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FURNITURE PANELS WITH THE FACE LAYERS MADE OF CHOSEN FIBROUS MATERIALS

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Abstract

The following paper presents the investigations of the possibilities of production of the particleboards with the face layers made from different materials, during single-step hot pressing of the panels. The cross-fibre rattan mat, as well as bamboo stripes were used for panels' face layers. The results have shown that the panels produced in single pressing cycle, with the face layers from mentioned materials, have the mechanical parameters enough to be used for interior equipment, including furniture, for use in dry conditions.

Key words: *particleboard, furniture, rattan, bamboo*

INTRODUCTION

In contemporary furniture industry, a significant share of the used materials are wood-based composites. One of these composites are particleboards. Due to the relatively uniform mechanical properties, a simple processing and a favourable price, compare to other panels, these materials are in the range of interest of furniture manufacturers. Today's trends to cost saving, which works also among the particleboard's producers, results in reducing the density of the panels. Proper strength of particleboards depends mostly on their density (Kowaluk 2009), and hence its reduction, e.g. in order to save raw materials, has limitations. The investigations to reduce the raw materials consumption or apply new, alternative raw materials in particleboards production, as well as modification of the binders (Mamiński et al. 2009) are preferential in wood composites.

The most commonly applied way of finishing the surface of particleboards, to give them the desired performance and aesthetic aspects, is a laminating. Less popular, also because of the cost, is finishing with veneers and other materials of natural origin. Examples of such materials is cross-fiber rattan mat or bamboo lamellas. Both laminating and other finishing methods of particleboards are carried out during a special production process after the hot pressing. Any simplification of technology and the introduction of panels' surface finishing in one cycle, while pressing the chips' mat (Borysiuk et al. 2011), could be beneficial for cost and productivity improvements.

Interesting, from a scientific point of view, would be to investigate the effect of the density of the particleboard with the surface layers made of cross-fiber rattan mat or bamboo stripes on the strength parameters of such composites. Positive test results would

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allow to wide the list of furniture materials, for a new panel material of lower density and attractive surface structure.

The goal of the research was to investigate the possibilities of production of the particleboards with the face layers made from different materials, during single-step hot pressing of the panels. In the range of the research the cross-fibre rattan mat, as well as bamboo stripes were used for panels' face layers.

MATERIAL AND METHODS

To produce the experimental 16-mm thick panels, the industrial softwood particles intended for particleboards' core layers production, were used. The chips were bonded with industrial urea-formaldehyde resin with following parameters: concentration 65%, viscosity 550 mPa s, curing time of the glue 82 s. The 10% water solution of NH_4Cl was used as a hardener. The hardener/resin dry mass ratio was 1:200.

The surface layers were made out from:

- cross-fiber rattan mat, about 1 mm thick, produced from 3 mm width rattan stripes, with density (assumed) about 500 kg/m^3;
- bamboo lamellas, 8-15 mm width, 2 mm thick, with the assumed density about 700 kg/m^3.

The type and chosen parameters of the produced panels are presented in table 1.

Table 1. The basic parameters of the produced panels

	Type of panel					
	0-500	**500B**	**500R**	**0-650**	**650B**	**650R**
Density (assumed) [kg/m^3]	500	500	500	650	650	650
Dimensions [mm]						
length	320					
width	320					
thickness	16	12+2x2	14+2x1	16	12+2x2	14+2x1
Chips' moisture content [%]	3					
Panel moisture content [%]	8					
Resination [%]	10					
Weight of panel [g]	819	614	717	1065	799	932
Weight of chips [g]	710	533	621	923	692	808
Weight of resin [g]	106	80	93	138	103	121
Weight of hardener [g]	3.45	2.59	3.02	4.48	3.36	3.92
Weight of matt [g]	817	615	717	1062	799	933

The chips were blended with glue in laboratory drum blender, where the glue was sprayed onto the chips. After blending the manual forming of the mat was conducted. The formed mat was pre-pressed in cold press. After cold pressing the rattan mat/bamboo lamellas, respectively, were placed on the outside surfaces of the mat. Prior the fixing the rattan mat/bamboo lamellas were subjected covering the surfaces with the same UF glue, with amount of 120 g/m^2. The bamboo stripes were outside layers out of the particleboard oriented. The panels were then pressed in hot press under the following parameters: temperature 180°C, pressing time factor 15 s/mm, maximum unit pressure

2.5 MPa. The control panels (0-500 and 0-650) were hot pressed directly after pre-pressing. The prepared panels were conditioned in normal environment (20°C/65% RH) for 14 days.

