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Effect of temperature of thermo-mechanical treatment of pine wood (*Pinus sylvestris* L.) veneers upon gloss and wettability

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Abstract: *Effect of temperature of thermo-mechanical treatment of pine wood (Pinus sylvestris* L.*) veneers upon gloss and wettability.* The aim of investigations was determination of gloss and wettability of pine wood veneers after thermo-mechanical treatment. Rotary cut veneer sheets of pine wood and moisture content of 5% were chosen for the experiments. In laboratory hydraulic press was densification at temperatures of 150, 180, and 210°C, pressure 3 MPa, and time 3 min. Gloss of veneers was determined with the photoelectric method with PICO GLOSS apparatus. Wettability measurements were performed microscope methods with the goniometric equipment. It was stated, that temperature of thermo-mechanical treatment influenced on the course of gloss and wettability.

Keywords: pine wood, thermo-mechanical modification, veneer, property, gloss, contact angle

INTRODUCTION

The concept of wood densification dates back to the early 1900s (Kollmann, Fuenzi, Stamm 1975). In recent years there has been a rapid increase in the application of different modification methods to wood and wood matterials (thermal, thermo-mechanical, and thermo-hydro-mechanical treatments) in order to improve their properties (Navi, Girardet 2000, Bekhta, Niemz 2003, Kamke 2006, Bekhta, Marutzky 2007, Bekhta, Hiziroglu, Shepelyuk 2009). Thermo-mechanical (TM) modification allows to obtain matterials with attractive appearance and with higher gloss. This method is very effective and improve a lot of wood parameters such as strength, hardness, dimensional stability and modulus of elasticity. During the last decades, the thermo-mechanical (TM) and thermo-hydro-mechanical (THM) densification of wood has been considered as an effective method to improve the properties of wood (particularly low-density species), such as modulus of elasticity, surface hardness, strength, and dimensional stability. TM/THM densification can also change the surface characteristics of wood (colour, roughness, wettability and surface chemistry). The impact of high temperatures may contribute to the inactivation of wood surfaces, which can cause problems regarding. In some papers of TM/THM densification considered solid wood specimens, and a very few studies have investigated the TM/THM densification of veneer (Bekhta and Marutzky 2007, Bekhta and Marutzky 2007, Bekhta, Niemz, Sedliačik 2012, Bekhta et al. 2014, Bekhta, Proszyk, Krystofiak 2014, Krystofiak, Muszyńska, Bekhta 2014). These methods of treatment can be used for improving properties of materials for veneering processing.

In the literature, there is enough information on the influence of thermo-mechanical treatment on the changes in gloss of densified solid wood specimens. Only it can found studies were performed on solid wood samples during long time treatment. Some authors gives information about influence of TM/THM of wood or veneer upon wettability. There is no information on how densification process applied to wood or veneer for a short period of time would affect its surface quality, particularly gloss changes. Therefore, the purpose of this work was to study the effect of short-term thermo-mechanical (STTM) densification temperature and pressure on the surface gloss and wettability of pine wood veneers.

MATERIALS AND METHODS

Rotary cut veneer sheets of pine wood (*Pinus sylvestris* L.) with dimensions of 300x300x1.5 mm and moisture content of 5 % were chosen for the experiments. Pine wood is used in large quantities especially for construction purposes. Veneer sheets without visible defects were selected. Prior to thermo-mechanical densification, all test specimens were equilibrated at relative humidity of 65 % and temperature of 20°C.

Wood veneer specimens with dimensions 100x100 mm were densified using heat and pressure. In laboratory hydraulic press was densification at temperatures of 150, 180, and 210°C, pressure 3 MPa, and time 3 min.

Investigations of gloss of veneers were determined with the photoelectric method with PICO GLOSS apparatus, model 503 (Erichsen firm). Gloss of non-densified and densified veneer surface was measured at 20, 60 and 85° angles of incident light. Ten measurements were carried out of each sample, 5 along and 5 across the grain. The classification of degrees of gloss together with the verbal evaluation was given in the Table 1.

Tab. 1 Classification of coatings gloss (Anonymous 2003)

Gloss unit (GU)	Verbal evaluation
< 10	matt
10 – 35	half matt
35 – 60	half gloss
60 – 80	gloss
> 80	brilliant gloss

Contact angle measurement of veneers surface after STTM using water as wetting liquid were carried out. Ten drops with volume 3.5 μl of the distilled water were applied with the chromatographic syringe. Measurements were performed after 10 s time with the microscope with the goniometric equipment.

Based on the results of conducted studies surface free energy (γ_S) with the dispersion (γ_S^d) and polar (γ_S^p) shares were calculated. Data for calculations for pine wood were adopted from the literature data (Liptáková, Paprzycki 1983) – γ_S = 64.9 mJ/m^2, γ_S^d = 26.0 mJ/m^2, γ_S^p = 38.9 mJ/m^2.

RESULTS

In the Table 2 results of investigations of gloss of non-densified and densified veneers were presented.

