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EFFECT OF VENEERING MODE ON THE ROUGHNESS OF CHERRY *(PRUNUS AVIUM L.)* VENEERED MEDIUM DENSITY FIBERBOARDS

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Abstract:
The veneering process significantly affects the roughness of the furniture elements. The article investigates the effect of the veneering mode on the roughness of cherry (Prunus avium L.) veneered wood medium-density fiber boards (MDF). Different veneering regimes were carried out with controllable variation of the mode factors temperature and pressing pressure. For this purpose, a two-factor experiment was performed with a change in temperature of pressing from 80 to 200°C and pressure from 0.07 to 0.19MPa. Before venneering process, the veneered surfaces are sanded with P150 sandpaper. The values of basic roughness parameters were measured after each technological treatment, in the same evaluation lengths. Based on the results, graphical dependences between the roughness of the veneered boards and the basic mode parameters are presented. The press pressure does not significantly affect the roughness of the veneer. The combination of high temperature and high press pressure reduced initial surface roughness by 16%.

Key words: *veneering; roughness; cherry veneer; medium density fiberboards (MDF).*

INTRODUCTION

Veneering enables the sustainable use of rare timber species and the use of some timbers which may be difficult to work otherwise. Surfaces of particle board (PB) and medium density fiberboard (MDF) are most often veneered. Medium density fiberboard is one of the most widely used interior wood composite substrates for cabinet and other furniture manufacture (Büyüksarı 2013; Bekhta et al. 2022). Wood veneer is used as prime overlay for MDF to manufacture expensive furniture units (Büyüksarı 2013). The surface of the furniture elements for veneering should be smooth, homogenous and clean out of dust and other contaminants. Veneering is done predominantly with urea-formaldehyde (UF) adhesives prepared with hot-bond hardeners, most commonly ammonium sulfate or ammonium nitrate. There are many factors affecting the performance of aesthetical veneers as well as decorative veneer overlayed wood-based panels (Xiong et al. 2020; Burnard et al. 2019; Rindler et al. 2019; Fang et al. 2021). The presence of many and varied factors that influence the result of veneering in different directions sometimes lead to the formation of defects on the veneered furniture elements. To avoid them, it is often necessary to develop advanced veneering modes. For economic reasons, the temperature and time of pressing are desirable to be as low as possible. The pressing time is the most important one which has to be as short as possible to maximize the process efficiency, but long enough to allow the adhesive curing (Bekhta and Salca 2018). Results of some studies also suggested that press temperature played an important role on surface quality of veneer sheets (Büyüksarı 2013; Büyüksarı et al. 2012; Hakkou et al. 2005; Aydin 2004; Unsal and Candan 2008).

Surface quality of solid wood and wood based panels is one of the most important properties influencing further manufacturing processes such as finishing or their adhesive strength characteristics (Zhong et. al. 2013). The concept of roughness is a very important problem in each wood or wood-based product manufacturing process (Bekhta et al. 2014). The surface roughness of the MDF panels changes according to the general characteristics of the materials used in production, production conditions and machining characteristics (Kılıç et al. 2009). Sanding is the most common method for wood surface machining before varnishing, which ensures sufficient smoothness before application of varnish materials (Williams 1999; Arnold 2010; de Paula et al. 2020; Bekhta et al. 2022). Surface roughness of wood and wood based products can be easily determined as numerical values using different terms employing various techniques (Merrild and Christensen 2009). However there is no established accepted standard method to evaluate the roughness of these products. Stylus, image analyses, optical profilometer and pneumatic methods were used in many studies to evaluate surface quality of solid wood and wood based composite panels (Hirata et al. 2001; Hiziroglu and Graham 1998; Hiziroglu, 1996; Zhong et. al. 2013). The most common instrument for accurate measuring surface roughness is the stylus profilometer (SP), which are currently the most widely used instruments in the mechanical manufacturing industry (Mathia 2011).