Fig. 1. The mat after cold pre-pressing, covered by rattan mat

The following investigations and tests were conducted:

- density profiles,
- modulus of rupture (MOR) and modulus of elasticity (MOE) were according to EN 310 standard,
- internal bond (IB) according to EN 319 standard.

RESULTS AND DISCUSSION

The density profiles of the investigated panels are displayed on fig. 2. Due to the symmetric structure of the panels, half of the thickness is presented only. All profiles presents the typical shape for particleboards, with the highest density close to the surfaces and lowest density near the middle of the panel. In case of panels with the lower assumed density (500 kg/m^3), the presence of the rattan mat (500R) causes the decrease of the density of the outside layers, and higher density on the chips/rattan mat border. The density decline can be caused by incorrect assumption of the density of the rattan mat, which can be in fact lower than assumed. The reason of the increase of the density between rattan mat and chips' mat can be the presence of the glue, which could intensify the densification of mentioned area under higher temperature and pressure during hot pressing. In case of panels with higher assumed density (650) and rattan mat surface layers, the presence of the rattan mat lowering the density of the surface layers (compare panels 0-650 and 650R). The particleboards' surface layers made from bamboo stripes (500B and 650B) causes the significant increase of the surface layers' density. It can be caused by higher density of the outside layers of the bamboo stripes. For panels with the face layers made from rattan mat, with the increase of the density of panels', the higher diversity of the core and face layers' density occurs.

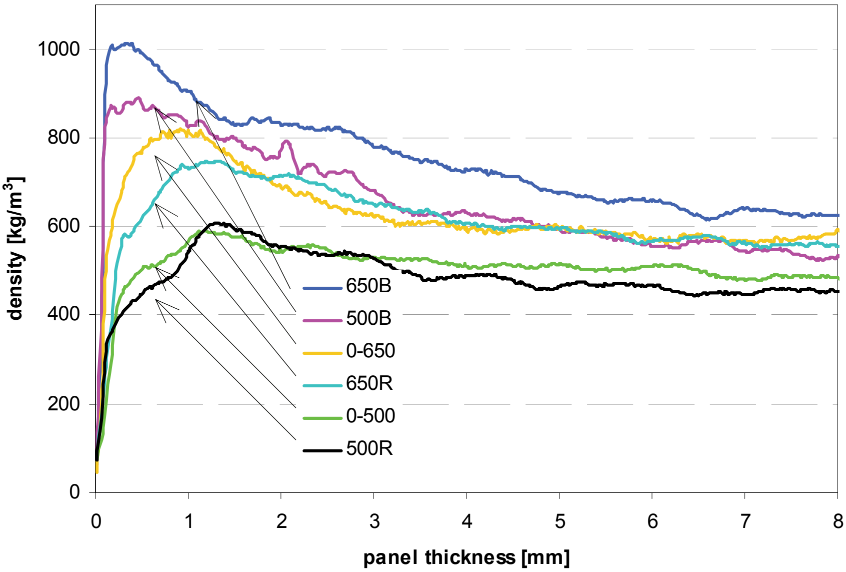

Fig. 2. The density profiles of the investigated panels (half thickness displayed)

The results of the modulus of elasticity measurement are presented on fig. 3. In case of panels with bamboo surface layers, the modulus of elasticity was measured during bending of the samples along (II) and across (#) the grain. As it is displayed, the panels with the surface layers made from bamboo, tested along the grain, have the highest modulus of elasticity. The MOE of the 500BII panel was over 6 times higher than for the panel without bamboo (0-500), and, similarly, the MOE of the 650BII panel was about 4.4 times higher than for the panel 0-650. The differences between the MOE for the panels 500BII and 650BII was about 27%, what means that in case of modulus of elasticity the influence of the surface materials was higher than the influence of the assumed density. According to Wilczyński and Kociszewski (2010) the elastic moduli of the particleboard layers are not proportionate to their densities. Such high values of modulus of elasticity for panels with bamboo stripes bended along the grain are caused by high modulus of elasticity for bamboo. According to Amada and Untao (2001), MOE for bamboo is in the range of 11 000-17 000 N/mm^2, compare to 6 500 – 8 800 N/mm^2 for pine.

When bending the panels with bamboo stripes, which were oriented across the sample, the modulus of elasticity was lower than for the control panels. The reason was the absence of the bonding lines along the stripes. The increase of the modulus of elasticity of the panels with the surface layers made from cross-fiber rattan mat was 46% for the panel 500R compare to the control panel (0-500) and 47% for the panel 650R compare to 0-650. In case of rattan mat the increase of the panel density from 500 to 650 kg/m^3 cause the 71% MOE increase.

