Chemical-free wood preservation

The effect of dry thermal treatment on wood properties with special emphasis on wood resistance to fungal decay

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Introduction

In a narrow sense, under thermal treatment we mean the heat transfer exceeding the usual temperature scope of timber drying, which significantly changes the properties of wood, due to the processes of degradation. The timber modification methods by the means of heat can be considerably different regarding the agent and schedule of treatment. Regarding the heat transferring agent we can mention technologies using liquids, or gas-steam. Spreading of treatments in gas agents is very fast since the appearance of Finnish Thermo Wood in the nineties.

Material and method

We performed tests to base the industrial realisation of thermal treatment of timber, with domestic species. The research was supported by the Ministry of Economy and Transport in the framework of „Chemical-free wood preservation" project. The aim of the project was to clear up the effect of thermal treatment from not only the aspect of the resistance to fungi, but of other properties as well. According to the preliminary tests, the temperature of tests was limited to 200℃ and the h eat transmitter agent was dry, normal atmospheric air, without blowing steam. The schedules of the treatment are the intellectual property of the consortium formed for the realization of the project, so we are not allowed to publish details about those. The increasing numbers of schedules mentioned (1,2 and 3) mean with a constant value increasing durations of the treatment. We tested beech, Turkey oak, oak, poplar, black locust and pine species and the developed schedules aimed high quality wood products. We publish the results of tests with the wood of beech (*Fagus sylvatica* L.) and Turkey oak (*Quercus cerris* L.) as follows. The most important physical and mechanical properties were analysed using the European Norms (EN). From statistical aspect, the number of samples was 25 pcs and evaluation of data was made by the SPSS program.

Resistance to fungal decay

During our research we made tests according to EN 113 standard, but sometimes we had to depart from it. In case of beech, we grafted mycelia of Turkey tail (*Coriolus versicolor*) to malt-agar soils. Turkey tail is the specie of fungi in the test standard, causing vigorous white rot. In case of Turkey oak, we grafted mycelia of oak maze gill (*Daedalea quercina*) to the soils. It causes brown rot and a common fungus causing decay on oak species. Oak maze gill is not listed in the standard EN 113. We set the sizes of samples according to the volume of the research, so we had to decrease those as compared to the prescribed sizes of the standard's. The sample size was 20 × 20 × 6 mm (tangential × radial × along the grain). The standard test lasts 16 weeks, which was also reduced by us due to the decrease of the sample size and the wood weight placed in one Kolle-flask. So the test duration was 12 weeks, after which the samples still were be able to be measured in whole, without crumbling. According to our tests, cca. 26% of the sapwood and 12% of the heartwood of the natural Turkey oak was decayed by the oak maze gill (*Daedalea quercina*). Modifying effect of the thermal treatment was recognised already in the case of 180℃ treatments, but in case of 200℃ treatments we succ eeded to achieve fungal decay under 3%. Average rate of fungal decay of Turkey oak sapwood can be seen on the fig. 1. left.

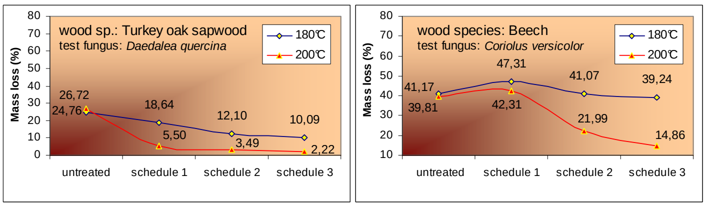

Figure 1. *Average mass loss of Turkey oak sapwood and beech caused by wood destroying fungi (lines are for guiding the eyes)*

In case of beech, treatments on 180℃ didn't show s ignificant changes of the rate of fungal decay. But the schedule 3 on 200℃ caused obvious p rogress against the decay of the Turkey tail (fig. 1. right).

Physical and mechanical properties

Table Nr. 1 illustrates the changes of other tested properties in case of beech and Turkey oak heartwood. Generally it can be stated, that as a result of the physical and chemical changes in the wood during treatment, the treated wood becomes a modified, more compact structure, which is less hygroscopic, and parallel to this, it can be regarded as a less „moving", so called dimension-stable raw material. It can be seen, that the equilibrium moisture content under normal climate (u_e) decreases, and the dimension stability (DS) increases both in radial (r) and tangential (t) direction. During heat transfer, the partial decay of the wood components starts, together with the mass loss and shrinkage as well. Density in normal climate (ρ) showed more than 5% decrease at 200℃. About the degree of degradation, the modified darker colour of wood shows information as well. In the CIELab colour space system, the decrease of lightness (L*) was well recognizable, which showed good correlation to other physical and mechanical properties. The red (a*) component values increased in case of both species, while yellow (b*) component values slightly decreased. As a result of the complex modification the strength properties are changing too.

Generally it can be stated, that the strength modifying effect of the thermal treatment is considerable. While the bending strength (σ_b) and the impact bending strength (w) vigorously decrease, on the other hand the compression strength along the grain (σ_c) increases by more than 25 % in case of beech and by 15-20 % in case of Turkey oak. Swelling anisotropy (a_s) and modulus of bending elasticity (E_b) of timbers slightly decrease, mainly in case of 200℃ treatments.

