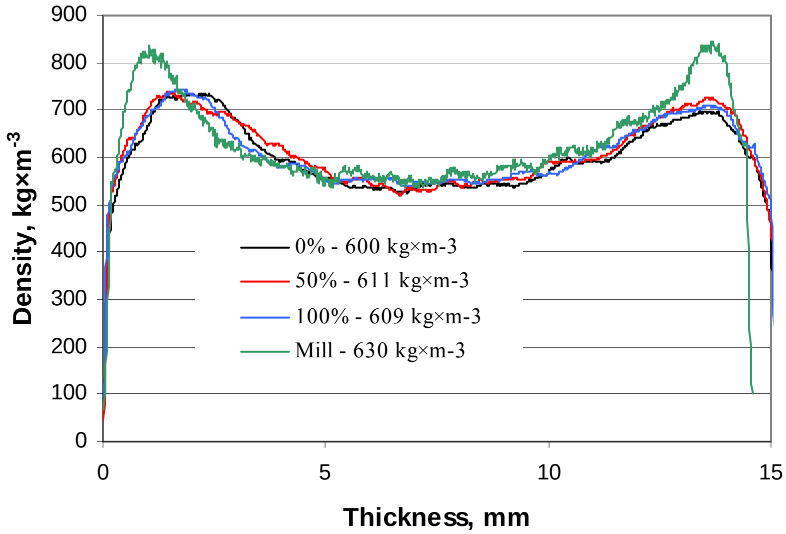

Fig. 8. Vertical density profiles of OSB board glued with MUPF resin

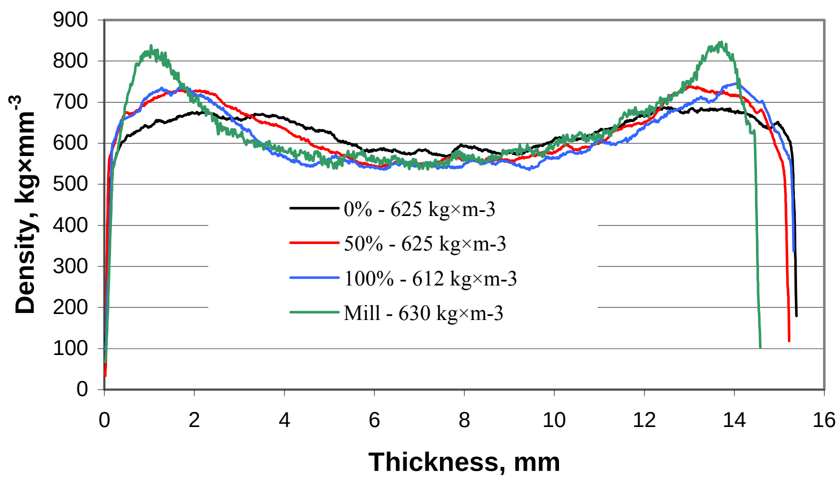

Fig. 9. Vertical density profiles of OSB board glued with pMDI

In turn, when comparing density profiles of manufactured boards with that of commercial OSB of 15mm thickness, resinated in the MUPF/pMDI system (face/core), then under commercial scale production conditions we obtain a density profile characterized by considerably much higher values of density in the face layers, which is probably a result of maximum pressure being reached faster, as well as a better plasticity of the material, resulting from the use of continuous presses.

CONCLUSIONS

1. All the manufactured OSBs are characterized by high mechanical strength, other than the boards resinated with MUPF, which exhibited slightly lower values.

2. The presence in the core of small chips does not affect the bending strength and modulus of elasticity determined for the longer axis. Irrespective of the share of small chips, these properties are found to be at the level of reference boards.
3. The significant effect of the core structure may be observed when analyzing strength and modulus of elasticity determined for the shorter axis. In this case a 100% substitution of flakes with chips in the core results in a reduction of MOR by approx. 40%. Still the recorded values both for MOR and MOE are higher than requirements of the standard EN 300.
4. The applied modification significantly affected internal bond. Here the initial strength increased with an increase in the share of small chips, and after reaching a certain maximum it decreased slightly. However, the recorded values are still higher or comparable with values found for control boards.
5. The applied resination rates make it possible in case of boards resinated with pMDI to obtain, irrespective of the amount of small chips in the core, values exceeding the requirements of the standard in relation to moisture resistance. The decision not to apply any hydrophobic agents in the manufacture of OSB resulted in a situation when the recorded values for swelling in thickness were almost 2 times higher than those recommended by the standard. However, also in this case the application of small chips in the core did not result in a deterioration of hydrophobic properties of boards; thus it may be inferred that the application of e.g. paraffin emulsions in the production process will make it possible to decrease their swelling in thickness.
6. Thus it seems that even a 100% substitution of flakes with chips typically used for the particleboard core will make it possible to manufacture, under commercial scale production conditions, OSB meeting the requirements for boards carrying loads to be used in the environment with moderate humidity both in the interior and outside (OSB/3).

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