EVENNESS OF SMOOTHING WOODEN SURFACES VIA LAPPING BY USING DIFFERENT TYPES OF WORKING TOOLS

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Abstract

The article presents and analyses the results from experimental research on the smoothing of veneered boards via lapping. Subject has been the lapping evenness, when we have deviations in the flatness of processed surfaces. The samples are made of double-sided veneered particleboards. It has been used two type of veneers - beech (Fagus sylvatica L.) and iroko (Chlorophora excelsa). The experimental lapping is performed with the use of three types of working tools. It is proven, that a guaranteed 100% flatness can be achieved if such lapping devices are used that have flexible base and ensure at least double pressure impact with the size of linearly distributed load q≥6 kN/m.

Keywords: *smoothing, lapping, veneered particleboards, beech (Fagus sylvatica L.), iroko (Chlorophora excelsa)*

1. INTRODUCTION

The workpiece accuracy and the quality of a created surface can be regarded as an objective indicator of the quality of the created product (Kminiak at al. 2017). Each technological operation leaves characteristic irregularities on the surface, affecting the integrity and usage of the treated surface of the specimen. It is necessary to regard these irregularities both in their macrogeometric and microgeometric aspects (Kvietkova et al. 2015). Among the main factors influencing the surface quality during processing are: the rotational speed of the cutting tool, the cutting speed, the feed rate and the thickness of the outcut layer (Vitchev 2019, Vitchev et al. 2018).

Smoothing is a type of mechanical impact over the treated wood surface aimed at decreasing any available micro roughness on it. Depending on the used way for performing that impact, the smoothing is implemented via cutting or via compression. The lapping of wooden surfaces represents specific type of impact over the processed surface performed via throughfeed pressure sliding of appropriately shaped working instrument. Its active part is a hard smooth edge with a certain curvature radius, which is in tight contact with the processed surface. As a result, irreversible pressure of the tops of the micro roughness is achieved (Angelski and Kavalov 2019). The other studies of contact between wood and metal have examined conditions, such as the friction of wood and metal (Mckenzie and Karpovich 1968, Ohtani at al. 2016), the effect of wood flowability when forming wood with a metal die (Seki at al. 2013).

The smoothing via lapping is perspective method for preparation of the wooden surfaces prior to the application of protective decorative film coating. Our previous research (Angelski at al. 2018, Angelski and Kavalov 2019) has found that for its successful implementation is quite essential the type and construction of the working tool, which will be used. It has been verified that the working tools, which contact area is steel wire with diameter of 2.2 mm, provide much better results upon smoothing. To confirm this conclusion, it is necessary to be explored also what is the impact of the base upon which is the steel wire fixed. Its type determines the evenness of smoothing, especially in those cases when we have deviations in the flatness of processed constructive elements. If the supporting base is hard and during the lapping does not allow changes in the contact area with the detail being under smoothing, then in case of any concave surface there would be interruptions of the contact area. This means practically to have any areas that are not lapped, which will worsen the smoothing evenness. Only if we provide flexible and elastic reaction for the working tool in its contact area, then the occurrence of similar unwanted unevenness could be prevented. The solving of that problem so thus to have implementation of the wooden surface smoothing via lapping in the

manufacturing, it is necessary to establish more appropriate constructions of the working tools. They need to ensure elastic bending of the contact line so thus to guarantee linearly distributed load *q*, regardless of the availability of deviations in the evenness of the processed wooden surface.

The current article presents and analyses the results of the researches conducted in this direction, which purpose is to determine the possibilities for overcoming this problem over the lapping. More specifically, as a subject of the research we have chosen three different in their construction working tools for lapping. They were used to perform the smoothing of sample details made of veneered boards, which have been purposely processed to have concave sections on the flat surface. For the lapping and formation of the contact area, we have used steel wire with diameter 2.2 mm. The choice of working tools was based on the advantages from previously proven researches we have conducted (Angelski and Kavalov 2019): the opportunity for easily applicable elastic bending without any residual deformation; achieving considerably more substantial by size residual compressing on the outer microlayer of the processed detail, due to the little curvature in the contact area.

2. MATERIALS AND METHODS

The samples are prism-shaped parts, made of double-sided veneered particleboards. It has been used two type of veneers - beech (*Fagus sylvatica L.*) and iroko (*Chlorophora excelsa*) with 0.6 mm thickness.

