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THE INFLUENCE OF TEMPERATURE ON THE SHRINKAGE OF WHITE POPLAR VENEERS

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Abstract:

The paper highlights some aspects of the influence of temperature on the shrinkage of white poplar veneers. Emphasis is placed on research methodology. Since larger sizes of veneers increases the accuracy of the measurement of shrinkage, current dimensions of specimens in the study were 100×100×3mm; larger than for solid wood specimens of 20×20×100mm, especially in the tangential direction (100mm versus 20mm). Shrinkage was determined in the radial direction as the thickness of veneers and in the tangential direction as the width of veneers. Some comparisons with shrinkage of solid wood are given and some similarities were found. A general tendency of low decrease of shrinkage was found. Differences in veneer shrinkage between 80 – 95^{0}C temperature (low increase) and 95-120^{0}C (low decrease) were also found. The background to some aspects of poplar and shrinkage are presented.

Key words*: poplar; veneer; shrinkage; temperature.*

INTRODUCTION

White poplar *Populus alba* L is a fast-growing deciduous tree (along with other species such as willow, acacia etc.), which reaches 20 to 30m in height. White poplar should be grown in full sun and tolerates almost any soil, wet or dry (Gilman and Watson 1994). Poplars are early maturing species (about 35-40 years) in temperate regions. They represent a potentially large source for timber production and biomass for fuels. Poplar wood, which is light white in colour (one the whitest woods), has no smell or taste, is easy to process and has been widely used for many years. Some of its most important uses are in veneer, plywood, matches and match boxes, pulp, paper and cellulose products. Data needed for the improvement of wood properties includes wood shrinkage as one of the selection criteria (Kord *et al*. 2010).

Recently some environmental studies have been made for phytoremediation of land or household waste polluted with heavy metals, nitrogen, or phosphorus. Some species, including poplar are used to produce biomass and to reduce phreatic groundwater pollution. Also, poplar groves in meadows and riverside coppice, totalling over 200,000ha in Romania are valuable sources of nectar and pollen for beekeepers (Scribd 2012). There are some chemical changes and modifications in the cell wall during heating that play an important role in wood hygroscopy. Other previous studies have shown that wood shrinkage decreases with heat treatment (Nazerian *et al*. 2011).

Shrinkage may occur in wood when the moisture content is changed (Fengyan 2010), namely as moisture content decreases. Dimensional changes and shrinkage are not equal in all directions. The greatest dimensional change occurs in a direction tangential to the growth rings. Radially shrinkage is usually considerably less than tangential shrinkage (about half), while longitudinal (along the grain) shrinkage is so slight as to be usually neglected. The shrinkage is about 5% to 10% in the tangential direction and about 2% to 6% in the radial direction (Wikipedia 2012, Wood Fuel Handbook 2013, Eckelman 2012).

Other results (Kollmann and Cote 1968) showed that the coefficient of wood shrinkage is higher at low temperatures. This coefficient firstly decreases and then increases as drying temperature increases. It can be stated that there is a constant decreasing curve for beech and for resinous species. The general rule of slightly decreasing shrinkage is observed but slightly increasing up to 90^0C and slightly decreasing after that (Sitova 1970). The general rule of a slight decrease of shrinkage is observed but with a slight increase up to 90^0C and slightly decreasing after that (Sitova 1970). Differential transverse shrinkage of wood is influenced by wood rays, the features of the cell wall structure such as micro-fibril angle modifications and pits and the chemical composition of the middle lamella.

No significant data were found in the scientific literature on shrinkage of veneers.

OBJECTIVES

The main objective of this paper was to find out the influence of temperature on shrinkage of poplar veneers. Shrinkage of solid wood for White poplar is difficult to determine in the tangential and radial directions, because of the indistinct structure of this species (it is a species with uniform diffused pores, annual rings are not well distinguished and there is no visible tangential and radial direction). Because constructional veneers are produced by rotary peeling, they have the tangential direction on the width and the radial on the thickness. Therefore constructional veneers were chosen to determine tangential and radial shrinkage of White poplar.

MATERIALS, METHODS AND EQUIPMENT

Veneers were cut on a laboratory Mihoma rotary cutting lathe, with an opening dimension of 1.2m. Veneers were peeled after heat treatment and debarking. Veneer sheets were trimmed on a guillotine cutter to dimensions of 100×100mm. Three sets of veneers were selected, two from the end (2×3 pieces) and one from the center (4 pieces), of the width of the sheet, to make a total of 10 pieces.