OBJECTIVE

The main objective of the present research was to evaluate the surface roughness of cherry (*Prunus avium L.*) veneered MDF, after different veneering modes. For this purpose, veneering regimes were carried out with two controllable variations of the mode factors - temperature and pressure. The roughness of the veneered surfaces was also measured after sanding with P150 sandpaper.

MATERIAL, METHOD, EQUIPMENT

To carry out the experimental work, MDF samples with a density of 750±7%kg/m^3 according to EN 323:1993, with dimensions 220x110x16mm were made. They were veneered with cherry *(Prunus avium L.)* veneer with a thickness of 0.55mm and a density of 480kg/m^3. The initial surface roughness parameters of used veneer are shown in Table 1. Veneering was done on a hydraulic press with a pressure time of 3 minutes. The press has four hydraulic cylinders with a diameter of 40mm. The degree of loading on the press was 40%. Two-factor experiment was performed with a change in temperature of the heating plates *t* from 80 to 200°C and press pressure (specific pressing power) *q* from 0.07 to 0.19MPa. To determine the influence of those veneering mode parameters on the surface roughness, a method of regression analysis was used. The variable factors vary at three levels: maximum (+1), medium (0) and minimum (-1). On this basis, a matrix composition plan of G. Box (Box et al. 1951) has been designed and performed (Table 1). QSTATLAB software was used for modelling. The factors with a lower influence on the surface roughness have constant values and are considered beneficial for the veneering process.

The veneering with urea formaldehyde glue, spread of 120g/m^2 were conditioned for 72 hours at a temperature of 18°C and a humidity of 60%, in order to obtain a constant moisture content of 10%. After measuring the surface roughness of the veneered test pieces, they were sanded on a wide belt sander. Sanding with sandpaper P150 was carried out in the following parameters: feed speed - 6m/min; cutting speed - 12m/s; sanding pressure – 0.15MPa.

Table 1

Initial surface roughness of cherry veneer and matrix compositional plan (values of the variable parameters)

Veneering mode №	Initial surface roughness parameters of cherry veneer (*Prunus avium L.*)				The variable parameters of veneering mode	
	R_a [μm]	R_k [μm]	R_{pk} [μm]	R_{vk} [μm]	$x_1 \equiv t$ [°C]	$x_2 \equiv q$ [MPa]
1	16.73	52.22	17.41	26.44	80 (-1)	0.07 (-1)
2	17.39	55.29	18.13	32.47	140 (0)	0.07(-1)
3	17.76	55.44	21.56	26.67	200 (1)	0.07 (-1)
4	16.82	55.05	17.73	25.77	80 (-1)	0.13 (0)
5	19.21	62.75	21.34	29.72	140 (0)	0.13 (0)
6	17.61	55.37	18.27	32.09	200 (1)	0.13 (0)
7	14.41	42.39	15.22	25.99	80 (-1)	0.19 (1)
8	13.62	39.12	11.47	29.58	140 (0)	0.19 (1)
9	13.10	37.76	12.27	27.87	200 (1)	0.19 (1)

Surface roughness of veneer and veneered samples was measured using a stylus type equipment. The Mitutoyo SJ-210 surface roughness measurer (Mitutoyo Japan) was used to indicate the surface roughness at the following settings: profile – *R* (radius - 5µm), filter-Gauss; number of segments, *N* - 6; cut-off length, λc – 2.5mm; measuring speed – 0.25mm/s. The measurements were made perpendicular to the wood grains. The surface parameter arithmetic mean deviation of the assessed profile (R_a) was estimated according to ISO 4287:1997. Roughness depth (R_k), reduced peak height (R_{pk}), as well as reduced valley depths (R_{vk}) were conducted accourding to ISO 13565-2:1996. The thickness of the veneered MDF samples was determined using a micrometer with an accuracy of 0.01mm.

