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UTILIZATION POSSIBILITIES OF POPLAR SPECIES IN PARQUET PRODUCTION IN ASPECT OF WOOD SCIENCE

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ABSTRACT

In the three-layer parquet production, emerging demand has been shown for wood species having similar properties to pines', which can be suitable for middle core material and could possibly be applied as a top layer as well. Because of its pine like mechanical and physical properties, steamed 'Pannonia' poplar hybrid (*Populus x euramericana* cv. 'Pannonia') was chosen as possible alternative. Comprehensive physical and mechanical tests have proven that steaming significantly decreases shrinkage anisotropy of poplar wood and it provides higher tensile strength for click-locks of parquet by applying steamed poplar as middle core. However, according to the analysis of mechanical properties, it can be stated that 'Pannónia' poplar wood is not suitable for top layer production without further modification because of its inadequate hardness.

KEYWORDS: Parquet production, three-layer parquet, Pannonia poplar, modification, click-lock.

INTRODUCTION

Utilization and production of traditional hardwood parquet sank by the turn of the millennium because of its high labour costs. Contrary, market share of the multi-layer parquet increased, of which nowadays the most popular and well-known is the three-layer parquet (Molnár and Várkonyi 2007).

Detailed description of the effect of steaming on physical properties of wood material can be found in technical literature, as for example Sullivan (1966), Varga and van der Zee (2008). Dessewffyné (1964) was steamed black locust and she analyzed the mechanical properties and the color change. Richter and Kühl (1998) said that color change of black locust is caused by the dissolve of extract materials. The temperature, the pressure and duration of steaming of wood are very important factor in color changing (Kollmann 1951). For most species (for example black locust and cherry) steaming produce significant color change and the color of the wood become homogenous (Dianiskova et al. 2008). The black locust has a very intensive color changing at the beginning of steaming, later it decreases (Tolvaj et al. 2010). Whereas the test of poplar showed, that the steaming caused hardly color change (Tolvaj 2005).

In Europe, back layer and middle core of the three-layer parquet are usually made of pine wood. After 2000, due to the changes on the market it is more difficult and expensive to purchase good quality pinewood raw material. Consequently there has been an increasing demand for a similar wood raw material purchased more easily and cheaply, and, which could be a substitute for spruce (*Picea abies*) i.e. the back layer and middle core of the three-layer parquet. The latest tests show that knots have weaker effects on strength in case of poplar than in case of pine species (Komán and Fehér 2011) moreover its mechanical properties can be improved by densification and pressing (Ábrahám et al. 2010). As a result, Pannonia poplar was chosen to be the substitute of spruce. Besides, there will be enough supply of Pannonia poplar raw material in Hungary as the rate of its sapling propagation was 43.9 % in 2003, followed by 1-214 Italian poplar, 28.2 % (Tóth 2006).

Pressing is widely used in the manufacturing technology of three-layer parquet resulting in certain degree of thermal treatment and densification. It was also a part of our research to find out whether these routine-like technological modifications improve the physical and mechanical properties of wood raw material from the aspect of parquet production, and if so, to what extent.

MATERIAL AND METHODS

Our research was started in two ways. One was focused on testing poplar species used for parquet production as a raw material; the other dealt with three layer parquet as end product. For investigating finished parquet, samples of three-layer parquets made of different wood materials were tested. The used species were sessile oak, spruce and Pannonia poplar. Altogether, there were test samples with seven different layer structures.

1. oak top-spruce middle core - spruce back layer (O-S-S)
2. oak top-spruce middle core - poplar back layer (O-S-P)
3. oak top-poplar middle core - spruce back layer (O-P-S)
4. oak top-poplar middle core - poplar back layer (O-P-P)
5. poplar top-poplar middle core - spruce back layer (P-P-S)
6. poplar top-spruce middle core – spruce back layer (P-S-S)
7. poplar top-spruce middle core - poplar back layer (P-S-P)

Technological data used during parquet production were as follows:

Pressure load:	118 $N.cm^{-2}$
Pressing time:	285 sec
Pressing temperature:	51-52°C
Glue:	KOR-LOK 700 (6FK 501) (D3 dispersion glue)
Glue convey-up:	top layer 136 g low layer 122 g
Moisture content of poplar:	middle core: 4.5-8.3 %
Moisture content of spruce plywood:	5.8-7.0 %

Physical and mechanical properties were tested on four different set of poplar samples: control (c), pressed (p), steamed-control (sc), and steamed-pressed (sp). Test samples were made of twenty-five-year old wood. The temperature of the 6-day steaming was 95°C.

