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Particleboard with addition of SBR rubber granules in the core layer

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Abstract: *Particleboard with addition of SBR rubber granules in the core layer.* The aim of study was to investigate a possibility of using the SBR ruber granulate as an addition to core layer of particleboards glued with UF resin. As part of the work there were made particleboards with density 650 kg / m^3, thickness 16 mm and weight fraction of granules SBR in the core layer: 0%, 10%, 20% and 30%. The prepared boards were examined for density and density profile, MOR, MOE, IB, swelling and water absorption after 2 and 24 hours of soaking in the water. The results showed that introduction of the granulate to the core layers of three layer boards deteriorate the mechanical properties of the particles, and improves (reduce) the swelling of the thickness after soaking in the water.

Keywords: SBR rubber granules, particleboards, properties of boards

INTRODUCTION

One of the main directions of development of wood-based materials is searching for new sources of raw materials, including non-wood materials. In this regard, studies often concern the possibility of using recycled post-consumer materials. One of such wastes, undoubtedly are worn tires, which number increases year by year. At the conference of European Tyre Recycling Association (ETRA) in 2007 was reported, that in 27 EU Member States is consumed more than 300 million tires every year (www.prnewswire.co.uk). One of the main products of used tires recycling is granulate. In 2003 granulates accounted 63% of recycled tires, wherein the production capacity of granulates was about 40% higher than the demand (Gronowicz and Kubiak 2007). SBR granulate is used for the manufacture of sports surfaces, asphalt enriched granules, element for vibration isolation and damping vibration, elements for sound insulation, road safety elements, etc. (Sybilski 2009). Within the research on expanding the possibilities of use comminuted tires, the attempts of their application in the production of wood-based panels were made. Ayrilmis et al. (2009a, 2009b) have shown that there is a possibility of adding the SBR granulate up to 10% to OSB to general purpose of glued pMDI. At the same time the authors studying particleboard with the addition of SBR granulate glued with pMDI and MUF, found that the mechanical properties decrease with the addition of waste rubber. Similar results were reported by Xu and Li (2012) investigating the possibility of particleboard production with addition of waste rubber with a greater fragmentation and glued with pMDI. However, the authors showed a positive effect of rubber addition to reduction of swelling the plates. Yang et al. (2004) as a result of the study boards produced from straw and waste tires glued with pMDI, have found that the boards are characterized by mechanical properties approximately as similar as boards made of wood chips and waste rubber. Zhao et al. (2008) considering process of production a larch particleboards with the addition of waste tires, glued with pMDI / UF adhesive, have found that with a thickness of 12 mm, density 1000 kg / m3 and the weight fraction of 40% of the gum, an optimal compression parameters are: pressure - 4 MPa, temperature of - 170 ° C, time - 300 seconds. Manufactured composites were characterized as compared to wood and particleboard preferred parameters of acoustic insulation (Zhao et al. 2010). Terzi et al. (2009)

studying the particleboards prepared with the addition of pieces of portioned tires have found that the addition of gum did not affect on reduction of susceptibility to fungi and termites.

In the studies carried out already, authors used the addition of comminuted tires in the entire volume particleboards glued with pMDI or MUF. The density of thus produced boards often reached to 1000 kg / m3. In the present study consider the effect on selected properties of three-layered particleboards glued with UF and with additive of SBR rubber granules (derived from comminuted used tires), whereby it was fed only to the core layer.

MATERIALS AND METHODS

For this study were prepared three-layer particleboards with parameters: 16mm thickness, density 650 kg/m³, containing in the core layer 0% by weight the (control option), 10%, 20% and 30% addition of SBR rubber granulates. The participation of the surface and core layers: 50%. As raw materials were used industrial particles applied to surface and core layer of moisture 7% and 5%, and rubber granulates with a density 1550 kg/m³ and a particle size fraction 1.0 - 3.0 mm, obtained by fragmentation of the tire. UF resin was used with 10% NH_4Cl solution as a hardener, and glue content: 10% surface layer and 8% the core layer. Selected properties of the resin are shown in Table 1. Pressing parameters were as follows: the maximum specific pressure 2.5 MPa, temperature 180 ° C, pressing time 288 s.