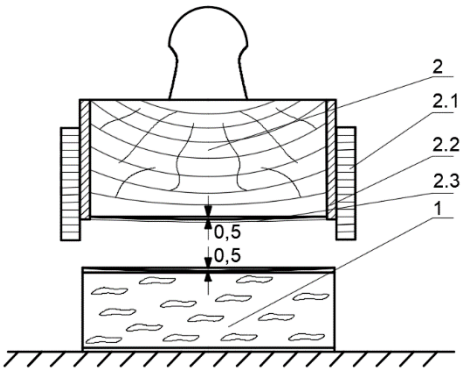

Fig. 1. Cross section of sanding mould (2) for making concave in sample detail (1): 2.1 – Guides for reciprocating motion of the mould; 2.2 – limiter for the sanding level; 2.3 – sandpaper.

Samples were produced with following dimensions 250/50/18 mm. Each sample detail has been sanded with sandpaper № 80. The sanding was made with the support of template mould, that guaranteed equal by shape and deepness curved groove on the veneer surface with maximum arrow of 0.5 mm. Layout scheme for the mould and the position of the groove on the veneer layer after sanding finish is shown on Fig. 1.

The experimental lapping is performed with the use of three types of working tools visualised on Fig. 2. The differences between them are in the way the supporting base is formed, to which is fixed the lapping instrument.

By variant A, the supporting base presents plywood body, where in appropriately shaped channel the wire is sticked. The so shaped construction owns high degree of hardness. Because of that, there are not even the slightest bending of details along the contact line with the concave wooden surface.

By variant B, in the channel on the base is built-in elastic rubber belt with width of 1.2 mm, to which the wire is glued. The belt is precondition for limited flexible displacement of the contact zone during lapping, thus also resulting increased area, along which is pressed the outer microlayer of the veneer. In practice, this means enlarged evenness of the lapping.

By variant C, there are conditions for creating elasticity of the element, from which the supporting base of the lapping tool is created. This can be achieved by transversal cuttings through the supporting body performed as per the scheme shown at Fig. 2C. In this case, the wire is again built in the channel and is glued to the carrier with elastic adhesive layer. The cuttings, which width is 2 mm and withstand at 10 mm from each other, ensure considerably bigger opportunity for easy elastic displacement of the contact line between the working tool and the processed wooden surface. In that way are created preconditions for significant increase of the lapping evenness regardless of the presence of deviations of the flatness on the processed sample details.

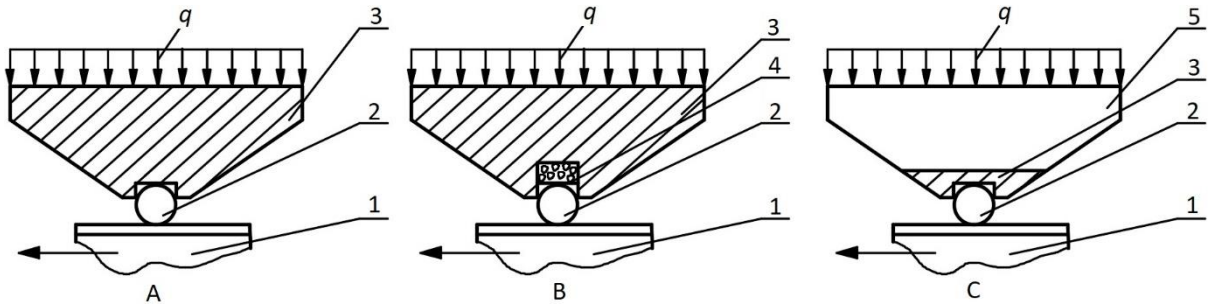

Fig. 2. Segments from cross section parts of the working tools used for experimental lapping: A – hard supporting base; B – semi elastic supporting base; C – flexible supporting base; 1 – sample; 2 – steel wire; 3 – supporting base; 4 – elastic pad; 5 – a transverse slot in the pad; q – linearly distributed pressure load.

The experimental lappings are performed by using a specially prepared for this purpose lapping instrument. It is characterised by the fact that creates possibility for changing the size of the linearly distributed pressure load *q* within the range from 0 till 10 kN/m at adjustable feeding speed. For the needs of the planned study, it was assumed that at constant feeding speed of 6 m/min, *q* varies stepwise: 2, 4, 6 and 8 kN/m. It has been also assumed that at each level of q, 1, 2 or 3 number of lappings (*n*) are performed for the same surface. By increasing *n*, the purpose is to check the possibility of increasing the evenness of the smoothing.

As criteria for quality evaluation of the lapping it was assumed to determine the relative scope of the really lapped surface compared to the whole surface for each sample detail. The differentiation between smoothen and non-smoothen areas is done via visual attestation for the availability of shines (areas with increased gloss), typical for all lapped surfaces. The range of shines is assessed with purposely-prepared instrument. It represents rectangular frame with inner size 70x50 mm, upon which is stretched a grid made of polyethylene sieve with 0.2 mm thick threads, forming square cells with size 5x5 mm. The counted number of cells with increased shine (N_{sh}) are compared to the total number of cells (N) on the frame. The degree of the lapping evenness (E) in percentage is calculated via the formula:

$$E = \frac{N_{sh}.100}{N} \qquad (1)$$

It is assumed that E is rounded to an integer. Scheme presenting the way of determination E by using a frame is shown on Fig. 3.

