Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 83, 2013: 86-89
(Ann. WULS - SGGW, For. and Wood Technol. 83, 2013)

Thermoplastic starch as a binder in MDF production: a grain size effect

GRZEGORZ KOWALUK[1)], AGNIESZKA SZADKOWSKA[2)], LIM WEI YOU[3)], CHUAH HOOI LENG[3)], MAŁGORZATA GRZEBYK[1)]
[1)] Warsaw University of Life Sciences – SGGW, Faculty of Wood Technology
[2)] Industrial Chemistry Research Institute, Department of Polymer Technology and Processing
[3)] Universiti Putra Malaysia, Faculty of Forestry

Abstract: *Thermoplastic starch as a binder in MDF production: a grain size effect.* The aim of the work was to investigate the influence of application of different size of thermoplastic starch grains to MDF structure during its production, on selected parameters of produced composites. The increase of the thermoplastic starch grains size from 0.6 to 1.2 mm causes decrease of bending strength and modulus of elasticity in bending, as well as internal bond. There is no significant influence of thermoplastic starch grains size on the swelling in thickness of the MDF panels produced with use starch.

Keywords: thermoplastic starch, TPS, medium density fiberboard, MDF, bonding

INTRODUCTION

An amine based resins are mostly often utilized in wood-based panels production. To eliminate the formaldehyde emission from these panels, there are trials to apply other, non-formaldehyde binding materials, e.g. water glass (Kowaluk et al. 2012). Another bio-based binder, which have the renewable resources, is thermoplastic starch. This material can be processed in the way typical for plastics (pressing, extrusion, injection). Additionally, thermoplastic starch is completely biodegraded (Mościcki et al. 2006).

TPS has hydrophilic properties, so it has small resistance when exposed to the outdoor environment. There are investigation on solution which helps with wide use of thermoplastic starch in order to fully replace the petroleum-derived materials. To realize this, the polymers with addition e.g. polyethylene or polylactide are produced, where the hydrophobicity is improved (Świerz-Motysia et al. 2011). This can lead to give the opportunity to apply thermoplastic starch also in wood-based materials production.

RESEARCH OBJECTIVE

The aim of this work was to investigate the influence of application of different size of thermoplastic starch grains to MDF structure during its production, on selected parameters of produced composites.

MATERIAL AND METHODS

As thick as 10 mm panels, with nominal density of 800 kg/m^3, from industrial coniferous fibers and urea-formaldehyde (UF) resin (10% resination), with 12% content (by weight) of thermoplastic starch (TS) with two different grain size: 0.6 and 1.2 mm. The raw material - thermoplastic starch as a conglomerate of starch and glycerol was provided as a grains with average size 5 mm by Industrial Chemistry Research Institute, Warsaw, Poland (Figure 1). To achieve above mentioned two fractions of thermoplastic starch, grains were subjected milling with use two types of mesh, which correspond to resulted fraction sizes. 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 (MOE) during bending, internal bond, as well as swelling

