Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 83, 2013: 82-85
(Ann. WULS - SGGW, For. and Wood Technol. 83, 2013)

Improving of fibrous composites structure by regenerated cellulose fibers

GRZEGORZ KOWALUK[1)], CHUAH HOOI LENG[2)], LIM WEI YOU[2)]
[1)] Warsaw University of Life Sciences – SGGW, Faculty of Wood Technology
[2)] Universiti Putra Malaysia, Faculty of Forestry

Abstract: *Improving of fibrous composites structure by regenerated cellulose fibers.* The aim of the work was to investigate the influence of addition of different amount of regenerated cellulose fibers to MDF structure during its production, on selected parameters of produced composites. The addition of 10% (by weight) of regenerated cellulose fibers significantly improves the bending strength and internal bond if MDF panels, as well as decreases water absorptivity and thickness swelling.

Keywords: regenerated cellulose fiber, RCF, medium density fiberboard, MDF, structure, reinforcing

INTRODUCTION

An example of converting of lignocellulosic pulp to achieve an added-value product is regenerated cellulose fibers' production. These fibers, based on a natural, plant resources, have some advantages compare to synthetic fibers: high strength-to-weight ratio, the resources of raw material to produce of them are renewable (Ekman 1984), as well as they are eco-friendly, because in propitious conditions can be completely decomposed in significantly short time. Thanks to these features regenerated cellulose fibers can be bonded together with other polymers (Franko et al. 2001), also lignocellulosic fibrous-based materials, like medium density fiberboards, to improve the mechanical parameters of the panel by structure modification (Bourban et al. 1997).

RESEARCH OBJECTIVE

The aim of this work was to investigate the influence of addition of different amount of regenerated cellulose fibers to MDF structure during its production, on selected parameters of produced composites.

MATERIAL AND METHODS

As thick as 10 mm panels, with the density of 800 kg/m^3, from industrial coniferous fibers and urea-formaldehyde (UF) resin, with 0, 10 and 30% content (by weight) of commercially available regenerated cellulose fibers (RCF), were produced. The pressing parameters were as follows: temperature 200ºC, 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. The density profiles were also measured with use GreCon Da-X, X-ray density profiler, to better characterize the tested materials.

RESEARCH RESULTS

The figure 1 shows the density profiles of three boards with 0%, 10%, and 30% regenerated cellulose fibers content. Due to the symmetrical structure of panels, only half of the thickness is shown. As it can be seen, the highest density of the surface layers is characterized to the boards without RCF content. The density peak is located ca. 1.8 mm depth from the surface, and, compare to the panels with RCF, is pretty narrow. The density

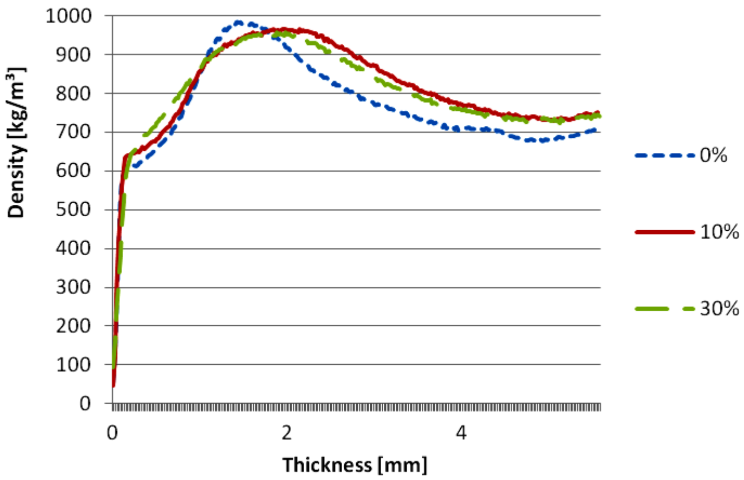

Figure 1. Density profiles of investigated panels

The influence of the regenerated cellulose fibers content on the bending strength of investigated panels is shown on figure 2. On the same figure the average density of the samples used to measure the bending strength is displayed. The bending strength increases with the 0-10% RCF content. Above this range the bending strength decrease was noted. The bending strength increase can be partly explained by average density increase from 785 to 815 kg/m^3. However, after addition of 10% of RCF the bending strength increases about 60% when the density increases about 4%.

