Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 85, 2014: 135-138
(Ann. WULS - SGGW, For. and Wood Technol. 85, 2014)

Foamed starch as a filler in lightweight particleboard

GRZEGORZ KOWALUK, IZABELA BORKOWSKA
Warsaw University of Life Sciences – SGGW, Faculty of Wood Technology

Abstract: *Foamed starch as a filler in lightweight particleboard.* The goal of the investigation was to characterize the influence of addition of different amount of foamed starch particles to lightweight particleboard structure during its production, on selected parameters of produced composites. The improvement of modulus of rupture for panels with 5 and 10% starch content was observed compare to control panel. The internal bond also increases with starch content increase. The water absorptivity and swelling in thickness increases with starch content increase.

Keywords: foamed starch, lightweight, particleboard, mechanical parameters, water absorption, swelling in thickness

INTRODUCTION

The main advantage of foamed starch, apart from ecologic aspects and renewable resources, is small bulk density, about 8 kg/m^3. Such raw material, introduced to particleboard structure, could create the regions with lowered density, when the minimal support for the adjacent wood particles can be provided. This solution can successfully compete with well known panels with density over 550 kg/m^3, filled by 2-3 mm diameter plastic grains, which are strong ballast when subjected recycling or landfilling.

Typical way to produce the panel with lowered density is application of the raw materials with lowered density, like fast growing trees (Kaniewski 1998), alternative raw materials (Güler et al. 2008) or modification of the structure of panel (e.g. sandwich board with honeycomb core). In case of fast growing trees, there is limitation of density reduction, connected to density of raw material. There is no such limit in case of sandwich boards, but the production of them is mostly for special, previously known purposes (with predefined dimensions).

RESEARCH OBJECTIVE

The goal of this work was to investigate the influence of addition of different amount of foamed starch particles to lightweight particleboard structure during its production, on selected parameters of produced composites.

MATERIAL AND METHODS

As thick as 28 mm, three layer panels, with the density of 500 kg/m^3, from industrial coniferous particles and urea-formaldehyde (UF) resin were produced. The following content (by weight) of foamed starch particles (figure 1a) in core layer was applied: 0% (control panel), 5, 10 and 30%. The starch was milled in the drum knife mill to the particles, of which the biggest dimension was less than 20 mm. The share of face layers was 32%. The share of the wood particles fractions is displayed on figure 1b. The resination of all layers was 12%. As a hardener an aqueous solution of NH_4Cl was used, and the curing time of glue mass in 100°C was about 82 s. Due to the high specific surface and small bulk density of starch particles, the wood particles were blended with glue prior to mixing with the starch particles. The moisture content of wood particles was about 6%. The pressing parameters were as follows: temperature 180ºC, time factor 15 s/mm, maximum unit pressure 2.5 MPa.

The following parameters of produced panels were investigated: bending strength and modulus of elasticity during bending, internal bond, as well as swelling in thickness and water absorption. The appropriate European standard procedures were applied (EN 310:1994, EN 319:1999, EN 317:1999). All samples were conditioned in 20°C/65% of R.H. to weight stabilization prior to testing.

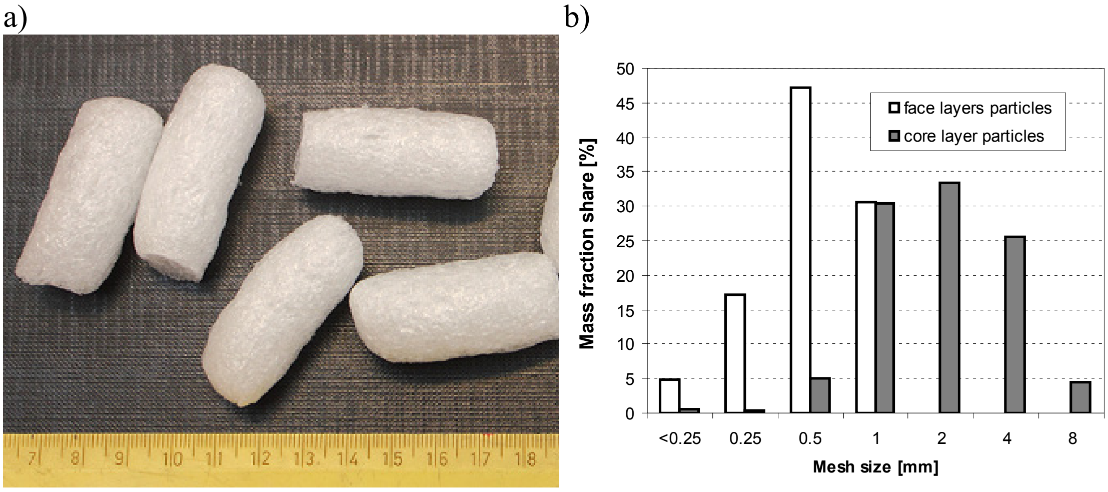

Figure 1. The commercial form (before milling) of foamed starch (a) and fraction share of wood particles (b)