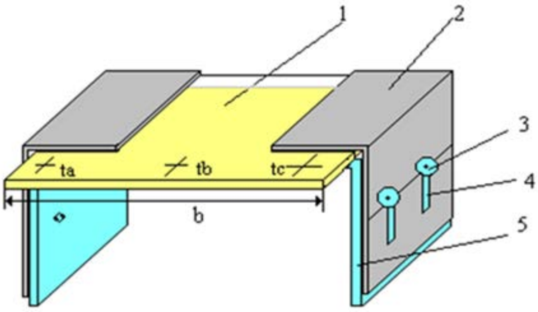

Fig. 1

Device for measuring the veneer width: 1 - veneers; 2 - L profile; 3 - screw; 4 - elongated hole; 5 - U profile; w - width of veneer.

In order to determine shrinkage, veneers were immersed in water for 24 hours to raise them above the fibre saturation point (FSP). Then, the excess water was removed; the sample was inserted into the device (Fig. 1) so as to measure its moist width, w_{max} and moist thickness, t_{max}. This device aims to straighten the undulations and curves of veneers produced especially after drying, in order to obtain good accuracy of measurements. Additionally, the moist mass (m_m) of veneer samples was determined, to demonstrate that the veneer moisture content exceeded FSP, usually over 30% (Fig. 2). After that, each veneer was introduced into an oven, at temperatures of 80, 90, 100, 110 and 120^{0}C, where they were dried to 0% moisture, after which the oven-dry width of veneer, w_0 was determined.

To obtain the anhydrous stare of specimens at temperatures below 100^{0}C, the drying time was increased (48 hours for 80^{0}C and 36 hours for 100^{0}C). Also, in the same way, after the constant value of mass was obtained, drying was continued until the standardized value of 103±2^{0}C was reached, to see if there were differences in mass.

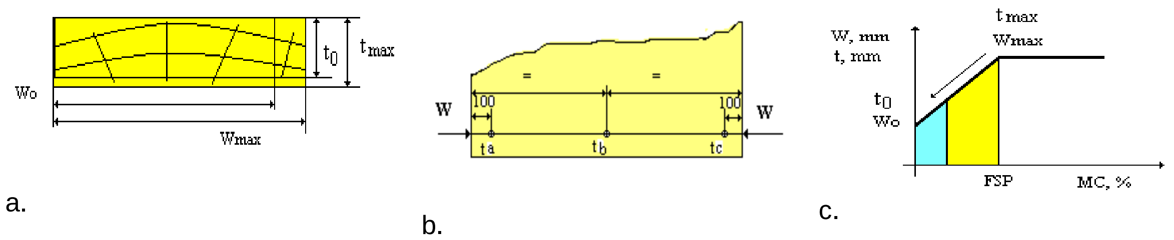

Fig. 2

Shrinkage on width and thickness: a - dimension of shrinkage samples; b - measurement of dimension; c - shrinkage chart; MC - moisture content; FSP - fiber saturation point; W_0-width at 0% MC; W_{max}-width over FSP; t_0-thickness at 0%; t_{max}-moist thickness over FSP; t_a, t_b, t_c -points of thickness measurement.

Also, the oven-dry mass of samples (m_0) and linear thickness (t_0) at the same 3 points were determined. Linear coefficient of shrinkage in the width direction (β_W) and thickness (β_t) are determined as the ratio between the difference in size and its initial size (Eq. 1, Eq. 2):

$$\beta_W = \frac{w_{max} - w_0}{w_{max}} \cdot 100 \ [\%] \quad (1)$$

$$\beta_t = \frac{t_{max} - t_0}{t_{max}} \cdot 100 \ [\%] \quad (2)$$

Moisture content MC of each veneer sample was determined in order to see if it exceeded the fibre saturation point (FSP), taking into account mass in moist sample m_u and the oven-dry mass m_0. In the radial direction, it is the mean of ten values of width w_i (Eq. 3) and in the tangential direction, the relationship for medium shrinkage can be a mean of 3 points (t_a, t_b, t_c) for all 10 samples, as the follow (Eq. 4):

$$\beta_w = \frac{\sum_{i=1}^{10} w_i}{10} \cdot 100 \ [\%] \quad (3)$$

$$\beta_t = \frac{\sum_{i=1}^{10} \left(\frac{t_a + t_b + t_c}{3}\right)_i}{10} \cdot 100 \ [\%] \quad (4)$$

RESULTS AND DISCUSSIONS

After the dimensions of veneers were measured in the width (in tangential direction) and thickness (in radial direction) the shrinkages were determined for each group of samples. Values were tabulated as in Table 1.