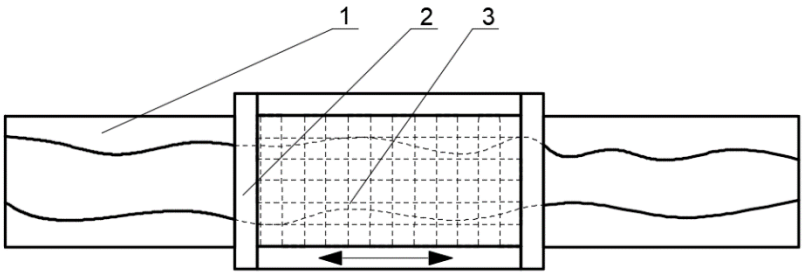

Fig. 3. Determining the evenness of smoothing by usage of frame with plastic sieve: 1 – sample; 2 – frame; 3 – polyethylene sieve.

3. RESULTS AND DISCUSSION

The results from the performed experiments for lapping are presented in tabular and graphical form (Table 1, Fig. 4 and Fig. 5).

Table 1. Summarized data on the evenness of lapping on veneered particleboards with three types of working tools (A, B and C).

***q*,**	**Beech veneer, number of lappings (*n*)**			**Iroko veneer, number of lappings (*n*)**		
kN/m	**1**	**2**	**3**	**1**	**2**	**3**
A – working tool with hard supporting base						
2	16	21	25	13	23	28
4	24	28	32	27	32	40
6	35	39	47	35	37	51
8	42	48	53	44	51	56
B – working tool with semi elastic supporting base						
2	31	40	48	33	42	50
4	37	46	56	38	46	57
6	46	53	61	42	58	63
8	57	66	75	51	56	69
C – working tool with flexible supporting base						
2	77	82	88	74	85	89
4	83	89	95	78	92	95
6	90	100	100	86	95	100
8	100	100	100	100	100	100

Table 1 consists of data for the evenness upon smoothing of sample details, veneered with two type of veneers - beech (Fagus sylvatica L.) and iroko (Chlorophora excelsa), treated by the three types of working tools (variant A, B and C) at variable mode parameters *q* and *n*. As it can be seen from the table, the highest quality of lapping is achieved when using working device from type C. It creates conditions for maximum and most easily achievable flexible change of the line of contact with the actual carved surface of the sample details. The differences in the smoothing produced via all three

lapping devices can be followed on the graphs at Fig. 4. There are comparison of the evenness *E*, calculated as average values from all sample details, subject of lapping with the working tools from type A, B and C. As it might be expected, the lowest degree of evenness (34% for beech and 37% for iroko) is obtained when using the tool with hard base. The degree of evenness when using flexible pad made of rubber belt (type B working device) is by 13% to 17% higher, but it also does not meet the expectations for achieving satisfactory smoothing quality from manufacture point of view. Only by the working tool from type C, where high degree of elasticity of the contact line is obtained, there are all circumstances for high quality smoothing. This is valid for the cases when the deviations in the flatness of the processed particleboards are too big. Another substantial conclusion from the analysis of the graphics on Fig. 4 is that the veneer type in practice does not influence on the choice of appropriate values for the parameters of the regime of smoothing via lapping. It has been proven that the differences in the evenness (*E*) for beech and for iroko veneers are not statistically reliable.

