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SESSION I STRUCTURE & PROPERTIES

Comparison of physical properties of heat treated and untreated hornbeam wood, beech wood, ash wood and oak wood

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ABSTRACT

Heat treatment is an alternative method for improving durability and dimensional stability of wood with no use of chemical additives. When we heat wood chemical changes are starting to take place inside the wood structure. Result of these changes is increased durability and dimensional stability of wood. In this thesis is shown mutual comparison between experimental results of physical properties of heat treated and untreated hornbeam wood, beech wood, ash wood and oak wood. Results of physical properties of heat treated hornbeam wood, beech wood, ash wood and oak wood found that their average value is lower and significantly different from average values of physical properties of untreated wood.

INTRODUCTION

Heat treatment is procedure of changing chemical structure in cell wall of wood only with influence of heath, pressure and eventually moisture without intaking any chemicals. Procedure of heat treatment is mostly conducting in reaction cylinder on temperatures between 150 °C and 260 °C without presence of oxygen (Rapp and Sailer, 2001; Yildiz *et al*. 2003; Kotilainen, 2000) or between 120 °C and 180 °C according to Patzelt *et al*. (2002). Treatment time spans between 15 minutes and 24 hours, depending on the type of the process, wood species, stock dimensions, initial moisture content, and the desired level of alteration of mechanical properties, resistance against biological deterioration, and dimensional stability of the product (Emmler and Scheiding, 2007).

Heat treatment of wood reduces its hygroscopicity, improves dimensional stability, enhances resistance against biological deterioration,

and contributes to uniform colour change from original to dark brownish tones (Stamm *et al*. 1937; Kollmann *et al.* 1975; Hill, 2006; Tjeerdsma *et al*. 1998). The disadvantages that have to be dealt with are reductions in various kinds of mechanical properties and long-term colour stability.

The objective of this research is to build knowledge of the interaction between untreated wood material properties and heat treated wood material. It is difficult to control and affect the intrinsic material properties of wood. However, it is possible to make selections and choose the most appropriate material and to reject unsuitable material. A prerequisite for this is a sufficient knowledge of relevant properties of wood. Compiled conclusions will contribute to the knowledge base on which decisions can be made that will enable the optimal choice of material and process control to achieve the desired quality in end products.

MATERIALS AND METHODS OF RESEARCH

Research was conducted on four different species of wood: hornbeam, beech, ash and oak. One heart board, length of 2 meters was taken from each wood species. The middle of heart boards was at breast height (1,3 m). Heart boards were sawn across the middle in transverse section. Samples for determination physical properties of untreated wood were made from the part beneath breast height. The parts of heart boards above breast height were heath treated at temperature of 200 ºC for 48 hours. Whole process of heating and cooling chamber lasted for 72 hours.

After finishing heath treatment, samples for determination of physical properties were made from heath treated boards. Samples were sawn from upper (breast height) part of boards down to root swelling so that the position of untreated and treated samples for determination of physical properties would be close to each other.

Heart boards of untreated wood were dried naturally too approximately 12 % of water content, and heath treated boards were 4% water content after treatment.

Testing’s of physical properties: density in absolutely dry condition, radial shrinkage and tangential shrinkage were conducted by valid European standards.

The most significant physical properties that are showing the greatest difference in heat treatment process apropos those who are most important for usage of heath treated wood are given in this research. These physical properties indicate higher dimensional stability of heath treated wood in relation to untreated wood.

RESULTS AND DISCUSSION

Mean values of density in absolutely dry condition, radial shrinkage and tangential shrinkage of untreated and heat treated hornbeam wood, beech wood, ash wood and oak wood are shown in Table 1. The rest statistical values of hornbeam wood, beech wood and ash wood are available in scientific papers from Govorčin *et al.* (2009) and Sinković *et al.* (2011). Statistical values of oak will be available in one of the upcoming articles from the same authors or if someone is particularly interested in results, original date can be obtained from authors. Results in published articles show significant difference between researched properties of untreated and heat treated wood. All values of mentioned properties of untreated wood are higher in relation to the heat treated wood (Govorčin *et al.* 2009 and Sinković *et al.* 2011).

Table 1 Survey of average values for density in absolutely dry condition, radial shrinkage and tangential shrinkage of untreated and heat treated wood.

