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CHANGING THE PHYSICAL PROPERTIES OF THERMO-MODIFIED HORNBEAM AND ASH WOOD DEPENDING ON PROCESSING SCHEDULES

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Abstract:
The work determines the influence of the heat treatment schedule parameters on the change of some physical properties of ash and hornbeam wood. The material treated at the temperatures of 160 and 220°C for 10 and 20 hours was studied. The reducing of the material density, increasing the sizes stability of the sizes due to the decrease of moisture absorption and the coefficient of shrinkage and improvement of appearance, which contributes to the expansion use of the different wood species.

Key words: *ash; hornbeam; physical properties; scope of use; thermal modification.*

INTRODUCTION

Wood, as a building and decoration material, has many undeniable advantages and positive features, but there are some negative aspects. It is used in the open air, which accompanied by the potential risk of adverse weather conditions (shrinkage, swelling) and biological destroyers. Thermal modification of wood is one of the ways to improve its characteristics. Under the influence of high temperatures, the equilibrium moisture content of the material (Jämsä and Viitaniemi 2001, Gosselink *et al.* 2004, Metsä-Kortelainen *et al.* 2006) decreases, dimensional stability improves and lifetime increases (Kollmann and Schneider 1963, Boonstra *et al.* 1998, Bourgois *et al.* 1998, Tjeerdsma *et al.* 1998, Epmeier *et al.* 2001, Militz 2002, Wang and Cooper 2005); the color changes throughout the entire cross section (Menezzi *et al.* 2009, Chen *et al.* 2012, Mitani and Barboutis 2013, Lovrić *et al.* 2014).

First years of the thermomodified wood production the darkening was considered as disadvantage. Nowaday this is one of the main arguments of using thermodiffication. Therefore, not only those species, which don't have commercial value in Ukraine (for example, hornbeam), find new use as a result of thermomodification, but also with a clearly expressed texture (beech, ash) acquire even more saturated color and aesthetic appearance. Take into account all this positive characteristics, the scope of application of the material is expanding, which is attractive for the manufacture of external products (facing of facades, garden furniture, terrace cover).

The growing demand and the reduction of stocks of valuable industrial wood in many countries require the introduction of less-demand speciesas substitutes. Accordingly, in many countries, the processing of less common species is encouraged (Shupe *et al.* 2005, Smith *et al.* 2005).

In Ukraine, hornbeam is slightly used, because this wood is heavy, prone to gutting, parts of products change shape and size in a humid environment, and lags are rarely straightforward. Traditionally, small parts of products, folk crafts, charcoal etc. were made from hornbeam.

Using thermal modification for valuable species is conditioned by the possibility of reducing the volume, which is increasing the products lifetime.

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OBJECTIVE

The purpose of this study is assessment the influence of the heat treatment schedule parameters on some physical properties of hornbeam and ash wood.

MATERIALS AND METHODS

The samples from untreated and thermomodified at the temperature of 160 and 220°C for 10 and 20 hours hornbeam and ash wood were used for the study. Sample sizes were standardized in quantities according to the standard requirements: 20×20×30mm – for determination of density and weight loss; 20×20×10 mm - moisture absorption; 20×5×300mm – for color.

The change in the physical properties of the material obtained is determined according to standard methods: basic density ($\rho_{баз}$, кг/м^3) (GOST 16483.1-84 1985), shrinkage indicators (β_V, %) (GOST 16483.37-88 1990), moisture absorption rate ($U_п$, %) (GOST 16483.19-72* 1974).

RESULTS AND DISCUSSION

Weight loss

Weight loss of wood during heat treatment is one of the most important features of the process and characterizes the degree of material modification. It has been established that with increasing processing temperature, weight loss (Fig. 1) increases, and the characters of the changes are different for the studied species of wood.

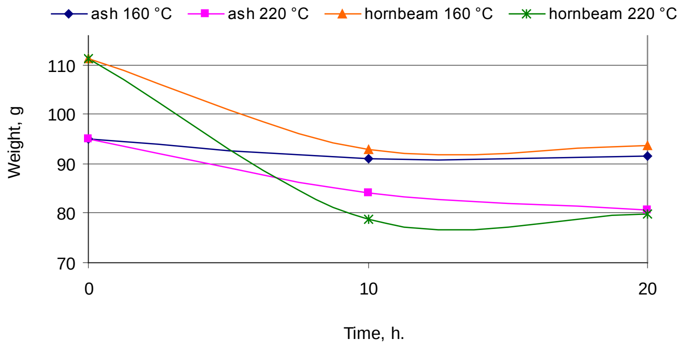

Fig. 1.
Weight loss of wood samples from different species during thermomodification.

It is difficult to generalize and compare the data of various studies because different processes, time and temperature of processing, species and initial moisture content were investigated at different times.

