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EFFECT OF ROTATIONAL SPEED AND WOOD SPECIES ON ROUGHNESS OF MACHINED SURFACE

OBUCINA, M[urco]; SMAJIC, S[elver]; SKALJIC, N[edim] & BELJO - LUCIC, R[uzica]

Abstract*: In this study, the surface roughness values of planed beech-wood (Fagus L.), thermally modified beech-wood, oak-wood (Quercus L.) and fir-wood (Abies alba Mill.) specimens were examined. The specimens were machined by planing in radial directions with two knives at 12 m/min feed speed. The cutting depth of planing was constant (1,0 mm) and knife rake angle was 15°. The machining experiments were carried out using a single cutter-block of a Weinig Powermat 500 with rotational speed of 5000 and 8000 (RPM) and the cutter-block diameter of 125 mm. Surface roughness was measured at the radial face of each sample according to DIN 4768 (1990). Comparison between the results of surface roughness of sample groups planed with different rotational speed showed significant difference. Better results of the machining performance have been obtained with the decreasing rotation speed for the softwood and with the increasing speed of rotation for hardwood.*
Key words: *surface roughness, wood planing, rotational speed, wood species*

1. INTRODUCTION

The quality of processing includes the precision of processing and quality of the machined surface. These two mutually dependent indicators of the processing quality, which depend on numerous factors, represent the most important conditions in achieving the required product quality. Full understanding and evaluation geometric condition of wood surface provides mostly technical information in solving the problems like capabilities of gluing, impregnation, strength of joints, control of blade sharpness, and decrease of waste. Monitoring of the roughness can provide valuable information on the condition of the blade and vice versa. The strength of the glued joints and other mechanical properties of wood products are also dependent of surface roughness (Malkoçoğlu, 2007) and (Keturakis & Juodeikiene, 2007). Studies show that smooth surfaces require relatively small amount of paint for surface protection (Marian et al. 1958).

However, it often happens that the dimensions of the detail are within the limit values, and the details are different in the quality of the machined surface. Sanding is the most common and most influential operation for achieving surface quality during the phase of surface preparation.

This paper presents the research of the influence of the planing regime on the quality of the machined surface and possibilities to leave out the sanding operation by replacing it with planing in the preparation of the surface. Also, the aim of the research was to compare the surface quality of the samples of different wood species and different wood treatment.

2. MATHERIALS AND METHODS

Testing was conducted on samples of beech-wood (steamed and thermally modified), oak-wood and fir-wood. Dimensions of samples were 70x21x600 mm for steamed beech-wood, oak-wood and fir-wood and 70x21x500 mm for thermally modified beech-wood at 212°C. Samples of wood elements were radial texture. Before planing, samples were kept in the conditioning room at 20°C temperature and 65±5% relative humidity. For each type of timber the average density and humidity of wood were determined. Machining process was conducted with a cabinet planer (Weinig Powermat 500). Only the top spindle of the machine with two knives was used at 125 mm tool diameter. Wood surfaces were planed with rotational speed of 5000 and 8000 (RPM). The knives were made of industry standard high-speed steel. The feed speed used were 12 m/ min. The used knife rake angle was 15° and the depth of cut was 1.0 mm.

Measurements in five different randomly selected surface spots at each sample were averaged. Surface roughness tests were conducted using a Mitutoyo Surftest SJ 201, and carried out according to DIN 4768, 1990. Table 1 lists the characteristics of the tracing process. The values of roughness were determined with a precision of ±0,01 µm.

Tracing length (L_t)	12,5 mm
Tracing speed	0,5 mm/s
Pick-up length (λ_c)	2,5 mm
Stylus tip radius	5 µm
Stylus tip angle	90°

Tab. 1. Characteristics of stylus tracing for surface roughness measurements

Figure 1 shows the Mitutoyo Surftest SJ 201 which was used for the current research and were carried out according to DIN 4768. Surface roughness was measured on one side of the sample. Descriptive statistics (mean, minimum, maximum, variance, standard deviation) was made for all of samples. The differences between the obtained values of roughness parameter *R*a were tested by the Student's t-test, under assumption that the condition of homogeneity of variance was met.

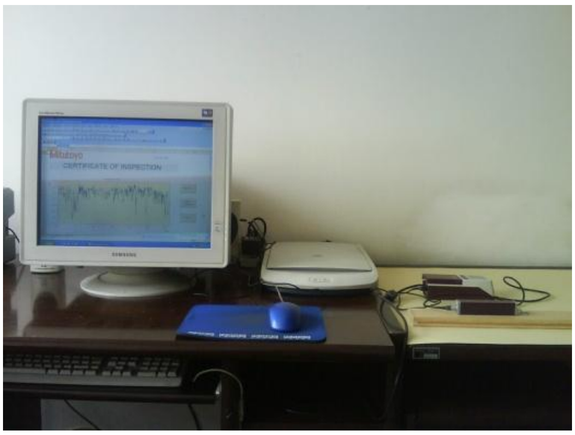

Fig. 1. Surface profilometer-Mitutoyo Surftest SJ-201 used in this study

All statistical analyses have been made by use of the Excel 2003 software.