Tab. 2 Results of investigations of gloss of veneers after STTM

Densification temperature [°C]	Arrangement	Angle [°]			Verbal estimation (acc. to scale from Table 1)
		20	60	85	
		GU [-]			
control sample	along	1.1	3.0	4.5	mat
	across	1.0	1.9	3.2	mat
150	along	1.9	7.1	15.5	mat
	across	1.5	5.2	10.1	mat
180	along	1.9	10.2	18.9	half mat
	across	1.4	9.5	14.4	mat
210	along	1.8	12.9	23.4	half mat
	across	1.4	10.2	18.6	half mat

Analysis of the data from the Table 1 it can be stated, that STTM modification had an impact on the gloss of veneer surface. Results obtained across fibres were slightly lower than along fibres. Densification of veneers in the temp. 180 and 210^{o}C allows obtained gloss classified as half matt. It is a reasonable solution to use a 60^{o} or 85^{o} angle of incidence for both matt and glossy surfaces in test measurements. When gloss is measured at a small angle (20^{o}) of incidence, is impossible to distinguish minor surface roughness, since such surfaces appear equally smooth (the light beam glides over the surface). Further research is also needed to establish the quantitative relationships between color, roughness, wettability and gloss of densified wood.
In the Table 3 results of calculation of surface free energy with dispersion and polar shares were presented.

Tab. 3 Influence of densification upon surface free energy of veneers

Densification temperature [^{o}C]	γ_S	γ_S^d	γ_S^p
	[mJ/m^2]		
150	50.64	32.50	18.14
180	44.35	32.74	11.61
210	37.91	31.61	6.30

It was stated, that temperature of STTM modification lowering γ_S from 64.9 to 37.9 mJ/m^2). Similar values of γ_S^d (at the level 31-33 mJ/m^2) were observed while the more sensitive parameter was γ_S^p. Raising the temperature of modification caused a slight decrease of this parameter.

It was stated, that STTM modification causes the growth of hydrophobic properties of the substrate. According to the adsorption theory of adhesion this kind of modification allows obtained surface with worse wettability.

CONCLUSIONS

According to the above presented experimental results, the STTM modification had an impact on the gloss and wettability of veneer surfaces. Generally densification process improves attractiveness of wood surface. It was stated, that with an increasing densification temperature gloss of all the investigated veneers increased slightly. Temperature of STTM modification lowering surface free energy causes the growth of hydrophobic properties of the substrate.

REFERENCES

1. BEKHTA P., HIZIROGLU S, SHEPELYUK O., 2009: Properties of plywood manufactured from compressed veneer as building material, Materials and Design 30; 947-953
2. BEKHTA P., MARUTZKY R., 2007: Reduction of glue consumption in the plywood production by using previously compressed veneer, Holz als Roh und Werkstoff, 65; 87-88
3. BEKHTA P, NIEMZ P., 2003: Effect of high temperature on the change in colour, dimensional stability and mechanical properties of spruce wood, Holzforschung 57; 539–546
4. BEKHTA P., NIEMZ P., SEDLIAČIK J., 2012: Effect of pre-pressing of veneer on the glueability and properties of veneer-based products, European Journal of Wood and Wood Products 70; 99–106
5. BEKHTA P., PROSZYK S., KRYSTOFIAK T., MAMONOVA M., PINKOWSKI G., LIS B, (*in press*): Effect of thermomechanical densification on surface roughness of

wood veneers, Wood Matterial Science & Engineering. DOI 10.1080/17480272.2014.923042
6. BEKHTA P., PROSZYK S., KRYSTOFIAK T., (*in press*): Colour in short-term thermo-mechanically densified veneer of various wood species, European Journal of Wood and Wood Products. DOI 10.1007/s00107-014-0837-1.
7. KAMKE F., 2006: Densified radiate pine for structural composites, Maderas. Ciencia y Tecnologia, 8 (2); 83-92.
8. KOLLMANN F.P., KUENZI E.W., STAMM A.J., 1975: Principles of wood science and technology. Wood-based matterials, vol II. New York, Heidelberg, Berlin: Springer
9. KRYSTOFIAK T., MUSZYŃSKA M., BEKHTA P., 2014: Adhesion of EVA copolymer to pine veneer after thermal-mechanical modification. Proceedings of the 3rd International Conference on Processing Technologies for the Forest and Bio-based Products Industries PTF BPI 2014, 24-26.09.2014, Kuchl, Austria: pp. 4
10. LIPTÁKOVÁ E., PAPRZYCKI O., 1983: Znaczenie zjawisk powierzchniowych w procesie tworzenia się układu drewno-powłoka lakierowa, Przemysł Drzewny, 34 (6); 7-10.
11. NAVI P., GIRARDET F. (2000): Effects of thermo-hydro-mechanical treatment on the structure and properties of wood, Holzforschung, 54; 287-293

Streszczenie: *Wpływ temperatury procesu termo-mechanicznej modyfikacji fornirów z drewna sosny zwyczajnej (Pinus sylvestris* L.*)* na *połysk i zwilżalność.* Celem badań było określenie wpływu temperatury procesu modyfikacji termo-mechanicznej fornirów z drewna sosny zwyczajnej na kształtowanie się połysku i zwilżalności powierzchni. Proces zagęszczania fornirów prowadzono w hydraulicznej prasie laboratoryjnej w temp. 150, 180 i 210^{o}C, ciśnieniu jednostkowym 3 MPa oraz czasie 3 min. Połysk określono metodą fotoelektryczną przy zastosowaniu połyskomierza PICO GLOSS, model 503 prowadząc pomiary przy trzech kątach 20, 65 i 80^{o}, odpowiednio wzdłuż i w poprzek włókien. Pomiary kąta zwilżania wykonano metodą mikroskopową. Na podstawie uzyskanych wartości, wyznaczono swobodną energię powierzchniową wraz z jej składowymi dyspersyjną i polarną. Stwierdzono, że prowadzenie obróbki termomechanicznej fornirów z drewna sosny w temp. 180 i 210^{o}C powoduje zwiększenie stopnia połysku z efektu mat na półmat. Zwiększanie temperatury modyfikacji powodowało obniżanie wartości swobodnej energii powierzchniowej, co wynikało z obniżania składowej polarnej.

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