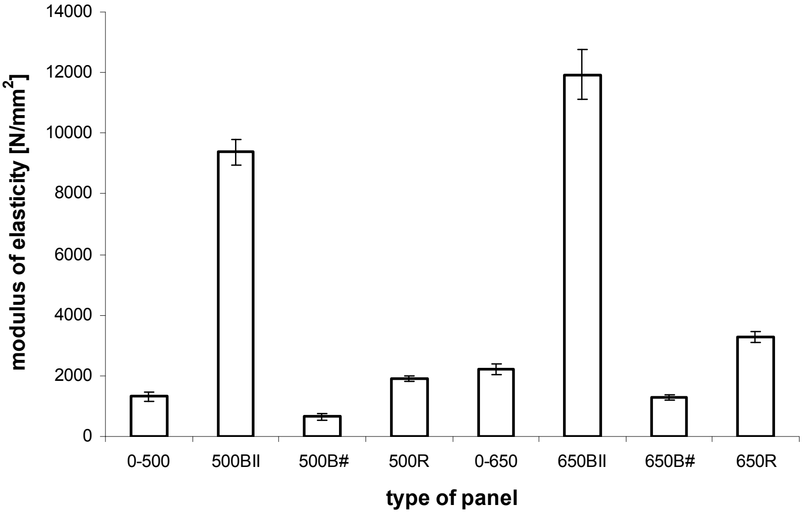

Fig. 3. The values of modulus of elasticity of investigated panels

The results of modulus of rupture (MOR) measurement, which are displayed on fig. 4, presents the similar dependencies as they were described in case of modulus of elasticity. Over 10 times higher MOR (compare to 0-500) for the panels with lower density and bamboo stripes (500BII) was observed, and similarly, 5 times higher MOR for panel 650BII compare to 0-650. The increase of the panel's density from 500 to 650 kg/m^3 causes 60% MOR increase for bamboo panels with stripes along the sample, and, 27% increase for panels with rattan mat (500R and 650R). The bending strength of the samples with bamboo stripes oriented across the sample was almost the same in case of panels 0-500 and 500B#, and decreased for panel 650B# compare to 0-650. The presence of rattan mat causes the 200% increase of the MOR value for panels 0-500 and 500R, and 30% increase for panel 650R compare to 0-650.

The interesting can be the type of damage of the bended samples of the panels with the bamboo stripes along the sample. As it is presented on fig. 5, there is no damage of the bottom layer, as it is typical for the bended materials, e.g. commercial 3-layer particleboards. The reason of the damage of the sample presented on above mentioned figure was shear forces located between support and force transmitter. Due to the panel's maximum shear strength exceeding, the sample was delaminated. According to Zou et al. (2009), bamboo is highly organized multiscale structured composites designed to be extraordinary tough while remaining hard and strong.

When investigating the cross-cut of the panels with bamboo stripes, the longitudinal cracks of the stripes are visible (fig. 6). Such cracks may occur due to the hot pressing schedule, where the press pressure was added before the higher temperature plasticized the layers of the bamboo stripes distant from the surface.