During the bending strength measuring also the modulus of elasticity (MOE) was investigated. The result shows that MOE of fiberboards with 10% of RCF content has the highest value (2189 N/mm^2) while the fiberboard with 30% RCF content has the lowest value with (1763 N/mm^2). The standard deviation shows that there is no significant difference between the values of MOE for three type of investigated fiberboards.

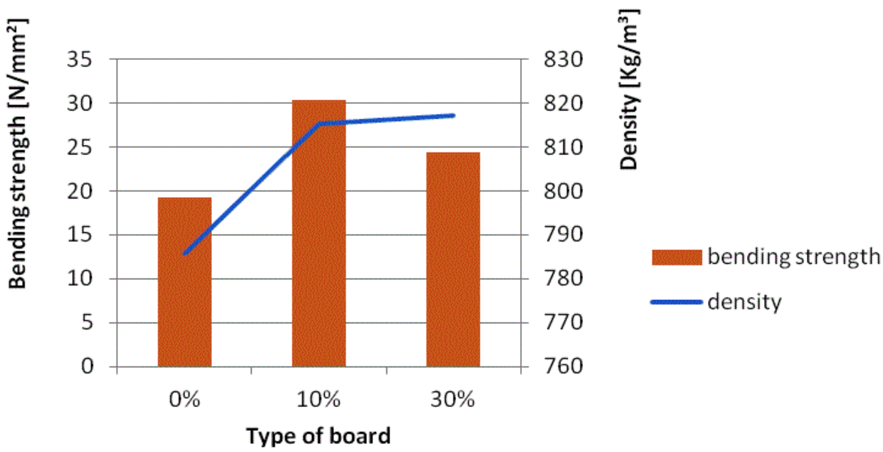

Figure 2. Bending strength and density of investigated panels

Significant influence of the regenerated cellulose fibers content in MDF panels was found when measuring internal bond (IB) (Figure 3a). The lowest IB value (0.07 N/mm^2) was for panel without RCF content. Addition of 10% RCF causes increase of IB to over 0.25 N/mm^2. Further increase of RCF content to 30% causes increase of IB till 0.36 N/mm^2. However, due to high dispersion of the results (displayed by error bars) the IB values' difference between 10% and 30% panels is statistically insignificant.

On the figure 3b an example of crack of 10% panel type is shown. It can be seen that the crack propagation ran close to the surface. The reason of this can be explained by density profiles of the panels, shown on figure 1. The lowest density zones of the panels are located close to the surfaces. On the basis of this remark it can be concluded, that in fact the investigated panels can have higher IB value when breaking in the middle of thickness. To avoid breaking close to the surfaces, in the further research, the panels will be grinded prior to testing to remove the layers with the lowest density.

a) b)

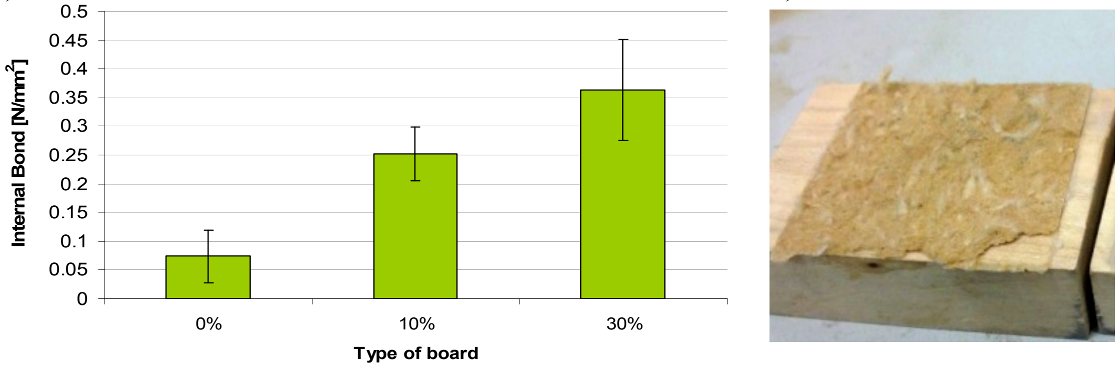

Figure 3. Internal bond of investigated panels (a) and an example of 10% panel type crack (b)

The results of thickness swelling, which are displayed on figure 4a, show, that the 10% RCF content in MDF panels causes panels' smaller thickness increase, in both cases, after 2 and 24 hours water immersion. In case of 30% RCF content the thickness swelling have the highest values from the conducted tests.

a) b)

