RESEARCH ON THE QUALITY OF PROCESSED SURFACES WHEN CUTTING SPRUCE LOGS WITH NARROW BAND SAW BLADES

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ABSTRACT

Research on the quality of the processed surfaces was performed with narrow band saw blades in winter conditions. For experiments was used horizontal band saw „Wood – Mizer“ WM 3000. Research was conducted in „Chil Tepe – 97“ Ltd. manufacturing facility in the town of Laki. The cutting tools are with normal and hardened teeth. The results after modification of some technological factors such as feed speed, cutting height and cutting tool operation time are analyzed. Practical recommendations are proposed.

Key words: horizontal band saw, narrow band saw blades, processed surfaces

INTRODUCTION

The quality determination of the mechanically processed surfaces is performed by the following criteria: accuracy of the dimensions, shape and the roughness (Gochev 2005). Accuracy of the dimensions means the degree of compliance between specifications by drawing or technical documentation parameters and obtained after the cutting. The shape accuracy means the degree of compliance between the real and the required form of the materials. The obtained surfaces after wood cutting aren’t perfectly smooth and include unevenness in the form of concavities and protrusions along its entire area. The size of this unevenness characterized the roughness of the materials.

There are many factors which influence the roughness. They can be divided into the following groups (Gochev 2005, Jakub and Martino 2005):

- wood anatomy;
- wood fibers direction;
- density and moisture of the wood;
- kinematics of the cutting process;
- condition and technical specifications of the machine and cutting tools;
- other – temperature and humidity of the air, wood defects, operator qualification, etc.

The factor with the greatest influence on the surface roughness is the tooth feed (u_z), which is in dependence of the cutting process kinematics (cutting and feed speed) and the teeth pitch (t) (Blagoev 2001). Therefore, one of the technological factors in determining the mode of cutting is the feed speed which depends on the roughness requirements (Grigorov 1992).

This study includes quality evaluation of machined surfaces by measuring roughness and dimensional accuracy.

METHODS

As a testing work station was used horizontal band saw "Wood-Mizer", Model WM 3000 (Fig. 1). The cutting logs were spruce (Picea abies) with density ρ=805 kg.m^{-3} and moisture W=45% (Fig. 2). The obtained materials were boards with thickness 25 mm and other lumber with cross-section 100/100 mm, 50/100 mm and 60/120 mm. As cutting tools were used two types of blades – „Double Hard“ and „Professional“ produced by „Wood – Mizer“.

Figure 1: Horizontal band saw, model WM 3000

Figure 2: Spruce logs

The parameters of the band saw blades are shown in Table 1. It's assumed that with less front cutting angle (γ) a smoother surface of the cutting materials is obtained (Gochev 2008).

Table 1: Parameters of the cutting tools

Number of cutting tool, №	Name	Angular parameters: front angle/ sharpening angle (γ/β) [°]	Pitch (t), Height of teeth (h'), Tooth part-set (s') [mm]	Thickness (s), Width of the band saw blade (B) [mm]	Type of the teeth
1	„Double Hard“	4/32	22/5/0,40	1,14/38	Hardened
2	„Double Hard“	4/32	22/5/0,45	1,14/35	Hardened
3	„Professional“	10/30	22/6/0,45	1,14/38	Normal

To determine surface roughness is used the parameter R_m. It is defined as the distance between the lines of protrusions (Y_g) and concavities (Y_d) within a base length (l) (Fig. 3) (BDS 4622-86):

$$R_m = Y_g - Y_d, \mu m. \quad \textbf{(1)}$$

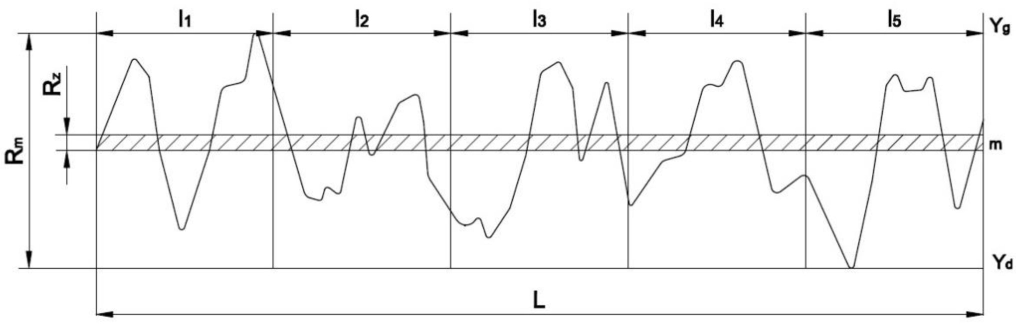

Figure 3: Scheme for determining the parameter R_m

For measuring the roughness (R_m) is used depth gauge with dial indicator according to the standard BDS 4622–86. The total number of measurements was 20. Figure 4 shows the pattern of distribution (Genchev 1978). Roughness values are reported over a period of machine operation for each of the used band saw blades: 20, 40, 60, 80 and 100 min.