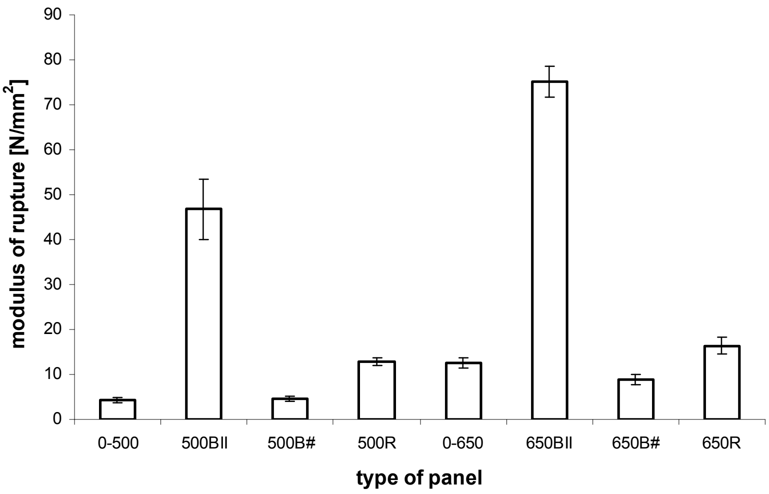

Fig. 4. The modulus of rupture of investigated panels

Fig. 5. The damage of the panel with bamboo stripes

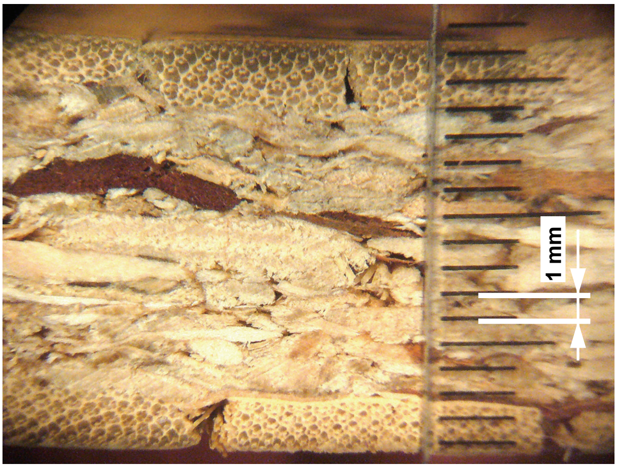

Fig. 6. The longitudinal cracks of bamboo stripes (top of the picture)

The results of the internal bond measurement for investigated panels are presented on fig. 7. According to this figure, the lowest IB was for control panel 0-500. It is important to add that the density of this panel, especially in core layer (fig. 2), was one of the lowest. The influence of the density on the internal bond can be confirmed by the higher internal bond of the panel 0-650. The presence of the different materials on the surface layers of the panels did not significantly influence on the internal bond of the investigated panels.

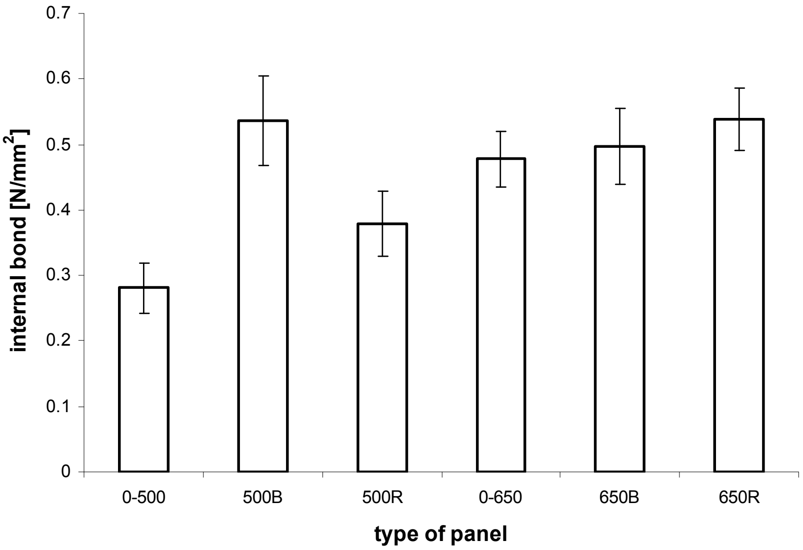

Fig. 7. The internal bond of panels with surface layers made of fibrous materials

On the basis of results of measured MOE, MOR and IB it can be concluded, that the panels with the surface layers made from rattan mat fulfils the requirements of the EN 312:2010 standard for boards for interior fitments (including furniture) for use in dry conditions. According to mentioned standard, the following requirements should be fulfilled: modulus of rupture minimum 11 N/mm^2, modulus of elasticity in bending minimum 1600 N/mm^2 and internal bond minimum 0.35 N/mm^2. In case of the panels with the surface layers from bamboo stripes, only the panels with the stripes oriented along the sample meet the above mentioned requirements for MOE and MOR.

CONCLUSION

The following conclusions and observations can be formulated on the basis of conducted research:

1. With the increase of the density of panels' with cross-fiber mat surface layers, the higher diversity of the core and face layers' density occurs.

2. The application of rattan mat for the face layers of the particleboards significantly improves the modulus of elasticity and modulus of rupture of the panels made of them.
3. The modulus of rupture and modulus of elasticity of the panels with the surface layers made of bamboo stripes is higher than for the panels with comparable density and without such surfaces, when measured during bending the samples with bamboo stripes along the samples.
4. There is no significant influence of the type of particleboards' surface layers on the internal bond of them.
5. The panels with density 500 kg/m^3 and higher, with the surface layers made of rattan mat and bamboo stripes, in the range of measured values, fulfils the requirements of EN 312:2010 standard for the panels for interior equipment, including furniture panels, for use in dry conditions (with the exception of bamboo panels with the stripes across the panel).
6. There is a technically justified possibility to produce the panels, in single hot pressing cycle of the mat, connected to simultaneous surface' finishing by rattan mat or bamboo stripes.

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