THERMALLY MODIFIED PARTICLES AS RAW MATERIAL FOR PARTICLEBOARDS PRODUCTION

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Abstract

The study compared the physical and mechanical properties of single layer particleboard made from thermally modified particles to particleboard from unmodified particles. Materials to particleboard were acquired industrially as particles for the core layer. Modification and the production of particleboard were performed in the laboratory condition. During the modification particles used smooth treatment parameters to significantly reduce the potential decrease in strength properties of the raw material. It was find that the short-term (2 h) thermal modification of particles allows their use as raw material in the production of particleboard glued with UF resin. Particleboard made of modified particles compared to the particleboard made of unmodified particles had lower MOR and IB and higher MOE. However particleboards produced from thermal modified particles compared to particleboard made of unmodified particles showed less swelling of the thickness and a lower water absorption (after 2 h and 24 h soaking in water), while the greater variation results were recorded at the short soaking.

Key words: *particleboard, thermal modification, strength properties, physical properties*

INTRODUCTION

Thermal treatment is one of the possibility to modify of wood properties (ThermoWood Handbook 2003, Hill 2006). The visual effect of this process is to change the color of the material. At the same time the material obtained suitable physical properties associated with increased resistance to moisture (Niemz *et al.* 2010). To the negative effects of thermal modifications include the generally more brittle of wood and increased susceptibility to cracking (Hill 2006, Yildiz *et al.* 2006). The final material properties depend mainly on the heat treatment process. Currently, the thermally modified wood is industry produced and its use is increasing. Along with this trend, there is also more and more waste thermal modified wood, which can be used in further processing as raw material for, inter alia, particleboards (Borysiuk *et al.* 2007). In the future also expected to be the appearance of post-consumer thermally modified wood as a raw material for further processing, not necessarily for energy purposes. Particle boards now account for over 60% of all manufactured wood based materials in Europe (Boruszewski 2012).

Such high position influenced by favorable (beneficial) mechanical properties, especially related to the relatively low production costs. All the while there are works on the modification of their physical properties, in particular improved resistance to moisture.

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Industrially for this purpose are most frequently used special adhesives giving waterproof joints (Niemz 2010). A good solution would be in the range of the use of thermally modified raw material. Research work carried out in this direction (Paul and Ohlmeyer 2005, Paul *et al.* 2006) shows a higher dimensional stability of the boards made from raw material treated thermal modification at the drying step.

MATERIAL AND METHODS

The study used two parties industrial pine particles used in the core layers of particleboard. One part of particles were subjected to thermal modification under an atmosphere of superheated steam. Processing parameters are shown in Fig. 1. In the processing gentle parameters of modification were used to significantly reduce the potential decrease in strength properties of the raw material.

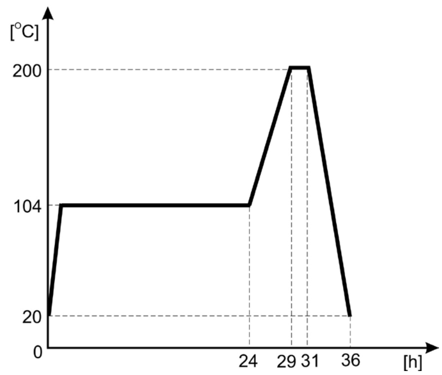

Fig. 1. Flow chart of the thermal modification particles (temperature dependence of the modification time)

For thermally modified particles and unmodified their fractional composition were established. The study was carried out on a laboratory classifier with a set of sieves with mesh sizes of 6 mm, 4 mm, 2 mm, 1.25 mm, 0.63 mm, 0.315 mm, 0.16 mm and a reservoir to "dust" (particles passing through a sieve of 0.16 mm).

The prepared particles were used to production of single-layer particleboard with a thickness of 12 mm and a density of 650 kg/m^3. To gluing the UF resin with a glue content of 10% was used. Parameters of pressing were: temperature of 180 °C, time of 216 s, maximal specific pressure 2.5 MPa. Obtained particleboards were conditioned for 7 days under laboratory conditions, then the test sample were prepared - 10 for each test. For manufactured board were determined:

- density according to EN 323;
- MOR and MOE according to EN 310;
- IB according to EN 319;
- swelling and water absorption after 2 and 24 h soaking in water according to EN 317.

RESULTS AND DISCUSSION

Comparison of fractional composition of particles unmodified and after thermal modification shows Fig. 2. Generally, the process of thermal modification does not change the composition of the fractional particles. However, it should be noted, that in the course of modification the particles were not exposed to mechanical stress (pouring, mixing). Taking into account the possible negative effects of modifications such as an increase in fragility and susceptibility to fracture of the raw material, it might be expected that the treatment may lead to increase of fines content.