Untreated wood				Heat treated wood		
ρ_o	$\beta_{r\ max}$	$\beta_{t\ max}$	wood species	$\beta_{t\ max}$	$\beta_{r\ max}$	ρ_o
g/cm^3	%	%		%	%	g/cm^3
0,716	8,02	9,86	hornbeam	5,27	3,65	0,666
0,680	5,78	12,60	beech	10,23	5,38	0,627
0,655	6,96	9,00	ash	3,45	2,15	0,600
0,681	5,34	5,90	oak	4,79	2,78	0,672

Key: ρ_o - density in absolutely dry condition, $\beta_{r\ max}$ - radial shrinkage, $\beta_{t\ max}$- tangential shrinkage

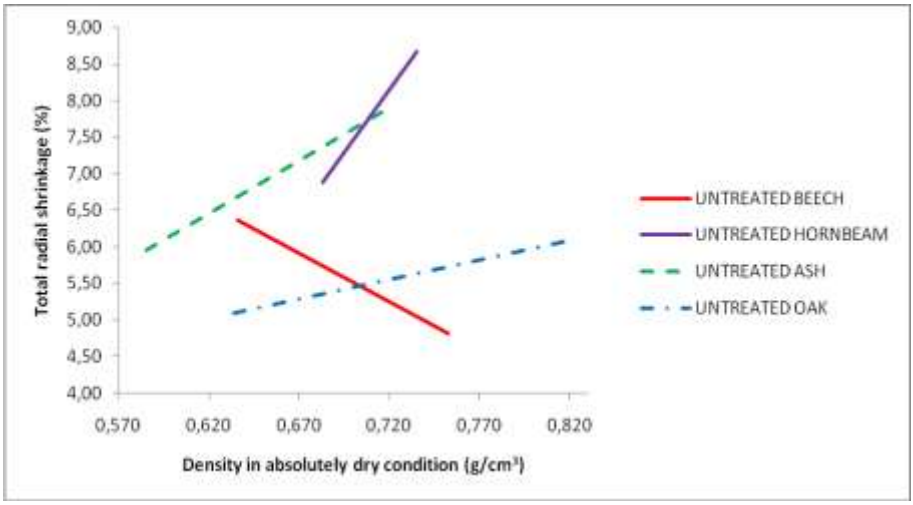

Figure 1 Relation between density in absolutely dry condition and total radial shrinkage for untreated beech wood, hornbeam wood, ash wood and oak wood.

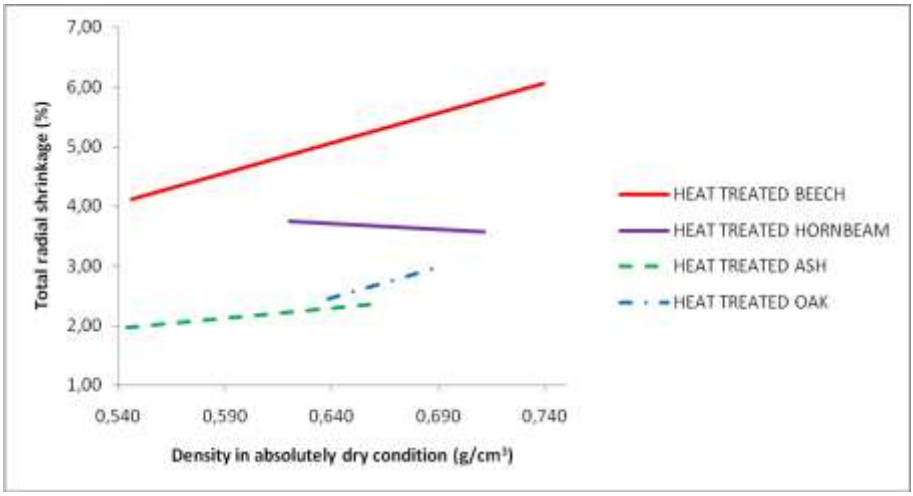

Figure 2 Relation between density in absolutely dry condition and total radial shrinkage for heat treated beech wood, hornbeam wood, ash wood and oak wood.

According to Figures 1 and 2 beech wood has changed trend of relation between density in absolutely dry condition and total radial shrinkage between untreated and heat treated wood.

Untreated beech wood has decreasing trend of relation between density in absolutely dry condition and total radial shrinkage, and heath treated beech wood has growth trend.

For untreated hornbeam wood by increasing density in absolutely dry condition total radial shrinkage increases, and for heat treated hornbeam wood total radial shrinkage decreases. For untreated and heath treated ash wood and oak wood by increasing density in absolutely dry condition total radial shrinkage increases.

Heat treated hornbeam wood has an average value of total radial shrinkage by 120% smaller compared to the untreated hornbeam wood. Total radial shrinkage of heat treated beech wood is by 7% smaller compared to the untreated beech wood and total radial shrinkage of heat treated oak wood is by 92,1% smaller compared to the untreated beech wood.