After production the boards were conditioned under laboratory conditions over 7 days, and then tested to: density according to EN 323; density profile with a device GreCon, MOR and MOE according to EN 310, IB according to EN 319, swelling and water absorption after 2 and 24 hours, according to EN 317.

Determination of each tested properties was performed on 10 samples, selected against density (± 5% deviation of assumed average density). Results were statistically evaluated by T-Student test at the significance level α=0,05 / level of 95%.

Table 1. Characteristics of the UF resin

Property	Value
pH	7 - 9
density, kg/m³	1270 - 1310
the viscosity not more than, mPa·s	400 - 600
gelation time, s	90
dry weight, %	74

RESULTS

Test results of particleboards with the addition of SBR rubber granules in the core layer are shown in Fig. 1 as well as in Tables 2 and 3.

Table 2. Results of particleboard mechanical tests

Content of granulat SBR	Density	MOR	MOE	IB
	kg/m³	N/mm²	N/mm²	N/mm²
0%	665 (21)	13.5 (1.0)	2469 (316)	0.52 (0.07)
10%	661 (24)	9.9 (1.3)	1559 (197)	0.15 (0.04)
20%	640 (37)	7.6 (1.2)	1145 (149)	0.12 (0.02)
30%	584 (15)	4.1 (1.3)	979 (344)	0.02 (0.01)

*values in parentheses are standard deviations

Generally it can be concluded, that addition of SBR granules to the core layer of particleboard (in the range of 10 - 30%) affects statistically significant decrease of their mechanical properties (Table 2). Similar results were obtained by Ayrilmis *et al.* (2009a, 2009b), and Xu *and* Li (2012), wherein authors used pMDI or MUF adhesives. The decline in the value of the strength properties of the tested boards were resulted from the imposition of two factors: lower density and lower adhesion to particles SBR granulates of UF resin. In Fig. 1 are shown examples of density profiles manufactured boards. Each variant had typical, similar to the "U" - shaped density profile. However, there was clearly visible increase of the boards thickness (up to 2 mm in relation to the control variant) with the increase of SBR granulates content, what was reflected by mentioned decrease in density (Table 2). The increase in board thickness due to recompression phenomenon of elastic SBR granulates after pressing process. During pressing process heated rubber compressed (volume deformation), as the result boards of established thickness were obtained. After the cessation of pressure occurred re-deformation of SBR granulate and what caused the return to its original shape. This phenomenon is accompanied by a relaxation of the internal structure of the boards, which was reflected in a decrease IB value. Its contribution in the phenomenon had also the poor wettability of the rubber surface by the UF resin, what caused that joints between the particles of the granules and wood particles were characterized by a significantly lower strength than those arising between the wood particles. Considering the strength parameters studied particleboards it is worth to add that also Wilkowski et al. (2014) have found that the addition of SBR rubber granules results in a significant improvement in machinability boards associated with the cutting resistance during drilling.

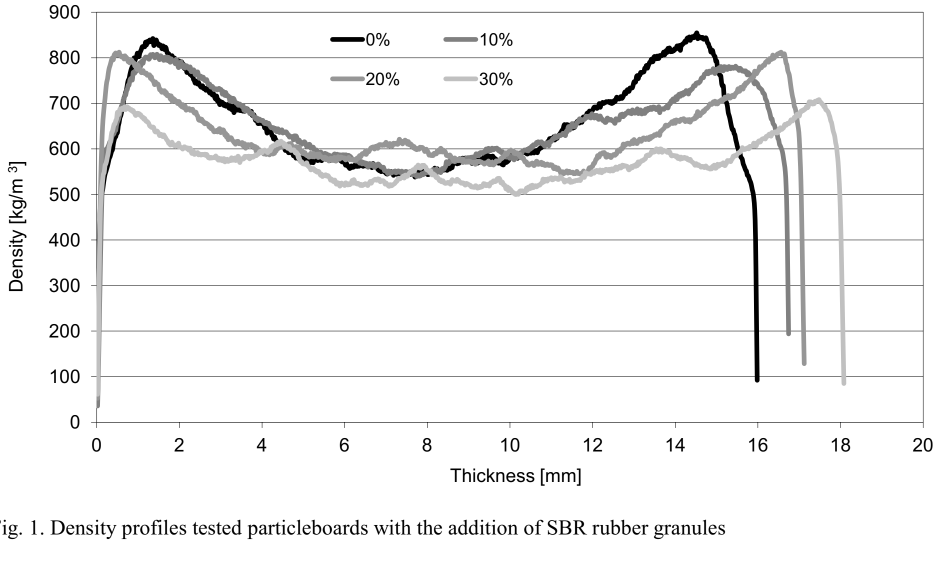

Fig. 1. Density profiles tested particleboards with the addition of SBR rubber granules