RESEARCH RESULTS

The figure 2a shows the values of the modulus of rupture and modulus of elasticity during bending of tested panels. As it can be seen, there is significant increase of modulus of rupture of the panels with 5 and 10% of foamed starch particles content, compare to the panel without such particles. The 30% content of starch particles in core layer of the panel causes slight decrease of modulus of rupture of tested panel, compare to control panel. Also modulus of elasticity significantly improves when starch particles content is 5%. The improvement of described mechanical parameters, which occurs in case of 5 and 10% content of starch particles, can be explained by filling of the gaps between the wood particles, which are present in the structure of the panel with lowered density. The starch particles can fill these gaps, and can support the adjacent wood particles. With the starch particles content increase, these particles are located not only in these free gaps, but also between wood particles, causing kind of bridge with low connection strength.

In case of results of internal bond testing, which are presented on figure 2b, a slight increase can be read with starch content increase. However, due to the spread of results, indicated by error bars on the plot (± standard deviation), the differences between internal bond of the tested panels are not statistically significant.

The changes of the samples subjected to soaking in water shows, that the starch content insensibly worsens the resistance to water. The results of water absorption, displayed on figure 3a show, that water is absorbed mainly during beginning of soaking, because the difference between water absorption after 2 and 24 h of soaking is very small. This is due to the ability of starch to absorb the water, which is similar to water absorptivity by wood.

In case of swelling in thickness, a slight decrease of this value occurs with 5% starch content in core layer. This is when the starch particles work as a kind of "sealing", and are covered by wood particles, what inhibits the water penetration. The increase of starch content over 5% causes increase of swelling in thickness. The described high ability to water absorption by starch in wood-based composites was also confirmed by Kowaluk et al. 2013, where the significant thickness swelling was found after soaking.

a) b)

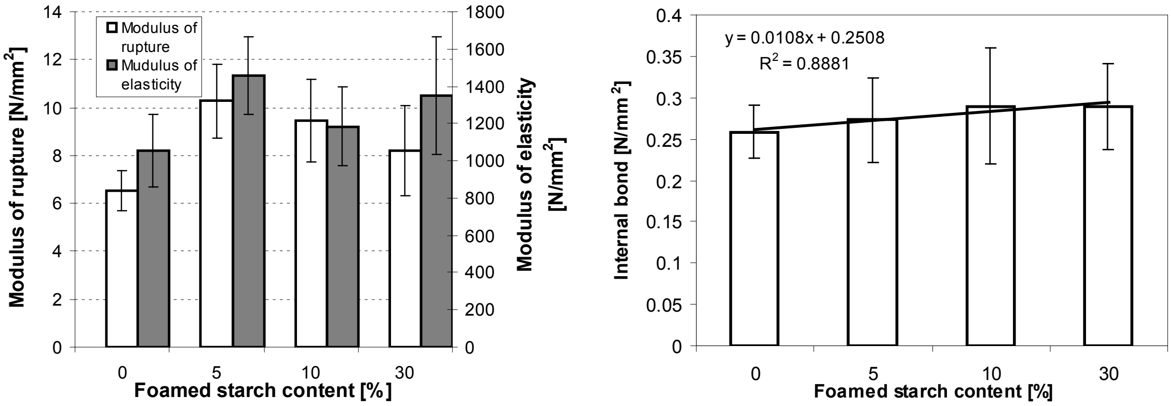

Figure 2. Selected mechanical properties of tested panels: modulus of elasticity in bending, modulus of rupture (a) and internal bond (b)

The pictures of the same sample of the panel produced with 10% content of the starch particles in core layer before and after 24 h of soaking in water are displayed on figure 4. It can be seen, that the starch presence is clearly visible after soaking, since on the dry panel cross-cut the foamed starch particles are marked as thin regions between wood particles. The starch particles presence causes the increase of panel thickness after soaking.