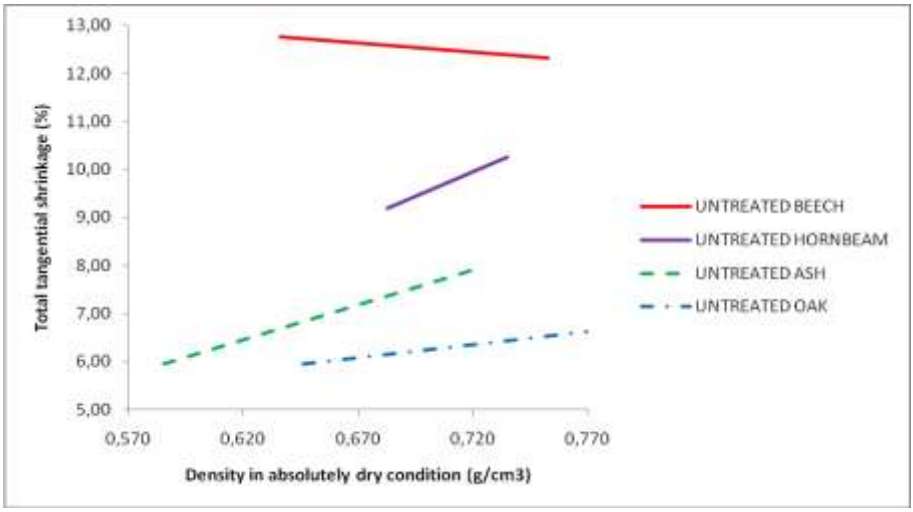

Figure 3 Relation between density in absolutely dry condition and total tangential shrinkage for untreated beech wood, hornbeam wood, ash wood and oak wood.

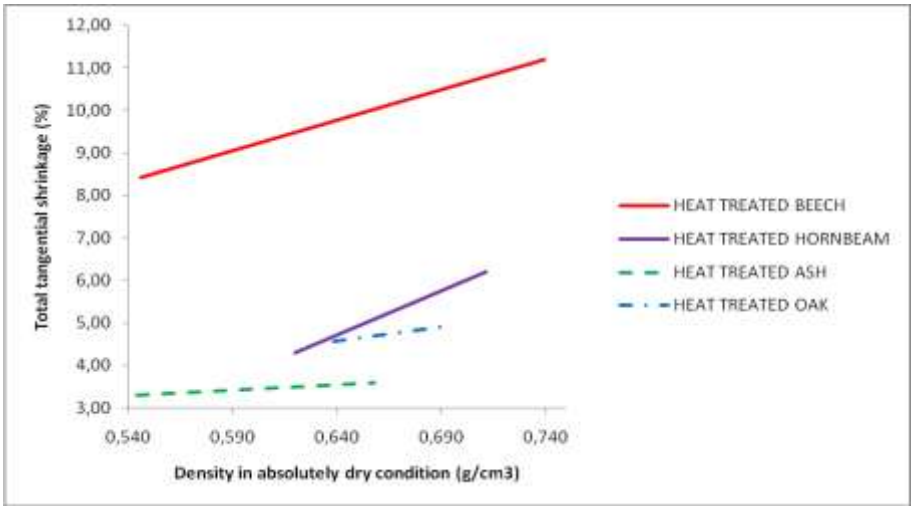

Figure 4 Relation between density in absolutely dry condition and total tangential shrinkage for heat treated beech wood, hornbeam wood, ash wood and oak wood.

Untreated beech wood has decreasing trend of relation between density in absolutely dry condition and total tangential shrinkage, and heath treated beech wood has growth trend. Both untreated and heat treated hornbeam wood, ash wood and oak wood have growth trend of relation between density in absolutely dry condition and total tangential shrinkage.

Heat treated hornbeam wood has an average value of total tangential shrinkage by 87,1% smaller compared to the untreated hornbeam wood. Total radial shrinkage of heat treated beech wood is by 23,2% smaller compared to the untreated beech wood and total radial shrinkage of heat treated oak wood is by 23,2% smaller compared to the untreated beech wood.

CONCLUSIONS

Heath treated hornbeam wood, beech wood, ash wood and oak wood have decreased density in absolutely dry condition, radial and tangential shrinkage in relation to the same physical properties of mentioned untreated wood species.

There is a change in trend of relation between density in absolutely dry condition and total radial shrinkage and total tangential shrinkage for heat treated beech. Untreated beech has decreasing trend of total radial and total tangential shrinkage in relation to increase in density in absolutely dry

condition. Heat treated beech has growth trend of total tangential and total radial shrinkage in relation to increase in density in absolutely dry condition.

According to researched results of radial and tangential shrinkage of hornbeam wood, beech wood, ash wood, and oak wood, heath treated wood has greater dimensional stability in relation to untreated wood.

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