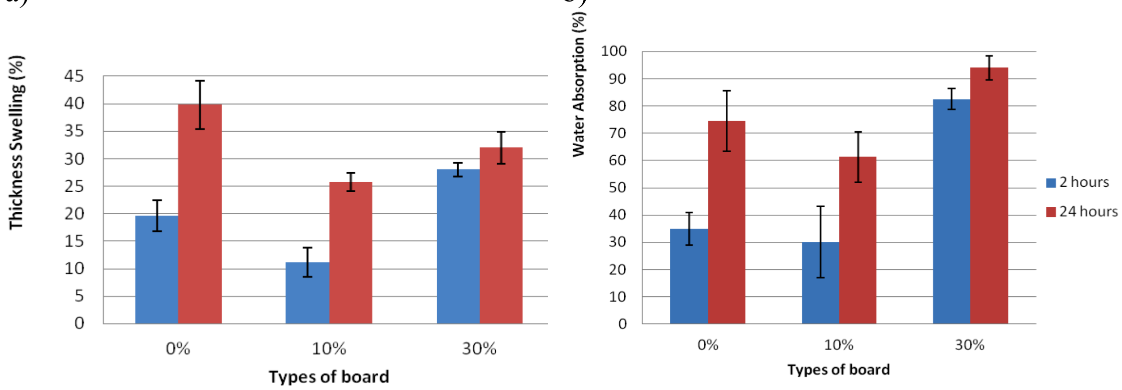

Figure 4. Thickness swelling (a) and water absorption (b) of investigated panels

When analyzing the water absorption of the investigated panels (figure 4b) it can be concluded, that there is no statistically significant change between 0 and 10% panel type. Only when compare 30% panel type to previous both, the significant increase of the water absorption can be observed. The reason of better properties of the panel with 10% RCF content compare to the 0 and 30% panel type can be assumption, that 10% of RCF content is that amount of fibers, which well fills possible free micro gaps inside the panel structure. Regenerated cellulose fibers are more plastic (compare to wood fibers) and can easily fit these gaps. Due to this water penetration is slow and difficult. Over 10% RCF content the optimal RCF/wood fibers ratio is unsettled and panels' reaction to water worsens.

CONCLUSIONS

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

1) The highest/lowest density difference on the thickness of the MDF panels gets lower with regenerated cellulose fibers content compare to the panels without regenerated cellulose fibers content.
2) The bending strength of the MDF panels increases with the regenerated cellulose fibers content increase, where the most significant increase is in the range of 0-10% of regenerated cellulose fibers content.
3) There is no significant influence of the regenerated cellulose fibers content (in the range of 0-30% content) on the modulus of elasticity of MDF panels.
4) The internal bond of MDF panels significantly increases with regenerated cellulose fibers content increase.
5) With the regenerated cellulose fibers content increase from 0 to 10% the thickness swelling and water absorption of the MDF panels decreases. Over 10% regenerated cellulose fibers content the mentioned water resistance worsens.

REFERENCES

1. BOURBAN C., KARAMUK E., DE FONDAUMIERE M.J., RUFFIEUX K., MAYER J., WINTERMANTEL E., 1997: Processing and characterization of a new biodegradable composite made of a PHB/V matrix and regenerated cellulosic fibers. *J. Environ Polym Degrad* 5(3), 159– 166.
2. EKMAN K., 1984: Introduction of regenerated cellulose fibers. Regenerated cellulose fibers from Cellulose Carbamate Solution. Retrieved May 11, 2013, from http://www.lenzing.com/fileadmin/template/pdf/konzern/lenzinger_berichte/ausgabe_57_1984/LB-0571984038.pdf.
3. FRANKO A., SEAVEY K. C., GUMAER J., GLASSER W. G., 2001: Continuous cellulose fiber-reinforced cellulose ester composites III. Commercial matrix and fiber options. *Cellulose* 8: 171–179.

Streszczenie: *Poprawa struktury kompozytów włóknistych za pomocą regenerowanego włókna celulozowego*. Celem badań była ocena wpływu różnego udziału regenerowanego włókna celulozowego w strukturze płyt MDF na wybrane parametry wytworzonych kompozytów. Wykazano, że 10% udział masowy regenerowanego włókna celulozowego istotnie poprawia wytrzymałość na zginanie oraz na rozciąganie prostopadle do szerokich płaszczyzn płyt, jak również obniża spęcznienie na grubość oraz nasiąkliwość płyt.

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

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