TRIESKOVÉ A BEZTRIESKOVÉ OBRÁBANIE DREVA, 9(1): 191–196, 2014
Zvolen, Technická univerzita vo Zvolene, ISSN 1339-8350

DIMENSIONAL STABILITY OF LAYERED ELEMENTS MADE OF THERMALLY MODIFIED WOOD

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Abstract

Heat treatment of wood at high temperature is one of wood modification methods often used to improve the dimensional stability of wood and give a darker more attractive color to the wood. The objective of this study was to determine the effect of heat treatment on dimensional stability of double layer flooring materials made of modified and non modified birch and beech face layer with typical anatomical cross-section (tangential and radial) adhered to a carrier layer formed of plywood. The results show that thermal modification of wood can reduce the panels total dimensional change up to 65% with compared to panels of unmodified face layer wood.

Key words: *sandwich panels (stratified panels), thermo wood, thermal modification*

INTRODUCTION

Heat treatment of wood at high temperature is fully ecological method of wood modification, which eliminate the necessity of use the toxic chemicals. As a result of the thermal modification the dimensional stability and biological durability are improved [Poncsak *et al.* 2011]

The first study about thermal treatment to stabilize the wood structure were reported by Stamm and Buro [Turner *et al*. 2010]. Since then variety of different study on the thermal treatment of wood were made. Currently in Europe, at industrial scale were developed five processes ThermoWood Process (Finland), OHT- Process (Germany), Plato-Process (The Netherlands), Retification Process and Bois Perdure (France) [Jun Li Shi *et al.* 2007].

Common elements of methods of wood thermal modification are controlled by pyrolysis under high temperature in inert enviroment with absence of oxygen to avoid oxidation process. The range of the temperature during thermal modification is 180-260ºC. The process of thermal degradation causes changes in chemical structure giving the wood new physical, chemical and mechanical properties. Thermal modification reduce shrinkage and swelling, decrease equilibrum moisture content, increase water resistance and gives decorative dark color to the wood [Korkut *et al.* 2008[b]; Denes and Lang 2013].

Thermally modified wood have numerous applications, including flooring materials.

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MATERIAL AND METHODS

The research has been conducted on double layer panels which where made of wooden face layer 5 mm thick and birch plywood 10 mm thick bonded with PVC water resistance class D4. Wooden face layer have been obtained from beech wood *(Fagus sylvatica)* with 740 kg/m3 density and from birch (*Betula* L.) wood 700 kg/m3 density. Wooden face layer material arranged in packages have been modified. The modification consisted in thermal changes under industrial conditions in the atmosphere of superheated steam, in temperature 195 ^{o}C and time heating 4h. The control variant was double layer panels made of face layer of unmodified wood. Prepared samples of panels were 450x120x15 mm. dimentions

There were prepared and analyzed panels with following variants of wooden face layer:

- unmodified birch tangential section
- modified birch tangential section
- unmodified birch radial section
- modified birch radial section
- unmodified beech tangential section
- modified beech tangential section
- unmodified beech radial section
- modified beech radial section

Panels were glued with use of cold press in laboratory. Bonding time was 10 min, and applying of adhesive - 120 g/m^2. The manufactured panels were conditioned in a climatic chamber (Fig. 1.) in three variants:

1. Air conditioning in optimal conditions corresponded to 20 ° C and air humidity of 61%. Conditioning time lasted 21 days
2. Air dry conditions correspond to a temperature of 22 °C and humidity of 30%. Air time lasted 14 days.
3. Air conditioning in humid conditions correspond to a temperature of 20 ^{o}C and relative humidity of 80%. Air time lasted 27 days.

Figure 1. Climatic chamber with panels

Terms of air conditioning with a relative humidity of 60% are comparable to those residential during the warm summer. Air conditioning samples under these conditions is a reference point for the calculation of the variability associated with shrinkage and swelling, while the total dimensional change is the difference between the dimensions of the sample conditioned with a relative humidity of 30% and 80% as shown in Figure 2.