Similar results are obtained (Alén *et al.* 2002, Mazela *et al.* 2003), when they determine the influence of processing schedules on fir wood and pine wood. Some authors, who studying the weight loss during heat treatment, came to the conclusion that it depends on the species of wood, the temperature and the length of the process.

Density

The process of thermal modification is associated with changing the density of wood. During the experiment, it was recorded that temperature is more significant schedule parameter for changing the density than the time. Decreasing the density of ash wood during processing at the temperature of 160°C – 4.43% for 10 hours of treatment and 5.75% for 20 hours, and for 220°C this data increased almost 2 times. For hornbeam, this value was less than 2 times for 160°C, 1.5 times for 220°C compared with ash (Fig. 2).

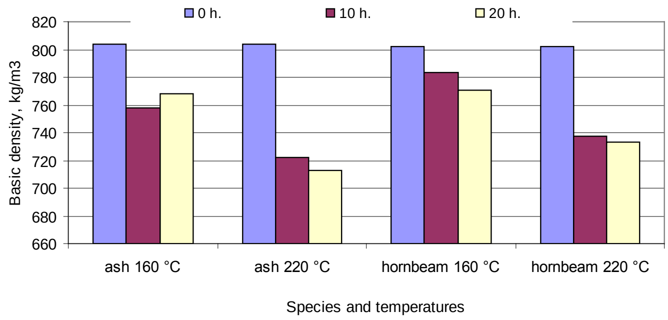

Fig. 2.
Influence of the thermal modification schedules on change of wood density.

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A similar decreasing the density of ash wood at different temperatures and duration of modification was described by Molinsky et al. (2016) and Andor, Lagaňa (2018). The most noticeable indicator – 12% – was recorded during 12-hour treatment at 200°C. Such changes can be explained by the decomposition of hemicellulose to volatile substances that evaporate during heat treatment.

Moisture absorption

Destruction of hemicelluloses under the influence of high temperature on wood leads decreasing of it hygroscopicity (Korkutet *et al.* 2012). The value of the absorbed moisture from the environment by ash and hornbeam heat-treated wood samples are shown in Tab. 1.

Table 1

Increase in the samples mass of heat-treated wood during keeping in a humid environment

Species	Schedule parameters		Change in the samples mass (g) while keeping in a humid environment, days							
	t, °C	τ, h.	dry	1	2	3	6	9	13	20
Ash	control		2,99	3,23	3,32	3,37	3,44	3,48	3,52	3,62
	160	10	2,78	2,97	3,03	3,07	3,15	3,19	3,23	3,26
		20	2,85	3,05	3,12	3,16	3,25	3,28	3,32	3,36
	220	10	2,58	2,68	2,73	2,76	2,79	2,82	2,84	2,86
		20	2,63	2,73	2,77	2,79	2□83	2,85	2,87	2,89
Hornbeam	control		3,65	3,92	4,01	4,06	4,15	4,20	4,25	4,32
	160	10	3,68	3,93	4,01	4,06	4,15	4,20	4,24	4,30
		20	3,47	3,67	3,75	3,81	3,87	3,91	3,95	4,01
	220	10	2,87	2,97	2,99	3,03	3,08	3,13	3,14	3,16
		20	3,01	3,12	3,16	3,18	3,21	3,23	3,24	3,27

In percentage terms for both species of wood similar results were obtained. The moisture absorption of wood modified at 160°C decreased by 18%, and at 220°C by 50% was compared to untreated wood.

Shrinkage coefficient

Form resistance and dimensions stability of heat-treated wood in the event of changes in the environment climatic parameters of operation can be expressed through the shrinkage coefficient, the decrease of which indicates an improvement in the stability of the sizes (Yildiz 2002, Esteves *et al.* 2007a, Kaygin *et al.* 2009, Akyildiz *et al.* 2009). The value of the shrinkage was determined as the volume change of the linear dimensions of ash and hornbeam thermomodified wood samples after drying in a chamber at a the temperature of 103 ± 2°C (Fig. 3).