Table 1. *Physical and mechanical properties of thermally treated Turkey oak and beech*

Properties measured (average values)		u_e (%)	ρ (kg/m³)	L*	a*	b*	DS_t (%)	DS_r (%)	a_s	σ_b (N/mm²)	E_b (N/mm²)	σ_c (N/mm²)	w (J/cm²)
Turkey oak heartwood	untreated	11,70	768,64	69,78	7,52	19,14	-	-	2,54	161,86	14138,10	83,75	10,22
	180°C - schedule 3	9,07	770,24	51,53	10,14	21,77	15,09	5,54	2,19	145,45	14660,96	84,25	7,75
	200°C - schedule 3	7,04	723,64	35,72	7,87	12,71	46,09	40,00	1,98	101,42	13080,16	98,01	6,26
Beech	untreated	12,34	674,05	81,02	5,20	19,23	-	-	2,28	125,95	12498,51	63,29	10,58
	180°C - schedule 3	10,91	672,27	56,16	10,95	22,04	7,80	7,95	2,30	124,85	12652,10	67,08	6,98
	200°C - schedule 3	7,12	613,62	38,34	9,29	15,71	40,16	31,16	2,00	101,13	11175,39	83,64	6,38

Testing the colour differences of sapwood and heartwood of Turkey oak, was recognised, that the total colour difference (ΔE) of the natural wood decreased vigorously after thermal treatment (fig. 2. left). While the total colour difference was 6,83 between the sapwood and heartwood in case of natural Turkey oak, it decreased to 1,77 on 200℃. According to the standard, if ΔE value is higher than 5, it means considerable colour difference, while a value between 1-2 means slight colour difference. It was also recognized, that the heat treatment has favourable effect on the decreasing of colour difference of beech with red heartwood, to a certain extent (fig. 2. right). The colour change of textures at the boundary surfaces of red heartwood is different, which causes an increasing of the inhomogenity in cases of treatments at 200℃. On the right side of the pictu re can be seen well, that certain parts with red heartwood, in the form of lighter stripes, significantly differ from the other textures. The measured value of total colour difference was 6,0 in case of the samples not treated, it decreased to 2,3 after treatment at 180℃, and to 3 ,82 after treatment at 200℃.

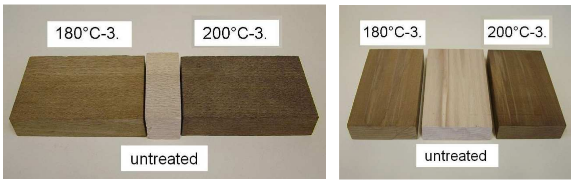

Figure 2. *Colour change of Turkey oak (left) and beech with red heartwood (right)*

Summary

As an effect of the thermal treatment, structure, composition of wood materials is changing during different physical and chemical processes. As a result of the thermal effect the decomposition of chemical substances is starting, the wood material is shrinking and a more compact structure is forming. Due to the removal of –OH hydroxyl groups and spherical reasons, the higroscopy of the structure is decreasing, so the equilibrium moisture is also decreasing. As a result of this, dimension stability of thermal treated timber is increasing (NÉMETH 1998).

Based on our tests, it can be stated, that the rate of fungal decay may be decreased by thermal treatment and so the fungal decay resistance of these two species can be increased. It may result new outdoor applications of these materials, such as outdoor floorings, wall covers, etc. Thermal treatment has a favourable modifying effect on the colours, it not only enables the reaching of darker shades of wood, but it may decrease the colour differences of certain wood parts.

The modified colour changes on the effect of UV, similarly to the not treated wood (PATZELT et al. 2002).

Strength values have an important role when reaching the required colour, as those have significant influence of the durability of the future product. Changes of strength led us to the conclusion, that the colour modifying treatments should be made at the lowest possible temperature in order to meet the requirements for the future product. However we have to emphasize the fact that we carried out our treatments in normal atmospheric air, which is favourable for the oxidative decomposition processes. Selecting suitable treating agent is a key factor, having effect on the quality of the final product, on the degree of degradation of the wood, and on the costs, environmental effect etc. of the technology.

The experimental development was realized in the framework of the "Chemical-free wood preservation" project, at the site of SOKON Co ltd. As a result of the experimental development, a 10 m³ volume vacuum drying kiln and a same size thermal treatment plant was developed.

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References:

NÉMETH, K. (1998): A faanyag degradációja. Mezőgazdasági Szaktudás Kiadó, Budapest
PATZELT, M. – STINGL, R. – TEISCHINGER, A. (2002): Thermische Modifikation von Holz und deren Einfluss auf ausgewählte Holzeigenschaften. Modifiziertes Holz –Eigenschaften und Märkte Band 3, VHÖ/IHF, BOKU Wien, 101-147
EN 113 Norm – Test method for determining the protective effectiveness against wood destroying

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