3. RESULTS AND DISCUSSION

Research results are shown in Table 2. The arithmetical mean deviations of the profile (*R*a) present the average roughness value in each group of samples. In order to obtain more accurate results for each sample, measuring of the value *R*a was performed by five measurements and hence we had in total 50 measurements in each group of samples. Mean values of these measurements of arithmetical mean deviation of the profile *Ra*, are presented by the diagram in Figure 2.

Rotat. speed °/min	Wood species	Num. of samp.	Roughness *Ra* [μm] Min	Max	Mean	Std. Dv.
5000 °/min	TMBW	10	1,81	5,45	3,47	3,53
	SBW	10	1,86	3,77	2,58	3,71
	OW	10	1,23	3,11	2,15	3,99
	FW	10	1,14	4,07	3,47	3,77
8000 °/min	TMBW	10	1,02	2,91	1,93	1,40
	SBW	10	2,47	4,98	3,58	1,38
	OW	10	1,02	2,18	1,49	1,28
	FW	10	3,11	4,92	3,97	0,99

Tab. 2. Statistical processing of measured parameter of surface roughness *Ra* (TMBW – Thermally modified beech-wood; SBW – Steamed beech-wood; OW – oak-wood; FW – Fir-wood)

The surface quality of samples of planed beech-wood, oak-wood and fir-wood were significantly different. The best quality of planed surface was achieved by samples of oak-wood, while the samples of fir wood had the highest values of surface roughness.

The results clearly show that the physical and mechanical properties and anatomical structure of wood affect the surface roughness. The strength of the glued joints and other mechanical properties of the wood products are also dependent of the surface roughness. Resistance to penetration blade cutting edge in the wood depends on the size, shape of cells, as well as thickness and strength of cell walls. Wood of conifers (fir) has a simpler structure, lower mechanical properties and lower density than deciduous trees (oak and beech). In their researches (Malkoçoğlu & Özdemir, 2006) and (Malkoçoğlu, 2007) showed that under the same parameters of processing the surface of conifers (spruce-wood) is of lower quality that the surface of hardwood species (beech wood). It is known from literature that mechanical properties of thermally modified wood are not as good as those of unmodified wood. The samples of thermally modified beech wood, compared with the other three sample groups, had the largest change of the average value of the arithmetical mean deviation of the profile *R*a depending on the changes in rotation speeds.

The axial tool leaves kinematic irregularities on the finished surface in the form of slot cycloid which is characterized by the length and depth of the wave. These parameters directly depend on the feed rate which is proportional to feed speed (Skaljic et al., 2009) and inverse proportional to rotational speed. As the surface roughness parameter *R*a was measured in direction of fibre length. Meanwhile, statistical tests have shown that neither of four group of samples (beech-wood, thermally modified beech-wood, oak-wood and fir-wood) shows any significant difference at a 5% level between mean values of roughness parameter *R*a of samples planed with different rotation speeds of 5000 and 8000 (RPM). Planed surface of thermally modified beech-wood and oak-wood had a higher value of *R*a at rotation speed 5000 (RPM), while the planed surface of beech-wood and fir-wood had a higher roughness at 8000 (RPM).

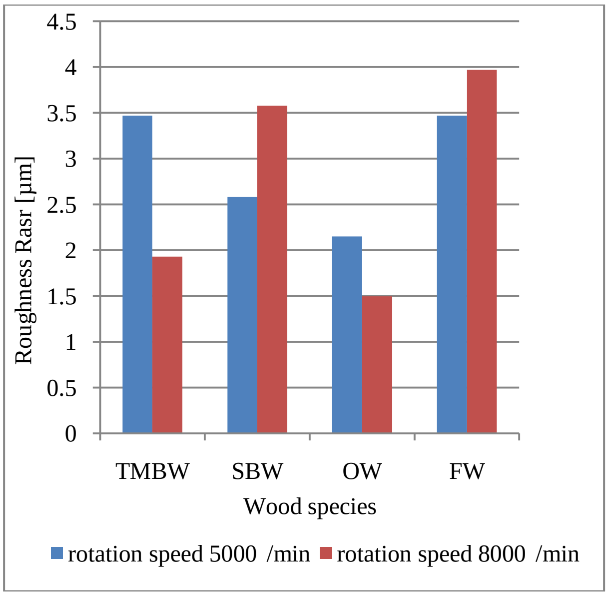

Fig. 2. Comparison of values of roughness parameter *R*a for different rotational speeds (TMBW – Thermally modified beech-wood; SBW – Steamed beech-wood; OW – oak-wood; FW – Fir-wood)

In future research will analyze the influence of the rotational speed on wood surface wettability and its effect on the glued joint strength, with the use of two types of glue.

4. CONCLUSION

The research of the surface quality of samples of beech-wood (steamed and thermally modified), oak-wood and fir-wood was conducted on samples planed at different rotational speed.

Oak-wood samples showed the lowest value of mean deviation profiles while fir-wood samples showed the highest value of surface roughness parameter. The thermally modified beech wood showed the maximum deviation the surface quality of tested samples. It can be concluded that for all four types of wood samples change of the rotational speed affect the change of the average value of the arithmetical mean deviation of the profile *R*a. In general, better results of the machining performance have been obtained with the decreasing rotation speed for the softwood and with the increasing speed of rotation for hardwood.

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