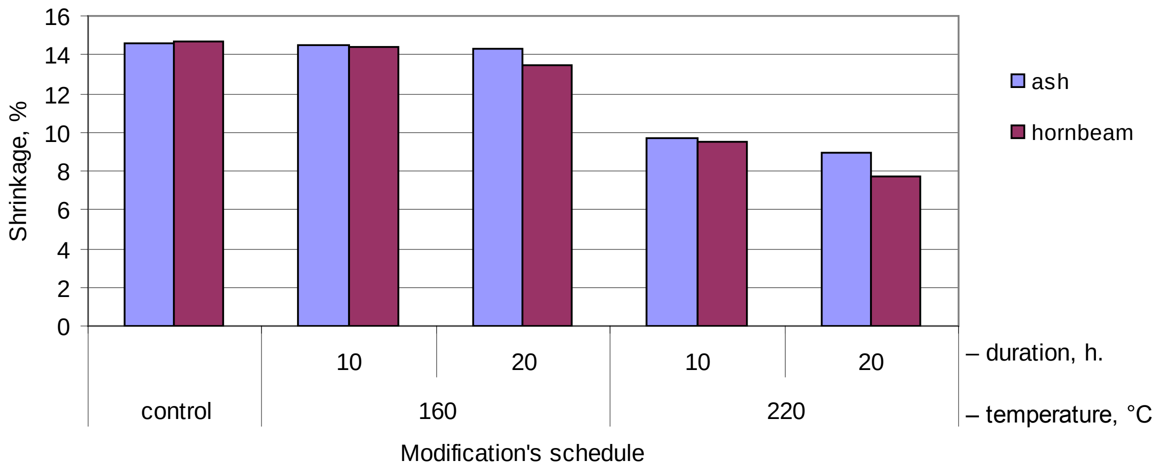

Fig. 3.

The shrinkage coefficient dependence on the schedule processing parameters.

There was similarity of the results for both investigated species during heat treatment for 10 hours. So at the temperature of 160°C the shrinkage indicators decreased by 0.42% for ash and by 1.4% for hornbeam; at the temperature of 220°C – by 33.57% and 35.35% respectively. An increase in the modification duration up to 20 hours showed a significant difference for hornbeam wood.

Color

Spectrophotometric color measurements show that thermal treatment results change in all color parameters for all species of wood (Esteves *et al.* 2008, Srinivas and Pandey 2012). The greatest influence on the overall color has an increasing of temperature treatment – Tab. 2.

Table 2

Correlation of processing temperature and heat-treated wood color

Species	Color coordinate	Thermal modification schedule parameters				
		control	160 °C		220 °C	
			10 h.	20 h.	10 h.	20 h.
Ash	Visually					
	L	59.1	48.2	53.4	21.0	19.3
	a	10.3	12.1	11.2	4.2	4.3
	b	13.2	16.9	16.1	2.1	1.9
	ΔE	–	10.9	6.7	40.2	42.1
Hornbeam	Visually					
	L	58.4	46.0	48.4	14.4	13.8
	a	12.0	17.6	14.4	4.8	4.4
	b	16.4	18.8	17.4	2.8	2.2
	ΔE	–	13.9	10.5	46.6	47.5

The important characteristic of the color changing ΔE is reduction of the «lightness» parameter L. It is clear that the color of ash and hornbeam has changed significantly, comparing with the natural light tone, and the character of the change is quite similar. The length of the treatment practically hasn't affect on the color change. For ash it is 5.2 units (at 160°C) and 1.6 units (220°C), for hornbeam wood – 3.4 units and 0.9 units in accordance. However, if we compare the effect of temperature during heat treatment on the color deviation, the difference between the indicators for both species is weightier – an average of 33 units.

CONCLUSION

The conducted studies made possible to determine the directions of thermomodified wood using. First of all, as the replacement of exotic species by obtaining a more aesthetic appearance under the influence of heat. In addition, the improvement of the shape and dimensions stability in medium with variable temperature and humidity parameters made possible to use this material in the manufacture of products, which are operated on the adjacent territory of the building (terraced covering and facade arrangement, garden architectural constructions).

REFERENCES

Akyildiz MH, Ates S, Ozdemir H (2009) Technological and chemical properties of heat treated anatolian black pine wood. African Journal of Biotechnology 8(11):2565-2572.

Alén R, Kotilainen R, Zaman A (2002) Thermochemical behavior of Norway spruce (Picea abies) at 180-225ºC. Wood Sci. Technol. 36:163-171.

Andor T, Lagaňa R (2018) Selected properties of thermally treated ash wood. ACTA FACULTATIS XYLOLOGIAE ZVOLEN, 60(1):51-60, 2018 Zvolen, Technická univerzita vo Zvolene DOI: 10.17423/afx.2018.60.1.06

Boonstra MJ, Tjeerdsma BF, Groeneveld H (1998) Thermal modification of nondurable wood species: 1. The PLATO technology; Thermal modification of wood. In: Proceedings of 29th Annual Meeting, 14–19 May; Maastricht, the Netherlands, Doc. No. IRG/WP/98–40123.

Bourgois J, Bartholin MC, Guyennet R (1998) Thermal treatment of wood: analysis of the obtained product. Wood Sci Technol 23:303-310.

Chen Y, Fan Y, Gao J, Stark NM (2012) The effect of heat treatment on the chemical and color change of black locust (Robinia pseudoacacia) wood flour. BioResources, 7(1):1157-1170.