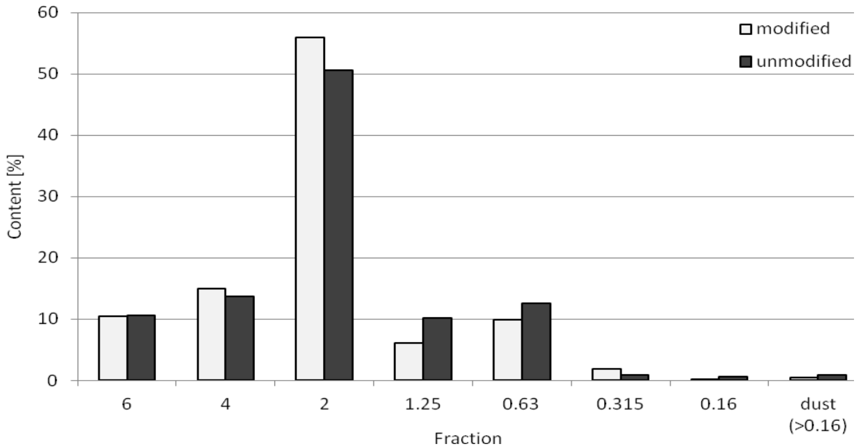

Fig. 2. Comparison of fractional composition of particles before and after thermal modification

The results conducted tests of properties of single-layer particleboards presents Tables 1 and 2.

Table 1. The mechanical properties of the tested particleboards.

Particalboard	Density		MOR		MOE		IB	
	[kg/m^3]	x[%]	[N/mm^2]	x[%]	[N/mm^2]	x[%]	[N/mm^2]	x[%]
unmodified particles	687	4	18,1	9	2518	4	0,68	12
modified particles	684	3	13,0	14	2985	12	0,53	13

x[%] – coefficient of variation

Table 2. The physical properties of the tested particleboards.

Particalboard	Swelling				Water absorption			
	2 h		24 h		2 h		24 h	
	[%]	x[%]	[%]	x[%]	[%]	x[%]	[%]	x[%]
unmodified particles	11.1	11	20.8	12	41.2	10	73.8	3
modified particles	8.7	12	19.7	14	28.5	11	66.3	7

x[%] – coefficient of variation

Based on the study it can be concluded that the use of short thermal modification (2 h) of particles under an atmosphere of superheated steam affects the physical properties and strength parameters of boards produced from the particles. For boards of thermally modified particles relatively to the unmodified particles boards was observed a significant decrease in 28 % MOR and 22 % in IB, and in case of MOE an increase of about 16 %.

The decrease in the strength properties of MOR and IB was probably related to limitation of surface wettability of the thermal modified particles (Boruszewski *et al.* 2012, Follrich *et al.* 2006, Sernek *et al.* 2008), what by applying an aqueous solution of UF resin hindered steady distribution of the binder on the surface of particles. The gluing quality of particles directly determines any subsequent strength properties (Niemz 1993). The increase in the value of MOE particleboard is associated with embrittlement and the rigidity (decrease of elasticity) of wood raw material subjected to short-term thermal modification (Hill 2006). In this case, the plasticized lignin stiffen the cell walls in the modified particles (Niemz *et al.* 2010) which resulted in an increase in the stiffness of the entire particleboard produced from these particles.

The thermal modification of particles contributed to the increase in resistance of produced boards to liquid water (swelling, water absorption). The beneficial effect (reduction of swelling of 20 % and a water absorption 30 %) was seen particularly in case of short-term wetting particleboards (2 h). Exposure to water over 24 hours caused reduction in swelling of 5 % and in a water absorption of 10 %. A similar effect of reduction in the swelling of particleboard and OSB obtained Ohlmeyer and Paul (2005) and Paul *et al.* (2006), however they conducted the thermal modification of particles under different conditions. It is worth noting that while the thermal modification of wood leads to lower its moisture equivalent and thus increase its dimensional stability (Hill 2006) it generally refers to the action on the wood water vapor but not liquid water .

CONCLUSION

Based on the results of a single-layer particleboards made from particles of thermally modified and unmodified a following conclusions were formed:

1. Short-term thermal modification of particles (2 h at temp. 200 °C) allows their use as raw material in the manufacture of particleboard.
2. Particleboards made of thermally modified particles with respect to the particleboards made of industrial unmodified particles were characterized by decreased in MOR (about 28 %) and in IB (approximately 22 %).
3. Particleboards made of heat-treated particles compared to the unmodified particles, characterized by an increase in MOE (about 16 %).
4. Particleboards made of thermally modified particles as compared to the boards with industrial unmodified particles, were characterized by lower swelling of the thickness and a lower water absorption, both at 2 h and 24 h soaking in water.

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