Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 82, 2013: 95-99
(Ann. WULS - SGGW, For. and Wood Technol. 82, 2013)

Particleboards with the addition of cenosphere

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Abstract: *Particleboards with the addition of cenosphere.* The aim of this study was to determine the influence of the addition of cenosphere to the middle layer of three-layer particleboard on it's properties. As a part of work, particleboards with density of 600 kg/m^3, thickness of 16 mm and a weight fraction of cenosphere in the middle layer: 0, 5, 10, 15 % were prepared. Manufactured boards were tested for the density and density distribution, MOR, MOE, IB, swelling and water absorption after 2 and 24 hours soaking in water. It was observed, that the addition of cenosphere in amount of 5 % to the inner layer does not significantly affect the MOR and MOE of boards. Particleboards manufactured with the addition of cenosphere in the range of 5 – 15 % to the inner layer, meet the strength requirements according to the standard PN-EN 312 with respect to particleboard type P2.

Keywords: cenosphere, particleboards, properties of boards

INTRODUCTION

Particleboards with addition of mineral agents are one of the directions of development of wood-based materials mainly intended for use in the construction industry. One of the main reasons for introducing mineral additives to wood-based materials is increasing their resistance to fire (Kozłowski *et al.* 1999, Okino *et al.* 2005, Qi *et al.* 2006, Giancaspro *et al.* 2008, Mamiński *et al.* 2011). One of the disadvantages of wood-mineral materials is their density, which often exceeds 1000 kg/m^3. For this reason, it may be beneficial to use cenosphere, called light mineral filler. Cenosphere is a granular fraction of fly ash, which is by-product of coal combustion. The main components of cenosphere are: SiO_2, Al_2O_3, Fe_2O_3, MgO, K_2O, CaO. Particles of cenosphere have a shape similar to a sphere with a diameter of 10-800 μm and wall thickness of 2-10 μm. Inside they are filled with gases generated by the combustion of coal, primarily CO_2, N_2. The main advantages of cenosphere include low bulk density, low water absorption, low thermal conductivity, high temperature resistance (Petri, Pichór 2003).

Within this study an attempt was made to evaluate the impact of addition of cenosphere, as light mineral filler, to the middle layer of three-layer particleboard on selected properties of these boards.

MATERIAL AND METHODS

In the study three-layer particleboards with a thickness of 16 mm and density of 600 kg/m³ were prepared, containing in the middle layer addition of cenosphere by weight 0 % (control variant), 5 %, 10 %, and 15 %. As a raw material, industrial chips for inner and outer layer with moisture content 6% and 4% and cenosphere were used. Properties of cenosphere are shown in Table 1. MUPF adhesive was used for glueing. Amount of glue was: 12 % for outer layer, 10 % for inner layer. Parameters of boards pressing were as follows: maximal specific pressure 2,5 MPa, temperature 180°C, time of pressing 288 s.

After manufacturing of boards, they were conditioned under laboratory conditions for seven days and then their properties were tested: density, according to EN 323, density distribution through GreCon device, MOR and MOE according to EN 310, IB in accordance to EN 319, swelling and water absorption after 2 and 24 according to EN 317.

Determination of each tested property was performed on 10 samples, selected against density (± 5% deviation of assumed average density). Statistic significance of differences was determined on the basis of T-Student test for the confidence level of 95%.

Table 1. Physical properties of cenosphere fractions 125÷250 μm (Petri, Pichór 2003).

Characteristic	Value
Bulk density, kg/m^3	391 ± 0.6
Density of the wall's material, kg/m^3	2432 ± 0.4
Melting temperature, ºC	~ 1650
Thermal conductivity coefficient at 23ºC, W/mK	0.107 ± 0.002
Specific surface according to Blaine, cm^2/g	~ 500
thickness of cenosphere's wall, μm	2 ÷ 10

Table 2. Properties of MUPF resin

Characteristic	Value
pH	8 - 9
Density, kg/m^3	1295 - 1300
viscosity of no more than, mPa·s	250 - 400
gel time, s	80 - 100
dry mass, %	64 - 65
miscibility with water	0.6 – 0.8

RESEARCH RESULTS

Test results of boards with the addition of cenosphere in the inner layer are shown in Figure 1 and in Tables 3 and 4.