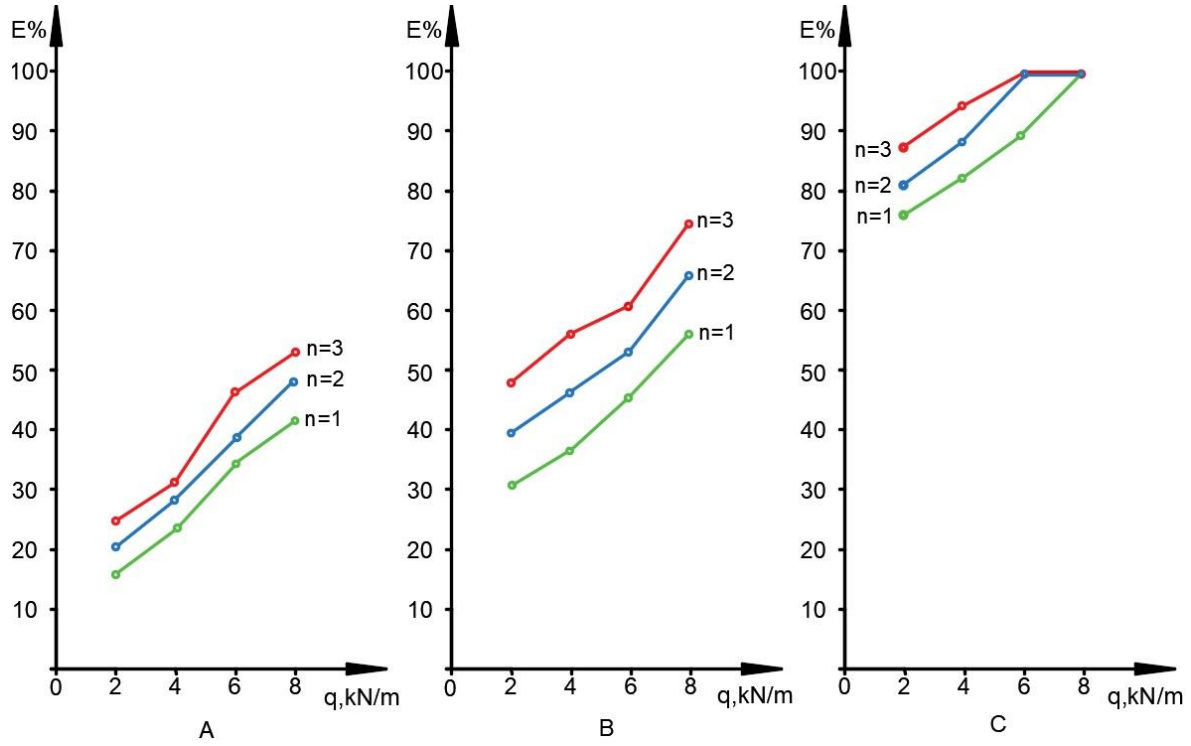

Fig. 4. Average values for evenness of smoothing after 1, 2 or 3 number of lappings in three variants (A, B and C) for veneered (beech and iroko veneer) samples.

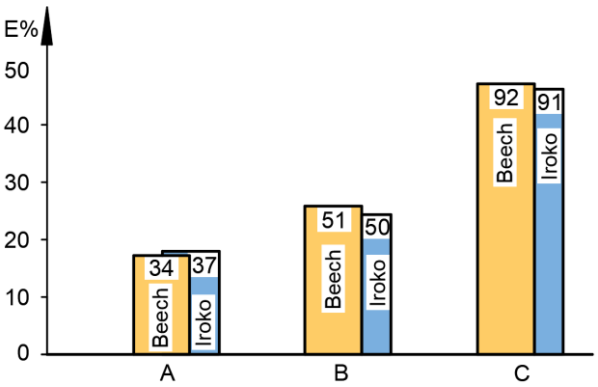

Fig. 5. Dependence of the evenness of smoothing (E %) on q and n after lapping of the samples with three working tools variants (A, B and C).

The analysis of the data in Table 1 shows additionally that both varied factors during the experiments influence significantly on the smoothing evenness. The influence of the linearly distributed pressure load q is better expressed. As it can be seen from the graphics at Fig. 5, by increasing *q* the evenness at lapping (*E*) grows approximately proportionately. This dependence stands out the best by the working tools from type A and B, which miss or have the lowest flexibility in the contact line with the processed surface. Obvious reason for the growth in *E* is the increased irreversible deformation of the surface micro layer. As a result, bigger portions of the concaves, produced purposely by sanding, are easily subject to compression, respectively to smoothing. In the range of the interval of variation for *q*, this growth occurs to be insufficient to provide overall evenness, especially when are available deviations in the evenness of the processed boards. Only by variant C of the lapping tool can be observed continuous smoothing at pressure load $q \geq 6$ kN/m.

The comparative data from the table, as well as the graphics at Fig. 5 show that the impact repeatability over the same surface guarantees higher quality of smoothing. The preliminary evaluations of the results by that indicator give us reason to state that the number of lappings *n* should be at least 2, and sometimes 3, especially if the pressure force *q* is lower than 6 kN/m, and the deviations in the evenness of the processed boards are considerable or unpredictable.

4. CONCLUSIONS

The summarized analysis of the results from the conducted experiments give us reasons to formulate the following conclusions that are more significant:

1. Providing flexibility for the supporting base of the lapping working devices is a must so thus to guarantee 100% - evenness of the smoothing of veneered furniture boards, especially when there are deviations in their flatness.
2. In order to ensure high quality of the smoothing it is necessary to use devices through which can be obtained linearly distributed pressure load force of at least 6 kN/m. At least twice should be also the impact over the same processed surface.
3. The hardness of the veneer does not influence on the smoothing quality of the veneer particle boards via lapping. Consequently, the wooden type of the veneer is not a factor that should be taken into account when choosing certain regime to run the lapping.

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