Table 3. Summary of physical test results manufactured boards

Content of granulat SBR	Thickness swelling		Absorbability	
	2 h	24 h	2 h	24 h
	%	%	%	%
0%	24.3 (2.2)	30.3 (3.3)	76.7 (7.8)	88.3 (6.5)
10%	32.3 (1.2)	38.3 (2.3)	92.3 (6.6)	195.4 (8.7)
20%	17.1 (1.2)	20.0 (1.4)	67.9 (7.7)	175.5 (12.5)
30%	14.4 (1.0)	16.5 (1.9)	67.7 (5.2)	158.6 (6.5)

*values in parentheses are standard deviations

Considering the physical properties of the tested boards it should be noted that the additive SBR granules preferably affected a decrease in swelling of the boards by up to 40% (in the case of the variant of containing 30% of SBR granulate) relatively to control variant. A similar effect of swelling decrease with increasing rubber content in particleboards also obtained in their study, Xu and Li (2012). Among the variants tested only for boards with 10% granulate was an increase in swelling compared to control variant. The decrease in swelling of the boards resulted from both the hydrophobic properties of rubber, as well as the already mentioned relaxation of the internal structure of the boards (increase of porosity), what caused that the wood particles inside the boards had a greater freedom to swelling. The relaxation of the structure of boards and increase in the porosity provides also an increase in the water absorption. After 24 h of soaking the absorption was about 100%. Some noticeable limitation wettability between variants is associated with an increase in the content of SBR granulate, which does not absorb water.

Considering obtained results (decrease of strength and swelling with the increase of SBR granule content), it can be assumed that produced boards (with 10 – 20 % of SBR content) could be used as components of products which do not carry the load and could be periodically exposed to higher humidity air (eg. the filling elements bathroom furniture).

CONCLUSIONS

Based on the studies on the possibility of using SBR granular rubber (in an amount of 10%, 20% and 30%) as a substitute for wood particles in the middle layer of three layer particleboard glued with UF resin, it was found that:

1. The addition of SBR granulated rubber (in an amount of 10 - 30%) for the core layer of particleboards causes a significant decrease in the strength properties of the boards (MOR, MOE, IB) glued UF resin ;
2. Increase additive SBR rubber granulate to the core layer of particleboard cause density decrease associated with the board re-deformation after pressing process (increase in thickness);
3. The increased additive SBR rubber granulate to the core layer of particleboards statically significant affects to increase of water absorption after 24 hours soaking in water;
4. Increasing the additive SBR rubber granulate to the core layer particleboards in an amount of 20% and 30% affected in a statistically significant decrease in the swelling of the thickness after 24 hours soaking in water (compared to the control boards and containing 10% of the addition of SBR granules).

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Streszczenie: *Płyty wiórowe z dodatkiem granulatu kauczukowego SBR w warstwie środkowej*. Celem pracy była próba wykorzystania granulatu kauczukowego SBR jako dodatku do warstwy wewnętrznej płyt wiórowych zaklejonych żywicą UF. W ramach pracy wytworzono płyty wiórowe o gęstości 650 kg/m^3 i grubości 16 mm oraz udziale wagowym granulatu SBR w warstwie środkowej: 0 %, 10 %, 20 % i 30 %. Dla wytworzonych płyt zbadano gęstość i profil gęstości, MOR, MOE, IB, spęcznienie i nasiąkliwość po 2 i 24h moczenia w wodzie. Ogólnie stwierdzono, że wprowadzenie granulatu do warstw wewnętrznych płyty trójwarstwowej spowodowało pogorszenie ich właściwości mechanicznych, oraz poprawę (ograniczenie) ich spęcznienia na grubość po moczeniu w wodzie.

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