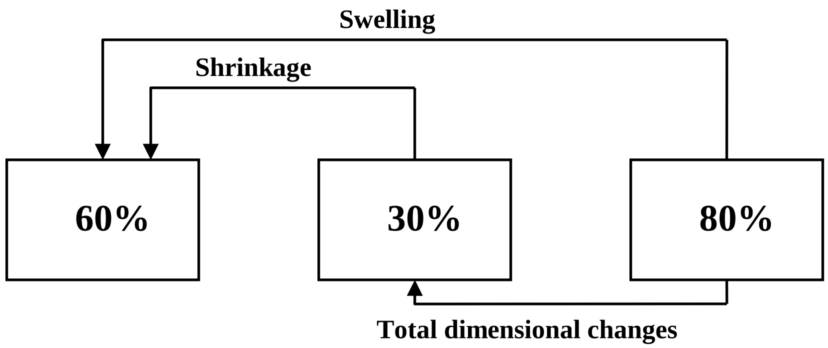

Figure 2. The reference points in determining the dimensional changes of samples

Due to the significant width of the panel and to accurately capture of the dimensional changes, panels were measured in 3 places along the designated lines (Fig. 3.)

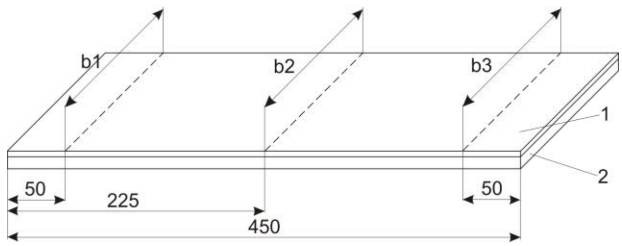

Figure 3. Measuring place the width of the panel

The methodology adopted to the measurements and the calculations show that whenever reference is made to shrinkage and swelling it is a partial shrinkage and swelling. Results were statistically analyzed by using Student's test.

DISCUSSION

Dimensional changes of flooring materials related with changes in relative humidity throughout the year can lead to weaken the laid floor aesthetics (the gap between the panels), or even, in extreme cases, damage it. The potential adverse situations arise mainly from changes in the width of each panel in the floor. In order to reduce that effect, the layered systems are used, in which the carrier layer - in the case at plywood - stabilize the double layer system.

It does not completely eliminate the dimensional changes, which the panels' top layer made of solid wood undergoes. The introduction of thermally modified wood can reduce the dimensional changes in both the swelling and shrinkage. Results of the measurement of dimensional changes of the tested panels fins thermally unmodified and modified in percentage terms are presented in Table 1.

Table 1 Dimensional changes of panels with thermal modified and non-modified lamellas in the basic anatomical directions expressed in percentage

Variants of conditioning	Statistical features	Variant of lamella glued to plywood							
		birch tangential		birch radial		beech tangential		beech radial	
		N	M	N	M	N	M	N	M
		[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
30% (shrinkage)	min.	0,40	0,20	0,32	0,19	0,66	0,32	0,74	0,18
	max.	0,34	0,15	0,27	0,12	0,50	0,25	0,45	0,12
	$X_{ŚR}$	0,37	0,17	0,30	0,14	0,56	0,28	0,59	0,15
	S	0,02	0,02	0,02	0,02	0,07	0,04	0,10	0,02
	significance of differences (N→M)	+		+		+		+	
80% (swelling)	min.	0,73	0,58	0,48	0,31	1,01	0,64	0,83	0,36
	max.	1,24	0,94	0,58	0,38	1,65	1,15	1,24	0,48
	$X_{ŚR}$	1,04	0,75	0,52	0,34	1,24	0,83	1,00	0,41
	S	0,24	0,16	0,04	0,02	0,29	0,21	0,16	0,06
	significance of differences (N→M)	-		+		-		+	
The total dimensional change	min.	0,88	0,94	0,77	0,46	1,52	0,90	1,29	0,51
	max.	1,44	1,35	0,90	0,50	2,21	1,47	1,99	0,65
	$X_{ŚR}$	1,21	1,12	0,83	0,49	1,81	1,11	1,60	0,56
	S	0,26	0,18	0,05	0,01	0,27	0,23	0,26	0,06
	significance of differences (N→M)	-		+		+		+	