Density, shrinkage anisotropy, bending properties including MOR and MOE of poplar control (pc) and different modified poplar raw materials were measured. Click lock strength of finished parquet was also investigated by testing its tensile properties.

Physical and mechanical properties of wood material were tested on 25 samples with a dimension of 20x20x300 mm. 24 samples with a size of 14x42x330 mm were used to test finished parquets in case of all the seven types

1. Density has significant importance among raw material's properties; it can be considered as a universal physical parameter. Further conclusions can be draw on other properties of wood from it. According to the related standards, its testing is evidently required. (Sitkei 1994, Molnár 2000).
2. Natural shrinkage and swelling of wood material and its anisotropy are among the most important properties from the aspect of parquet production. Tests were carried out on test samples.
3. Static bending strength tested on finished products is the most important strength property of the parquet elements. In case of longer parquet elements, this kind of stress arises in parquet elements intensively depending on unevenness of the floor or the distance of bridging joins used in case of sports parquet systems.
4. Tension tests of click lock show how the fitted parquet behaves when click lock is affected by tension load occurring during shrinkage in the middle core. Tests were carried out on samples sized 25x300 mm.

RESULTS AND DISCUSSION

Density

Analyzing the data of the Tab. 1, it can be seen that density of the pressed raw material is higher (0.430 g.cm^{-3}) than that of the control material (0.419 g.cm^{-3}). The difference is rather small but it can be stated that pressing increases the density of wood. During steaming of the raw material, it is clear (Németh et al. 2009a, b) that the density decreases by 3.6 % in average according to our survey data from 0.419 g.cm^{-3} down to 0.404 g.cm^{-3}. It is due to leaching of the extract materials. Density of such wood increases after pressing at a significantly higher rate than that of unsteamed and unpressed control material. Presumably, this minimal 1 % growth in density could be more significantly increased with stronger densification.

Tab. 1: Density of untreated and steamed raw material, u=12 % (g.cm^{-3}).

	Control (c)	Pressed (p)	Steamed (s)	Steamed-pressed (sp)
Min.	0.387	0.371	0.349	0.351
Max.	0.477	0.483	0.484	0.499
Average	0.419	0.430	0.404	0.423
Std. deviation	0.022	0.023	0.035	0.044
Coeff. of Var. (%)	5.320	5.257	8.588	10.340

Shrinkage, expansion and anisotropy

Analyzing the survey data of volumetric shrinkage (Tab. 2), a significant increase can be realized after both pressing and steaming. The average volumetric shrinkage degree of pressed wood (11.78 %) is better than that of the control (12.14 %), and just a little lower than that of the pressed-control (pc) test sample, 11.54 % (Tab. 3). It clearly shows that streaming improves shrinkage characteristics of wood more significantly than densification of the same degree. According to the test results, pressing improves the level of shrinkage by 3 % while steaming by 5 %.

Tab. 2: Values of volumetric shrinkage (%).

	Control (c)	Pressed (p)	Steamed (s)	Steamed-pressed (sp)
Min.	10.60	9.69	8.87	9.55
Max.	13.66	13.22	13.32	13.61
Average	12.14	11.78	11.54	11.73
Std. deviation	0.78	0.91	1.08	1.11
Coeff. of Var. (%)	6.45	7.71	9.39	9.44

Tab. 3: Anisotropic values of untreated and steamed base material.

	Control (c)	Pressed (p)	Steamed (s)	Steamed-pressed (sp)
Min.	1.02	1.02	1.02	1.01
Max.	2.83	3.3	3.11	2.7
Average	1.92	1.6	1.53	1.8
Std. deviation	0.52	0.61	0.44	0.46
Coeff. of Var. (%)	27.11	37.93	28.35	25.45

Average volumetric shrinkage value of the steamed and pressed wood is 11.73 %, which could be connected to the decreasing amount of moisture found in the cell walls of wood.

The test data of shrinkage anisotropy (Fig. 1) show that none of the test sample groups' values reach the value of 2 which means that propensity for warping can be acceptable from the aspect of parquet production. Considering the relation of these values, it can be stated that steaming significantly decreases the anisotropy. The same can be stated about the effect of densification.

Standard deviation of survey data of the pressed raw material is 37.93 % (Tab. 3). It indicates that we cannot rely on the improvement approached by densification; i.e. a higher level of propensity for warping is expected.