RESULTS AND DISCUSSION

Fig. 1 shows the test specimens after sanding. In the samples treated at a temperature of 200°C (№ 3, № 6 and № 9), a change in colour can be seen.

Fig. 1.
Test specimens after sanding.

The surface roughness parameters of veneered samples obtained from the experimental test are shown in Table 2. The table presents data on the roughness after veneering and after subsequent sanding of the test bodies with P150 sandpaper. In general, the roughness parameters after sanding are simular in value, as the average value of R_a is 5.3μm. In practice, the sanding of the veneered samples equalizes the differences in the roughness of the surfaces obtained by carrying out the experimental veneering modes. In this regard, only the roughness data of the surfaces after veneer pressing (veneering) will be analyzed.

Table 2

Average values from the experimental test

№	Arithmetic mean deviation, R_a [μm]		Roughness depth, R_k [μm]		Reduced peak height, R_{pk} [μm]		Reduced valley depths, R_{vk} [μm]	
	After pressing	After sanding	After pressing	After sanding	After pressing	After sanding	After pressing	After sanding
1	16.39	5.12	53.90	14.45	16.13	5.64	26.96	12.48
2	16.59	5.08	49.91	15.38	9.76	4.97	29.05	13.93
3	13.58	6.24	50.91	14.37	10.21	4.86	29.11	11.89
4	15.76	5.39	52.94	14.31	13.99	6	28.23	13.98
5	16.06	4.88	53.71	14.60	8.75	5.91	27.92	12.31
6	11.54	5.31	53.35	14.92	11.15	6.43	25.92	11.03
7	16.21	4.96	42.68	16.75	9.78	6.62	26.47	17.43
8	16.62	4.95	34.06	14.81	5.4	7.42	26.45	11.60
9	11.01	5.81	31.86	17.45	6.99	5.72	26.73	13.75

The second-order equations and for the investigated parameters after pressing are as follows:

$$Ra = 16 - 2.04x_1 - 0.45x_2 - 2.34x_1^2 + 0.6x_2^2 - 0.6x_1x_2 \quad (1)$$
$$Rpk = 9.03 - 2.32x_1 - 1.93x_2 - 1.59x_1^2 + 3.41x_2^2 - 0.78x_1x_2 \quad (2)$$
$$Rk = 52.19 - 7.69x_1 - 2.23x_2 - 9.45x_1^2 + 1.71x_2^2 - 1.96x_1x_2 \quad (3)$$
$$Rvk = 27.45 - 0.91x_1 + 0.23x_2 + 0.53x_1^2 - 0.78x_2^2 - 0.47x_1x_2 \quad (4)$$

Based on Eq. 1, the dependence of R_a on the variable parameters of the veneering mode is presented in Fig. 2. From the model, it is seen that the change in temperature of the heating plates (x_1) has sufficient effect on the arithmetic mean deviation R_a. The coefficients in front of x_2 have relatively small values and reflect the relatively weaker influence of press pressure (q) on R_a. A similar dependence is represented by Eq. 3 for Roughness depth R_k. In the surface layer reflected by the model of the parameter R_{pk} (Eq. 2) the coefficients in front of the variables x_1 and x_2 are commensurable, which shows that both factors influence the parameter value. In the last equation presented, all the coefficients in front of the variables are insignificant, which means that both factors have no effect on the R_{vk} parameter values. The large values of the free coefficient in Eq. 1, 3 and 4 reflect the significant influence of the structure of the wood base on its roughness. In Eq. 2, the free coefficient has a smaller value due to the influence of the surface of the heating plates.

Fig. 2 shows the relationship between the arithmetic mean deviation R_a and the temperature of the heating (*t*) plates during the veneering of MDF with cherry veneer in the observed range.