N – unmodified, M – modified, (+) – statistically significant difference, (-) – difference not statistically significant, S – standard deviation, $X_{ŚR}$ – the arithmetic mea

In both cases - panels with blades made of birch and beech, there were reported a beneficial effects of thermal treatment on the dimensional stability in the tangential and in the radial directions systems, it confirms the information presented in the literature on the effects of thermal modification to the behavior of wood [Korkut and Guller, 2008] Regarding test panels should be noted that both the birch and beech greater dimensional stability of the panels with fins modified compared to unmodified reported for the radial. Improvement of dimensional stability in case of the panels of fins modified birch wood was approximately 40%, while in the case of panels with face layer modified beech wood was more than 60% (Figure 4.).

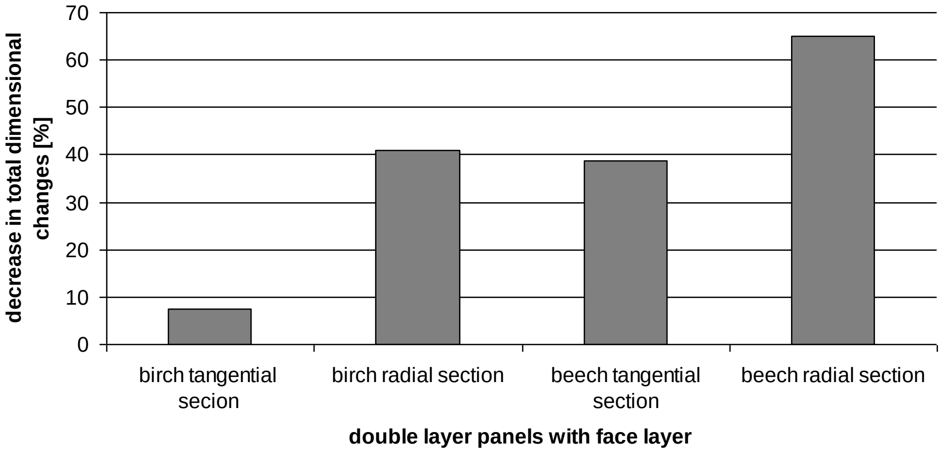

Figure 4 Percentage decrease in total dimensional changes of panels with thermally modified wooden face layer comparing to non-modified

It is worth to add, that regardless of wooden face layer in the panel (a variant of tangential / radial) greater improvement in dimensional stability was observed in the case of the use of thermally modified beech wood. While discussing the dimensional changes of panels, it should also be noted that in the case of the use of wooden face layer with tangential section much more warp phenomenon occurred in the panels. In extreme cases, especially with regard to the beech modified material, there have even became a delamination between the face layer and plywood. Partly it is result of difficulty with gluing of thermal modified wood by using water-based adhesives. This is confirmed by data on thermally modified wood bonding reported in the literature [Hill 2006, Boruszewski *et al*, 2011].

CONCLUSION

1. Dimensional stability double-layer elements made of plywood and a face layer of thermally modified wood (birch and beech), underwent conditioning with air at 20°C and sequentially humidity of 60%, 30% and 80%, is improved (in the range from 8 to 65%) compared to corresponding components made of wood using unmodified undergoing conditioning in the same conditions.
2. For the same conditions for thermal modification greater improvement in dimensional stability characterized by panels in which the wooden face layer are made of modified wood of beech.

3. In terms of dimensional stability and shape stability the double layer components made of wooden face layer generated in radial system adhered to the plywood behave more preferable - for both variants modified and unmodified heat.

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