Static bending strength

Analyzing the average values of 3 layer parquets with different structure (Tab. 4), it can be seen that the three test samples with the lowest static bending strength were made with poplar back layer. This value is 39.69 MPa for the P-S-P, 42.20 MPa for the O-S-P and 46.11 MPa for the O-P-P structure, i.e. the structure of O-S-S (51.97 MPa) is 23 % better in average than the O-S-P (42.20 MPa).

Bearing capacity of the back layer is the most important property of the three-layer structures in case of bending stress. Considering the top- and middle core, no substantial advantage or

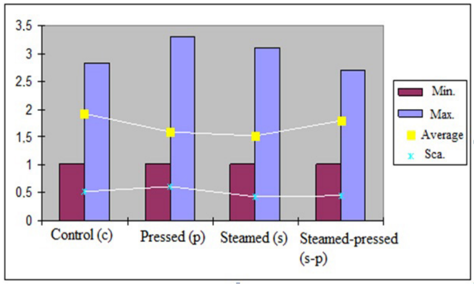

Fig. 1: Effect of the treatment on the shrinkage anisotropy.

Tab. 4: MOR values of floating parquets with different structure.

Bending strength (MPa)							
	O-P-P	**O-P-S**	**O-S-P**	**P-P-S**	**P-S-S**	**O-S-S**	**P-S-P**
Min.	33.28	28.35	25.89	30.41	28.76	31.23	25.48
Max.	69.03	61.22	56.70	60.40	56.70	67.80	56.70
Average	46.11	46.72	42.20	48.99	48.35	51.97	39.69
Std. deviation	9.90	9.13	8.57	7.19	7.23	10.96	8.45
Coeff. of Var. (%)	21.46	19.54	20.31	14.67	14.94	21.09	21.29

disadvantage can be distinguished that would depend on the species because load occurring in these layers during the bending test is not so significant. However, there is a big load in the top layer but lamella-pieces cannot transmit them.

The variance values (14.67 % and 21.46 %) are striking. It is due to the complex structure of the test samples. For instance, the coincidence of gaps in lengthening of the top layer and lath elements of the middle core, or knots in back layer can significantly affect bending strength of the test sample.

Tensile strength of click lock

The samples with poplar middle core seemed to be stronger than those with spruce middle core during testing the tensile strength. Analyzing the values in column 2 and 4 of the Tab. 5 and the value of real length of click-lock/mm, it is clear that this value in the test sample with poplar middle core is approximately 13 % higher than that of spruce (20.7 %).

Although variation values are rather high (14.74 % and 17.68 %), it is due to the unsuitable measuring device, the clamping parts that were not produced for such measurement and because of the short (ca 25 mm) click-lock in the test samples, which can cause significant differences between gaps of lath elements of middle core or the physical properties of the lath in middle core. Technically we had no chance of using longer test samples. During the testing procedure test samples with spruce middle core stuck out of their flush several times.

Based on our data mentioned above, it can be presumed that parquet with a poplar middle core is less likely to form jointing than those with spruce core. Further research is needed to prove it or analyze differences between click-locks in poplar and spruce.

Tab. 5: Tearing values of click-lock in case of different layer orders.

	O-S-S (N)	**O-S-S ($N.mm^{-1}$)**	**O-P-S (N)**	**O-P-S ($N.mm^{-1}$)**
Min.	322.80	12.68	350.80	12.57
Max.	635.00	25.29	738.00	29.62
Average	520.23	20.77	588.13	23.38
Std. deviation	87.09	3.47	86.71	4.14
Coeff. of Var. (%)	16.74	16.69	14.74	17.68

CONCLUSIONS

When steaming the raw material, its density decreases probably due to the leaching of extract materials. Density of this lower density-level wood increases during pressing to a higher level than in case of the unsteamed one; consequently it has more favourable density than the unsteamed and undensified control sample.

Volumetric shrinkage falls by 3 % during pressing, while it decreases by 5 % during streaming.

The average value of anisotropy is bellow the value of 2 in each test samples; that means Pannonia poplar is suitable for parquet production considering its propensity for warping. However, both its densification and streaming improves this property which is important in floor covering.

It was proved that static bending strength of the three-layer parquet with poplar back layer is much lower than that of parquet with spruce back layer.

Click-lock in oak parquet with poplar middle core can be assumed to bear higher tensile strength suffering no harm; moreover it is less propensive for sticking out of its flush and it is less likely to form jointings than spruce.

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