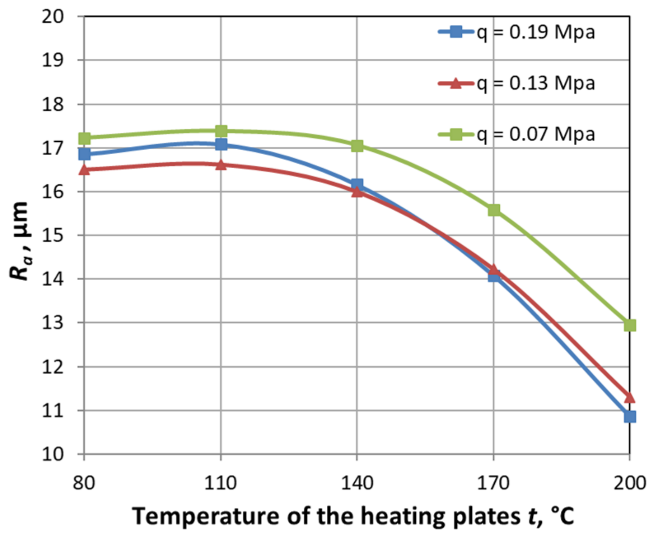

Fig. 2.
Effect of the temperature of the heating plates q and the press pressure q on the arithmetic mean deviation R_a of veneered MDF with cherry veneer.

A significant reduction in the roughness of the veneer surface occurs at temperatures above 140°C. This is due to the plasticization of the wood and the onset of permanent deformations in the surface layer (Eq. 2, 3). The combination of high temperature and high press pressure led to a 16% reduction in initial surface roughness. The increase in temperature (140 ÷ 200°C) and pressure (0.19MPa), on the other hand, causes considerable compression of the samples, resulting in a 2.3% reduction in initial thickness. It means that the reduction in surface roughness is caused by densification of the surface layer in addition to general densification of the samples.

Increasing the press pressure from 0.13 to 0.19MPa does not significantly affect the roughness of the veneer (Fig. 2). Low-pressure veneering (0.07MPa) does not result in changes in the thickness of the samples, even at temperatures of 200°C. At the same time, at high temperature (200°C), a significant reduction (23%) in the roughness of the veneer can be achieved. However, in most cases, the appearance and roughness of the veneer after veneering do not meet the requirements for applying protective-decorative coatings. This means that sanding is required, and low surface roughness characteristics can be obtained (Table 2). In this case, it is not necessary to achieve low roughness by pressing the veneer.

CONCLUSIONS

The results of this study showed that different modifications in veneering modes can result in a significant reduction in the roughness of veneered MDF. The temperature of the heating plates is the determining factor on the roughness parameters of the veneer surface. At temperatures exceeding 140°C, the roughness of the veneer surface rapidly decreases. The increase in temperature and pressure compresses the samples significantly, leading to a decrease in initial thickness. The press pressure does not significantly affect the roughness of the veneer. The combination of high temperature and high press pressure reduced initial surface roughness by 16%. However, the appearance and roughness of the veneer after veneering do not meet the requirements for applying protective-decorative coatings. The sanding of the veneered samples equalizes the differences in the roughness of the surfaces obtained by carrying out the experimental veneering modes.

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REFERENCES

Arnold M (2010) Planing and sanding of wood surfaces - Effects on surface properties and coating performance. In Proceedings of the PRA's 7th International Woodcoatings Congress "Reducing the Environmental Footprint", Amsterdam, The Netherlands, 12-13 October 2010.

Aydin I (2004) Activation of wood surfaces for glue bonds by mechanical pre-treatment and its effects on some properties of veneer surfaces and plywood panels. Applied surface science, 233(1-4):268-274.

Bekhta P, Proszyk S, Krystofiak T, Mamonova M, Pinkowski G, Lis B (2014) Effect of thermomechanical densification on surface roughness of wood veneers. Wood Material Science & Engineering, 9(4):233-245.

Bekhta P, Salca EA (2018) Influence of veneer densification on the shear strength and temperature behavior inside the plywood during hot press. Construction and building materials, 162:20-26.