a) b)

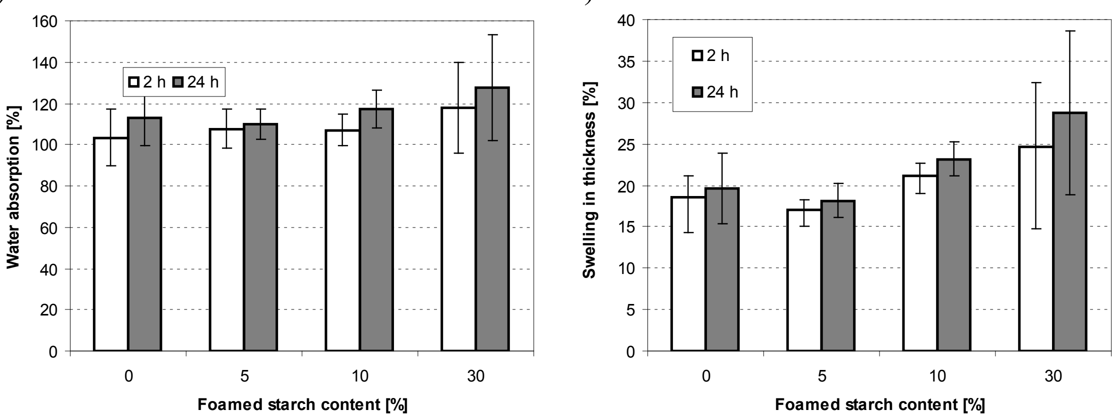

Figure 3. Water absorption (a) and swelling in thickness (b) of investigated panels

a) b)

Figure 4. The sample with 10% of foamed starch content before soaking (a) and after 24 h of soaking in water (b); sample width before soaking 50 mm

Due to quite low modulus of elasticity, as well as high water absorption and thickness swelling, the tested panels could not be applied in constructions, where mechanical features play significant role. Also external applications should not be taken into account. However, since tested panels have lower density, can be successfully applied as a filler of indoor structures, e.g. doors.

CONCLUSIONS

On the basis of conducted investigations and result analysis the following conclusions and remarks can be drawn:

1) There is significant improvement of modulus of rupture of the panels with 5 and 10% content of foamed starch particles in core layer, compare to the control panel. Further increase of starch content causes slight decrease of modulus of rupture.
2) The increase of starch content in the range of 0 – 30% causes insignificant increase of internal bond.
3) The water absorption and swelling in thickness after 2 and 24 h of soaking in water of the panels produced with use of starch particles increases with starch particles content increase.

REFERENCES

1. GÜLER C., COPUR Y., TASCIOGLU C., 2008: The manufacture of particleboards using mixture of peanut hull (*Arachis hypoqaea* L.) and European Black pine (*Pinus nigra* Arnold) wood chips. *Bioresource Technology* 99: 2893–2897.
2. KANIEWSKI W., 1998: Utilization of wood from plantations with short harvesting cycle [in polish], *Biuletyn Informacyjny OBRPPD* no. 2, 111-115.
3. KOWALUK G., SZADKOWSKA A., WEI YOU L., HOOI LENG CH., GRZEBYK M., 2013, Thermoplastic starch as a binder in MDF production: a grain size effect, Ann. WULS-SGGW, *For and Wood Technol.* 83, 86-89.

Streszczenie: *Spieniona skrobia jako wypełniacz w lekkich płytach wiórowych*. Celem badań była charakterystyka wpływu różnego udziału cząstek spienionej skrobi w strukturze płyt wiórowych o obniżonej gęstości na wybrane parametry wytworzonych kompozytów. Zauważono poprawę wytrzymałości na zginanie płyt z udziałem spienionej skrobi na poziomie 5 i 10%, w stosunku do płyt kontrolnych bez udziału skrobi. Stwierdzono również wzrost wytrzymałości na rozciąganie prostopadłe. Wykazano istotny wzrost spęcznienia oraz nasiąkliwości wraz ze wzrostem udziału cząstek spienionej skrobi.

Corresponding authors:

dr. eng. Grzegorz Kowaluk, Izabela Borkowska
Warsaw University of Life Sciences, Faculty of Wood Technology
Nowoursynowska Str. 159/34, 02-787 Warszawa, grzegorz_kowaluk@sggw.pl