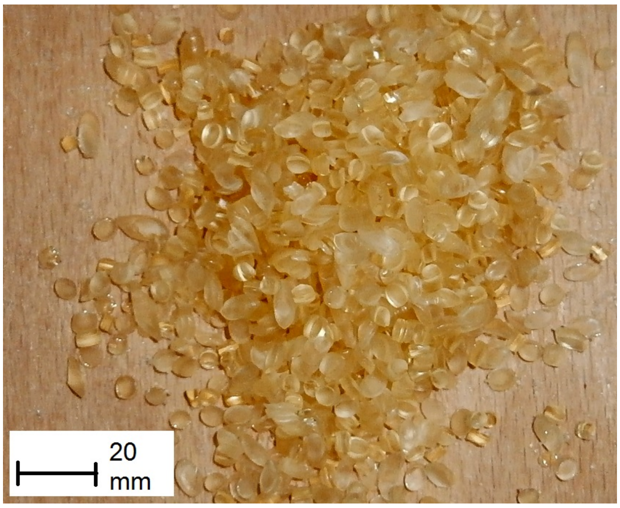

Figure 1. Non-milled grains of thermoplastic starch

RESEARCH RESULTS

The figure 2 shows the bending strength and modulus of elasticity in bending of MDF panels produced with use two different sizes of grains of thermoplastic starch, and the panel made with use UF resin. Despite higher amount of TS used to produce panels (12% by mass) the bending strength and modulus of elasticity are generally lower compare to UF panel, where the resination is 10%. Lowering of described mechanical parameters can occur due to different way of bond line creation, caused by state of aggregation of bonding substances. Thermoplastic starch was applied as a dry powder, while UF resin as a liquid. The bond line achieved with use thermoplastic starch is probably local and irregular: is created only where the TS grain occur and is melted under temperature and pressure. In case of UF resin, this binder covers significantly larger surface of resinated fibers and efficiency of bond line is higher. This explanation can be supported by achieved results on figure 2. When using the same mass of TS but bigger grain size, the panels' bending strength and modulus of elasticity decreases.

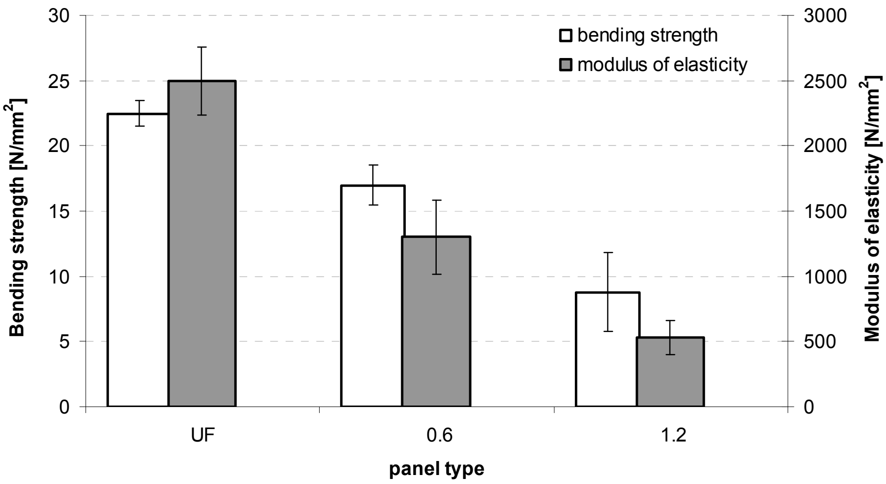

Figure 2. Density profiles of investigated panels

The influence of thermoplastic grains size on the internal bond of investigated panels is shown on figure 3a. As it can be observed, the internal bond of the panels produced with use 0.6 mm thermoplastic starch grains is over 4 times lower compare to UF panel. When the grain size is 1.2 mm, the internal bond decreases till 0.1 N/mm^2 and the scattering of results increases. This mean that the internal structure of produced panels is non-uniform due to local presence/absence of the TS grain in micro scale.

On figure 3b the thickness swelling of investigated panels is displayed. As it can be noted, the swelling in thickness of both panels produced with use thermoplastic starch as a binder is in the range of 95-100%, when thickness swelling of UF panel is 15% only. Such high swelling is caused by high water absorptivity and hydrophilicity of thermoplastic starch, as well as local connection with wood fibers, which do not block the access of the water to fibers. There is no significant influence of the thermoplastic grain size on thickness swelling of investigated panels.