Table 3. Compilation of mechanical tests results of manufactured boards

Content of cenosphere	Density	MOR	MOE	IB
	kg/m³	N/mm²	N/mm²	N/mm²
0%	621 (24)	14.5 (1.8)	3027 (231)	0.69 (0.11)
5%	623 (19)	15.1 (1.5)	2975 (262)	0.39 (0.09)
10%	601 (16)	13.2 (1.8)	2196 (314)	0.42 (0.03)
15%	608 (17)	13.7 (1.1)	2071 (267)	0.43 (0.05)

*values in parentheses are standard deviations

Table 4. Compilation of physical tests results of manufactured boards

Content of cenosphere	Thickness swelling		Absorbability	
	2 h	24 h	2 h	24 h
	%	%	%	%
0%	7.4 (0.7)	10.2 (1.0)	36.4 (2.7)	43.9 (1.5)
5%	9.4 (0.5)	11.4 (0.4)	39.9 (2.1)	43.2 (1.2)
10%	8.6 (0.6)	10.6 (0.5)	40.6 (2.5)	44.5 (1.3)
15%	7.4 (0.7)	10.0 (0.4)	37.2 (2.2)	44.6 (1.8)

*values in parentheses are standard deviations

Generally it can be stated that the addition of cenosphere to the inner layer of particleboard (in the range of 5 - 15%) affects in decrease of their mechanical properties (Table 3). However it should be noted, that this decrease with respect to the MOR value, although visible, is not statistically significant. With regard to the MOE, only addition of cenosphere in the range of 10 – 15 % resulted in a statistically significant decrease in the average value of 30 %. For IB value, regardless of the amount of inserted cenosphere (5 – 15 %) there was a statistically significant decrease in the strength of an average of 40%, when compared to the variant without cenosphere. This decrease is directly related to the introduction of fine cenosphere particles to the board structure, with much larger specific surface area than chips. With regard to the strength value of boards, it should be noted that despite their decrease, the results meet the strength requirements for the boards type P2 (according to EN 312). The addition of cenosphere to the middle layer of particleboard was also reflected in the density distribution, with increasing content of cenosphere decrease in density variation of outer and inner layers was observed (Fig. 1). Decrease in the density of the outer layers of boards, with an increase in the share of cenosphere was reflected in a decline in the value of the previously discussed MOR and MOE.

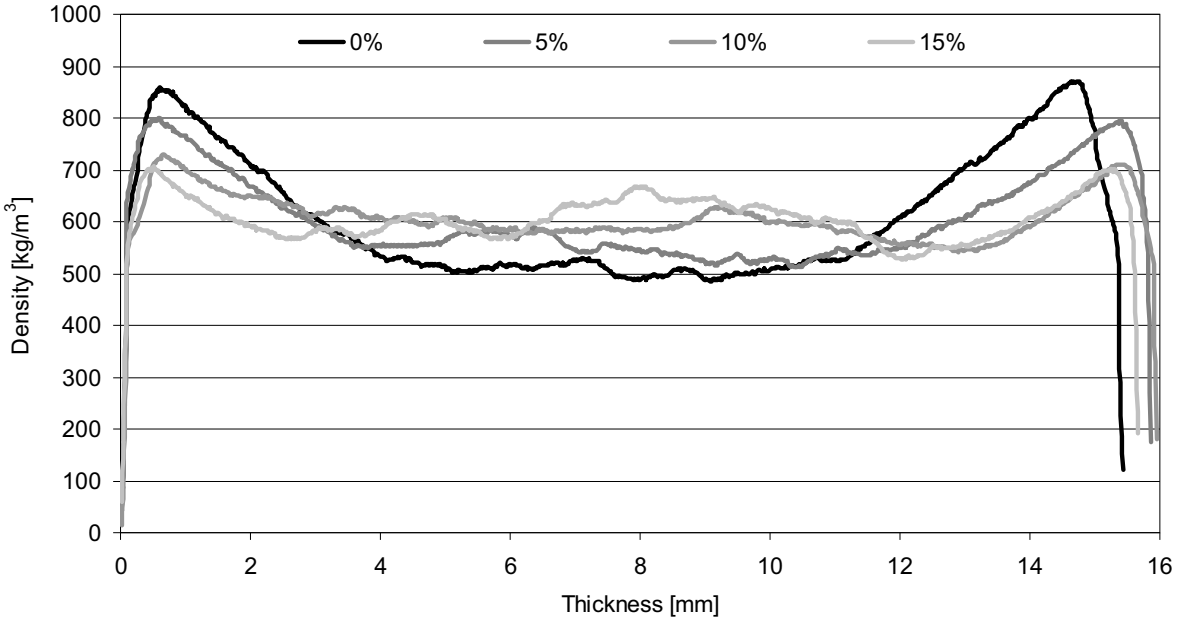

Fig. 1. Density distribution of tested particleboard with the addition of cenosphere