Epmeier H, Bengtsson C, Westin M (2001). Effect of acetylation and heat treatment on dimensional stability and MOE of spruce timber, In: Proceedings for the First Conference of the European Society for Wood Mechanics, April 19–21; Lausanne, Switzerland.

Esteves B, Marques A, Domingos I, Pereira H (2007) Influence of steam heating on the properties of pine (Pinus pinaster) and eucalypt (Eucalyptus globulus) wood. Wood Science and Technology 41(2007):193-207.

Esteves B, Marques AV, Domingos I, Pereira H (2008) Heat-induced colour changes of pine (Pinus pinaster) and eucalypt (Eucalyptus globulus) wood. Wood Science and Technology 42:369-384.

Gosselink R, Krosse A, Van der Putten J, Van der Kolk J, Klerk-Engels B, Dam J (2004) Wood preservation by low-temperature carbonisation. Ind Crop Prod 19:3-12.

ГОСТ 16483.1-84 (1999) Древесина. Метод определения плотности. (Wood. Method for determination of density)

ГОСТ 16483.37-88 (1999). Древесина. Метод определения усушки. (Wood. Method for determination of shrinkage).

ГОСТ 16483.19-72* (1999). Древесина. Метод определения влагопоглощения. (Wood. Method for determination of moisture absorption).

Jamsa S, Viitaniemi P (2001) Heat treatment of wood – better durability without chemicals. In: Proceedings of Special Seminar; Antibes, France.

Kaygin B, Gündüz G, Aydemir D (2009) Some physical properties of heat-treated Paulownia (Paulownia elongata) wood. Drying Technology 27(1):89-93.

Kollmann F, Schneider A (1963) On the sorption-behaviour of heat stabilized wood. Holz Roh Werkst 21:77-85.

Korkut S, Korkut DS,Kocaefe D, Elustondo D, Bajraktari A, Cakicier N (2012) Effect of thermal modification on the properties of narrow-leaved ash and chestnut. Ind. Crop. Prod. 35(1):287-294.DOI:10.1016/j.indcrop.2011.07.016

Lovrić A, Zdravković V, Furtula M (2014) Influence of thermal modification on colour of poplar (Populusxeuramericana) rotary cut veneer. Wood research 59(2):661-670.

Mazela B, Zakrzewski R, Grzeskowiak W, Cofta G, Bartkowiak M (2003) Preliminary research on the biological resistance of thermaly modified wood. In: Abstracts of the First European Conference on Wood Modification, Ghent, Belgium.

Menezzi CHS, Tomaselli I, Okino EYA, Teixeira DE, Santana MAE (2009) Thermal modification of consolidated oriented strandboards: effects on dimensional stability, mechanical properties, chemical composition and surface color. European Journal of Wood and Wood Products 67:383-396.

Metsa-Kortelainen S, Antikainen T, Viitaniemi P (2006) The water absorption of sapwood and heartwood of Scots pine and Norway spruce heat-treated at 170°C, 190°C, 210°C and 230°C. Holz Roh Werkst 64:192-197.

Militz H (2002) Heat treatment technologies in Europe: scientific background and technological state-of-art. In: Proceedings of Conference on Enhancing the Durability of Lumber and Engineered Wood Products; Kissimmee, Orlando. Madison, WI, USA: Forest Products Society.

Mitani A, Barboutis I (2013) Heat treatment effect on colour changes of beech (Fagus sylvatica) wood. Pro ligno, 9:658-663.

Molinski W, Roszyk E, Jablonski A, Puszynsk J, Cegiela J (2016) Mechanical parameters of thermally modified ash wood determined by compression in radial direction. In Maderas-Ciens Tecnol, 2016, 18/4: 1x18, ISSN 0718-221X.

Shupe TF, Aguilar FX, Moslcy RP (2005) Wood properties of selection lesser used Honduran wood species. Journal of Tropical Forest Science 17:438-446.

Smith RL, Mcdaniel PW, Felln D (2005) Opportunity for the utilization of alternative species in secondary wood manufacturing. Forest Product Journal 55(4):71-74.

Srinivas K., Pandey K.K. (2012) Photodegradation of thermally modified wood. Journal of Photochemistry and Photobiology B: Biology 117:140-145.

Tjeerdsma B, Boonstra M, Pizzi A, Tekely P, Militz H (1998) Characterisation of thermally modified wood: molecular reasons for wood performance improvement. Holz Roh Werkst 56:149-153.

Wang J, Cooper P (2005) Effect of oil type, temperature and time on moisture properties of hot oil-treated wood. Holz Roh Werkst 63:417-422.

Yildiz S (2002) Effect of heat treatment on water repellence and anti-swelling efficiency of beech. The International Research Group On Wood Preservation, Document No: IRG/WP 02-40222.