Bekhta P, Lis B, Krystofiak T, Tokarczyk M, Bekhta N (2022) Gloss of varnished MDF panels veneered with sanded and thermally compressed veneer. Coatings, 12(7):913.

Burnard M, Leavengood S, Muszynski L, Ganio L (2019) Investigating Face Veneer Check Development in Decorative Plywood Panels: The Impact of Four Common Manufacturing Factors. Eur. J. Wood Wood Prod. 77:961–979.

Büyüksarı Ü, Hiziroglu S, Akkılıç H, Ayrılmış N (2012) Mechanical and physical properties of medium density fiberboard panels laminated with thermally compressed veneer. Composites Part B: Engineering, 43(2):110-114.

Büyüksarı Ü (2013) Surface characteristics and hardness of MDF panels laminated with thermally compressed veneer. Composites Part B: Engineering, 44(1):675-678.

Box GEP, Wilson KB (1951) On the experimental attainment of optimum conditions. Journal of the Royal Statistical Society, Series B13:1-45.

de Paula MH, de Mesquita RRS, Costa MDA, Gonçalez JC, Ananías RA, Janin G (2020) Effect of applying finishing products and sanding on the surface of marupa wood. Maderas. Ciencia y tecnología, 22(1):45-54.

Fang L, Zeng J, Zhang X, Wang D (2021) Effect of Veneer Initial Moisture Content on the Performance of Polyethylene Film Reinforced Decorative Veneer. Forests, 12:102.

Hakkou M, Pétrissans M, Zoulalian A, Gérardin P (2005) Investigation of wood wettability changes during heat treatment on the basis of chemical analysis. Polymer degradation and stability, 89(1):1-5.

Hirata S, Ohta M, Honma Y (2001) Hardness distribution on wood surface. Journal of Wood Science, 47:1-7.

Hiziroglu S (1996) Surface roughness analysis of wood composites: a stylus method. Forest Products Journal, 46(7,8):67.

Hiziroglu S, Graham M (1998) Effect of press closing time and target thickness on surface roughness of particleboard. Forest Products Journal, 48(3):50.

ISO 13565-2 (1996) Geometrical Product Specifications (GPS) - Surface texture: Profile method; Surfaces having stratified functional properties - Part 2: Height characterization using the linear material ratio curve. International Organization for Standardization, Genève, Switzerland.

ISO 4287 (1997) Geometrical product specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters International Organization for Standardization (ISO), Genève, Switzerland.

Kılıç M, Burdurlu E, Aslan S, Altun S, Tümerdem Ö (2009) The effect of surface roughness on tensile strength of the medium density fiberboard (MDF) overlaid with polyvinyl chloride (PVC). Materials & Design, 30(10):4580-4583.

Mathia T G, Pawlus P, Wieczorowski M (2011) Recent trends in surface metrology. Wear, 271(3-4):494-508.

Merrild H, Christensen TH (2009) Recycling of wood for particle board production: accounting of greenhouse gases and global warming contributions. Waste Management & Research, 27(8):781-788.

Rindler A, Vay O, Hansmann C, Konnerth J (2019) Adhesive-Related Warping of Thin Wooden Bi-Layers. Wood Sci. Technol. 53:1015-1033.

Unsal O, Candan Z (2008) Moisture content, vertical density profile and janka hardness of thermally compressed pine wood panels as a function of press pressure and temperature. Drying Technology, 26(9):1165-1169.

Williams RS (1999) Finishing of wood, Wood Handbook: Wood as an Engineering Material. Madison, WI: USDA Forest Service, Forest Products Laboratory. General Technical Report FPL: 15-1.

Xiong X, Niu Y, Yuan Y, Zhang L (2020) Study on Dimensional Stability of Veneer Rice Straw Particleboard. Coatings 10:558.

Zhong ZW, Hiziroglu S, Chan CTM (2013) Measurement of the surface roughness of wood based materials used in furniture manufacture. Measurement, 46(4):1482-1487.