Manufactured boards with the addition of cenosphere characterized by a comparable or higher values of swelling and water absorption, especially for short-term soaking in water (2 h) (Table 4). Differences between swelling and water absorption after 24 h of soaking in water were generally in all variants statistically insignificant. On this basis, it can be stated that the addition of cenosphere in a tested range of 5 – 15 % does not affect long-term changes in the board's resistance to moisture.

CONCLUSIONS

On the basis of the research of particleboard with the addition of cenosphere in the middle layer (in the range 0 – 15 %), the following conclusions can be drawn:

1. Cenosphere can be used as an addition to the middle layer of three-layer particleboard, while its share should not exceed 5% by weight.

2. Addition of cenosphere in an amount of 5% (by weight, in relation to absolutely dry chips) does not affect the value of MOR and MOE. A further increase in the content (up to 10 and 15%) affects on a decrease in mentioned strength properties.
3. Addition of cenosphere independently of its share affects IB values of particleboard.
4. Increasing share of cenosphere affects equalization of density distribution in cross-section of boards, while preserving similar average density.
5. Generally, addition of cenosphere does not modify hydrophobic properties of boards in the long-term wetting (24 h), when compared to the control boards without the addition of cenosphere.

REFERENCES

1. EN 310:1994 Wood-based panels - Determination of modulus of elasticity in bending and of bending strength
2. EN 312: 2005 Particleboards - Specifications
3. EN 317:1999 Particleboards and fibreboards - Determination of swelling in thickness after immersion in water
4. EN 319:1999 Particleboards and fibreboards - Determination of tensile strength perpendicular to the plane of the board
5. EN 323: 1999: Wood-based panels – Determination of density
6. GIANCASPRO J., PAPAKONSTANTINOU C., BALAGURU P., 2008: Fire resistance of inorganic sawdust biocomposite. Compos Sci Technol 68: 1895–1902
7. KOZLOWSKI R., MIELENIAK B., HELWIG M., PRZEPIERA A., 1999: Flame resistant lignocellulosic-mineral composite particleboards. Polym Degrad Stabil 64: 523–528,
8. MAMIŃSKI M. Ł., KRÓL M., JASKÓŁOWSKI W., BORYSIUK P., 2011: Wood-mineral wool hybrid particleboards**.** European Journal of Wood and Wood Products, Vol. 69, 2, 337-339
9. OKINO EYA., DE SOUZA RM., SANTANA MAE., DA S. ALVES MV., DE SOUSA ME., TEIXEIRA DE., 2005: Physico-mechanical properties and decay resistance of Cupressus spp. cement-bonded particleboards. Cement Concrete Comp 27: 333–338
10. PICHÓR W., PETRI M., 2003: Właściwości mikrosfer pozyskiwanych jako uboczny produkt spalania węgla kamiennego. Prace Komisji Nauk Ceramicznych PAN, Ceramika / Ceramics, 80, 705-710.
11. QI H., COOPER PA., WAN H., 2006: Effect of carbon dioxide injection on production of wood cement composites from waste medium density fiberboard (MDF). Waste Manage 26: 509–515

Streszczenie: *Płyty wiórowe z dodatkiem cenosfery*. Celem pracy było określenie wpływu na właściwości trójwarstwowych płyt wiórowych dodatku do warstwy środkowej cenosfery. W ramach pracy wytworzono płyty wiórowe o gęstości 600 kg/m^3 i grubości 16 mm oraz udziale wagowym cenosfery w warstwie środkowej: 0, 5, 10, 15 %. Dla wytworzonych płyt zbadano gęstość i profil gęstości, MOR, MOE, IB, spęcznienie i nasiąkliwość po 2 i 24h moczenia w wodzie. Stwierdzono, że dodatek cenosfery w ilości 5 % do warstwy środkowej nie wpływa istotnie na MOR i MOE płyt. Płyty wiórowe wytworzone z dodatkiem do warstwy wewnętrznej cenosfery w zakresie 5 – 15 % spełniają wymagania wytrzymałościowe według normy PN-EN 312 w odniesieniu do płyt wiórowych typu P2.

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