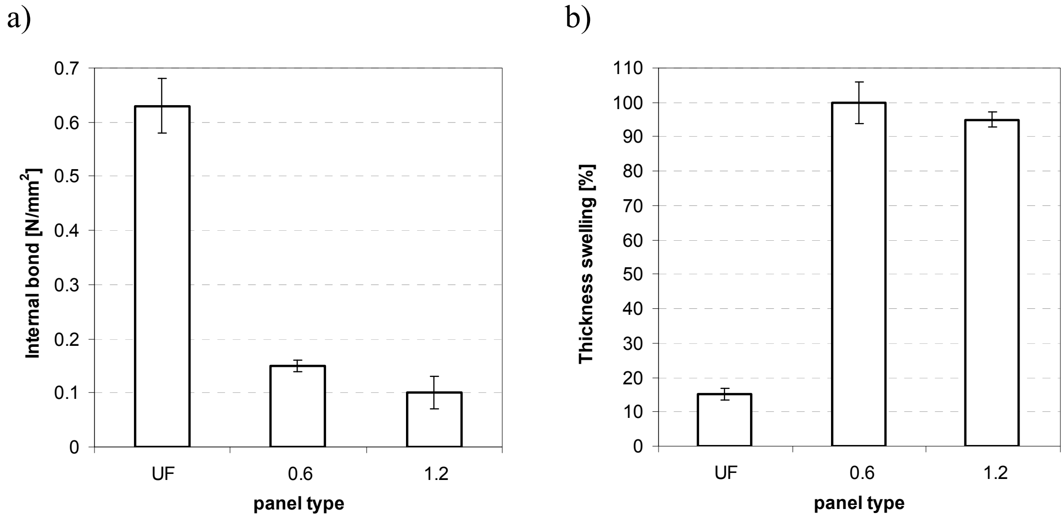

Figure 3. Internal bond (a) and thickness swelling (b) of investigated panels

However above mentioned results show that the application of thermoplastic starch in medium density fiberboards production is unjustified on present moment, the further investigation should be focused on modification of thermoplastic starch to change its hydrophilicity, as well as on the method of introduction of starch to fibers.

CONCLUSIONS

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

1) The bending strength and modulus of elasticity in bending of the MDF panels produced with use different size grains of thermoplastic starch depends on the size of grains: above mentioned parameters decreases with grain size increase.
2) The internal bond of the panels produced with use thermoplastic starch decreases with thermoplastic starch grains increase.
3) There is no significant influence of the thermoplastic starch grains' size on the swelling in thickness of MDF panels produced with use these grains.

REFERENCES

1. KOWALUK G., KĘDZIERAWSKI K., ZBIEĆ M., FUCZEK D., 2012: Possibilities of wood bonding with water glass. Ann. WULS-SGGW, Forestry and Wood Technology 78, 158-161.

2. MOŚCICKI L., JANSSEN L., MITRUS M., 2006: Przetwórstwo skrobi termoplastycznej na cele opakowaniowe. *Inżynieria Rolnicza* nr 6 (81): 65-72.
3. ŚWIERZ-MOTYSIA B., JEZIÓRSKA R., SZADKOWSKA A., PIOTROWSKA M., 2011: Otrzymywanie i właściwości biodegradowalnych mieszanin polilaktydu i termoplastycznej skrobi. *Polimery* 56, nr 4: 271-279.

Streszczenie: *Skrobia termoplastyczna jak spoiwo w produkcji płyt MDF: efekt wielkości ziaren*. Celem badań była ocena wpływu różnej wielkości frakcji ziaren skrobi termoplastycznej, wykorzystanej do produkcji płyt MDF jako spoiw włókien, na wybrane parametry wytworzonych kompozytów. Wykazano, że wraz ze wzrostem wielkości frakcji ziaren skrobi termoplastycznej w zakresie 0,6 – 1,2 mm maleje wytrzymałość na zginanie i moduł sprężystości przy zginaniu, jak również wytrzymałość na rozciąganie prostopadłe. Nie odnotowano istotnego wpływu wielkości frakcji na spęcznienie na grubość płyt MDF wytworzonych z wykorzystaniem tejże skrobi.

Corresponding authors:

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

M.Sc. Agnieszka Szadkowska
Department of Polymer Technology and Processing
Polymer and Biopolymer Processing Group
Industrial Chemistry Research Institute
Rydygiera 8 Str., 01-793 Warszawa, Poland

Lim Wei You, Chuah Hooi Leng
Universiti Putra Malaysia,
Faculty of Forestry
43400 UPM Serdang,
Selangor, Malaysia