Table 1

Result of shrinkage when samples are subjected to a temperature of 80^{0}C

Nr	m_m m_0,g	MC, %	Width, mm		Thickness, mm		β_w	β_t	
			w_{max}	w_0	t_{max}	t_0			
1	33.60 18.68	79.8	113.05	102.81	3.28	3.08	9.05	6.09	6.11
					3.24	3.03		6.48	
					3.29	3.10		5.77	
2	33.93 18.98	78.7	109.83	100.20	3.26	3.09	8.76	5.21	5.25
					3.31	3.14		5.13	
					3.32	3.14		5.42	
3	35.22 19.13	84.1	111.61	101.76	3.32	3.14	8.82	5.42	5.45
					3.34	3.16		5.38	
					3.23	3.05		5.57	
4	34.72 18.55	87.1	109.92	98.84	3.18	2.94	10.08	7.54	6.13
					3.13	2.93		6.38	
					3.12	2.98		4.48	
5	35.92 19.21	86.9	112.59	101.82	3.43	3.13	9.56	8.74	5.57
					3.42	3.28		4.09	
					3.33	3.20		3.90	
6	35.81 19.11	87.3	110.52	100.19	3.40	3.19	9.34	6.17	5.60
					3.41	3.22		5.57	
					3.34	3.17		5.08	
7	39.55 22.26	77.6	114.20	101.70	3.22	3.12	10.94	3.10	5.83
					3.32	3.08		7.22	
					3.34	3.10		7.18	
8	36.67 19.77	80.2	113.25	100.88	3.30	3.11	10.92	5.75	5.90
					3.29	3.10		5.77	
					3.23	3.03		6.19	
9	36.85 20.99	75.5	112.38	100.46	3.30	3.05	10.60	7.57	7.52
					3.36	3.12		7.14	
					3.30	3.04		7.87	
10	30.65 16.99	80.4	113.41	103.43	3.07	2.80	8.79	8.79	6.32
					2.95	2.73		7.45	
					2.94	2.86		2.72	
Mean							9.68	6.08	

The primary data were summarised in Table 2. In this table the volume shrinkage was introduced, calculated from radial and tangential values, with the next relationship (Eq. 4):

$$\beta_v = \beta_t + \beta_r - \frac{\beta_t \cdot \beta_r}{1\quad 0} \tag{4}$$

Table 2

Summary of data of shrinkage values related to temperature

Temperature	Shrinkage on width, β_w, %	Shrinkage on thickness, β_t, %	Shrinkage on volume, β_v, %
t=80 ^{0}C	9.68	5.96	15.17
t=90 ^{0}C	10.18	6.17	15.72
t=100 ^{0}C	9.83	6.08	15.31
t=110 ^{0}C	9.61	6.02	15.05
t=120 ^{0}C	9.60	6.00	15.02
Mean	9.78	6.04	15.25
Ratio, R=β_w/β_t		1.61	

The total volumetric shrinkage value of 15.25% obtained in the paper was close to that provided by the literature (Aebiom 2013) of 13.5%; differences are caused by growth conditions, slope and sun, soil moisture content etc. Results show that there is no single trend of temperature influence on shrinkage, but a slight increase is observed when the temperature increases from 80 to 100^{0}C and a slight decrease when temperature increases from 100 to 110^{0}C. Between 110-120^{0}C, there was not a clear rule of temperature influence, so the temperature of 120^{0}C was removed in Fig. 3. The small ratio R=1.61 between tangential and radial shrinkage shows that White poplar is a homogeneous species, which is normal for a species with uniform scattered pores.

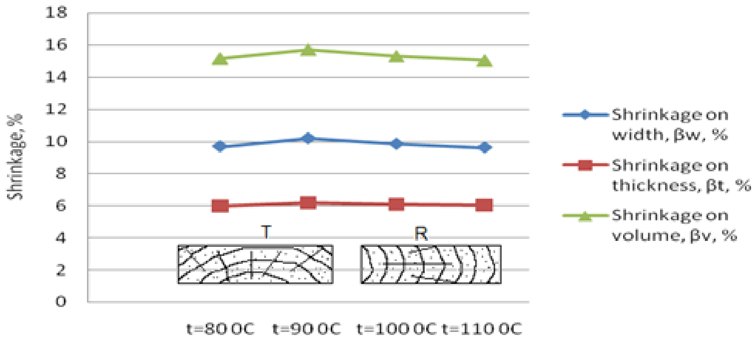

Fig. 3
Influence of temperature upon veneer shrinkage.

The data obtained during the experiment followed the general trend, but there were some exceptions to the general rule for various reasons (Table 3).

Table 3
Tendencies of experimental values for tangential and radial shrinkage

No	Value types	Possible causes	Examples: β_w-β_t	Frequency
1	Extreme values	Veneer with two clearly defined directions	11.22 - 5.93 11.20 - 5.85 11.45 - 6.27	Very high (over 92%)
2	Close values	Veneer with no outlined two directions	8.29 - 6.87 8.24 - 7.46	Sporadically (less than 5%)
3	High values	Veneers with compression wood	11.60 - 8.20 11.00 - 9.17	Sporadically (less than 3%)

Furthermore, it gives an example for the application of research values to establish over-size shrinkage when the timber is cut. The commonly accepted value of the allowance for over-size shrinkage of broad-leaved species is 7% for a range from 30% (FSP) to 0% moisture, which means that the over-size for 30-15% is 3.5%. The moisture content of 15% is considered for expressing the nominal thickness of timber. It is also considered that common pieces of timber are 40, 60 and 80mm, in thickness. These nominal thicknesses are taken into consideration for determining their over-sizes and cutting thicknesses. Based on a common over-size of 3.5%, these nominal thicknesses of timber will have different cutting thicknesses. If the radial and tangential over-size for different drying temperature are taken into consideration the results will be those from Table 4. Note that the differences are almost negligible when the dependence is on temperature, but significantly different when the timber is radially or tangentially cut. For instance if the nominal thickness is 80mm, differences in tangential and radial direction are from 82.46 to 84.07mm (for 90^{0}C), namely 1.61 mm (is high and had to be take into consideration), but inside of the same direction, the differences related to temperatures are smaller, from 82.38 to 82.46mm, namely 0.08mm (is very low, neglectable).

Table 4
Cutting thickness (t_c) related to nominal thickness (t_n) by over-size of timber

Temp/Timber type t_{ct}=(1+ β_t/200)·t_n t_{cr}=(1+ β_w/200)·t_n	t_n=40mm t_c=41.45mm		t_n= 60mm t_c= 62.10mm		t_n= 80mm t_c=82.80mm	
	Tangential t_{ct}	Radial t_{cr}	Tangential t_{ct}	Radial t_{cr}	Tangential t_{ct}	Radial t_{cr}
80 ^{0}C	41.19	41.93	61.78	62.90	82.38	83.87
90 ^{0}C	41.23	42.03	61.85	63.05	82.46	84.07
100 ^{0}C	41.21	41.96	61.82	62.94	82.43	83.93
110 ^{0}C	41.20	41.92	61.80	62.88	82.40	83.84

CONCLUSIONS

In accordance with the objectives set, the paper has completed some investigations into the influence of temperature on shrinkage of poplar veneers. Using constructional veneers obtained by rotary peeling, the tangential and radial directions are displayed and the specific shrinkage can be determined. General results show a slight decrease of shrinkage in the range of 80-110^{0}C drying temperature. Particularly, a slight increase in shrinkage was observed up to 95^{0}C and a slight decrease thereafter, in the range of 95-110^{0}C. Lastly, it must be appreciated that after a certain temperature the wood starts to thermally decompose (especially in the case of veneers, because of the large surface that comes into contact with the high temperature), increasing the amount of removed volatile substances. As a general conclusion, the influence of temperature upon the wood shrinkage is low, and can be neglected. Despite this, it is most important to observe that there is a great difference between shrinkage in the tangential and radial direction, even for a structurally uniform species such as White poplar. This large difference between the axes in wood, forces timber producers to take into account the over-size required in radial and tangential timber, using values and the method from the paper.

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