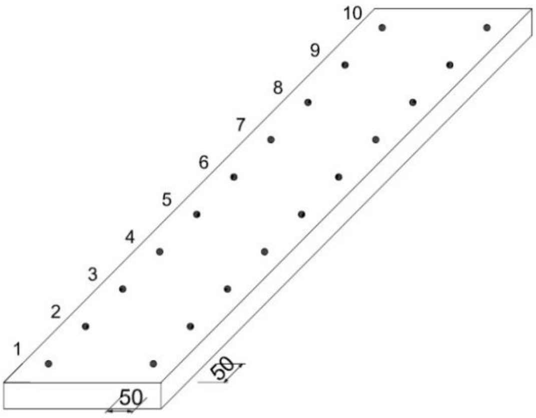

Figure 4: Scheme for determining the roughness (Genchev 1978)

In the cutting with band sawmills the feed speed (U) is continuously changing. This is due to the incorrect geometric shape of logs, the presence of various defects in the wood, etc. Therefore, the average feed speed was determined by the formula (2) (Gochev 2008)

$$U_{av.i} = \frac{L_{\log}}{t_i}, \qquad \textbf{(2)}$$

where:

L_{log} – log's length, m;

t_i – time for a cut of the log, s.

Besides the class of roughness the feed speed (U) depends on the cutting height (h) (Filipov 1977). Due to the irregular shape of logs the cutting height was measured in the middle of lumber.

Measuring the accuracy of the dimensions was carried out under a scheme similar to that shown in Fig. 4. The difference is that the values were measured in 10 points.

Another factor which is associated with the quality of the surface is pre-tensioning of the band saw blade ($\sigma_{t.}$). It was recorded directly from the indicator on the machine. This method of determining the values is more accurate than the practical one: the teeth height is subtracted from the width of the saw blade and the resulting value in millimeters is necessary band saw blade tension in megapascals (MPa).

RESULTS AND DISCUSSION

The obtained values from the measurements are shown in Table 2.

Table 2: Measurement results

Measurement, №	Band saw blade, type and number														
	Double Hard, № 1					Double Hard, № 2					Professional, № 3				
	$\overline{R}_{m.}$, [μm]	$t_{o.}$, [min]	$U_{av.}$, [m.s^{-1}]	$h_{av.}$, [m]	$\sigma_{t.}$, [MPa]	$\overline{R}_{m.}$, [μm]	$t_{o.}$, [min]	$U_{av.}$, [m.s^{-1}]	$h_{av.}$, [m]	$\sigma_{t.}$, [MPa]	$\overline{R}_{m.}$, [μm]	$t_{o.}$, [min]	$U_{av.}$, [m.s^{-1}]	$h_{av.}$, [m]	$\sigma_{t.}$, [MPa]
1.	102,5	20	0,12	0,24	14,7	112	20	0,20	0,19	14,7	104	20	0,09	0,38	15
2.	118,5	40	0,17	0,20	14,7	111,5	40	0,13	0,20	14,7	184	40	0,13	0,22	15
3.	122	60	0,21	0,17	14,7	127	60	0,22	0,19	14,7					
4.	119,5	80	0,11	0,29	14,7	148,5	80	0,19	0,17	14,7					
5.	228	100	0,17	0,20	14,7	214	100	0,14	0,26	14,7					

The analysis of the results shows that with increasing of the operating time of the blades the roughness also increases. This is due to the wear of the teeth which leads to rupture of some wood fibers instead of cutting. Figure 5 shows the relationship between duration of blade operation ($t_{o.}$) and the average roughness ($\overline{R}_m$).

It is noteworthy that band with ordinary teeth "Professional" wears out faster and after ~ 50 min had to be removed and sharpened. The bands with hardened teeth „Double Hard“ show good resistance. The values of $\overline{R}_m$ for 80 min ranged from 100 to 150 μm and after this period they increase significantly. After 100 min bands had to be sharpened again as surface roughness were visibly worse (Fig. 6).

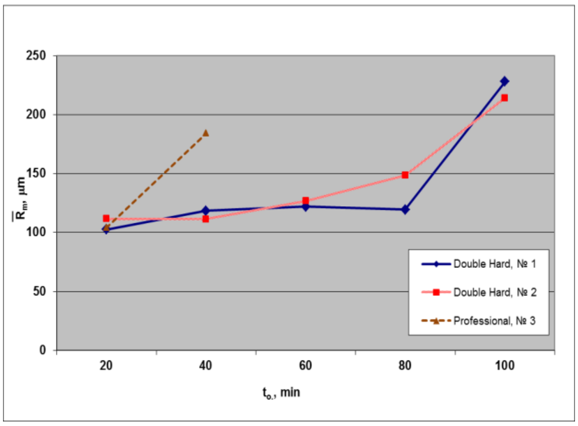

Figure 5: Influence of the cutting tool operation time ($t_{o.}$) on the roughness ($\bar{R}_m$) of the resulting surfaces

Figure 6: Surfaces after 100 min operation without changing the cutting tool

The factor feed speed (U) has a significant impact on the roughness (R_m). In manufacturing conditions maintaining the specified levels of this factor would be very difficult because of the changing cutting height (h) which can be seen from the graph on Fig. 7. Comparison between the obtained results can only be done in an equal amount of working time ($t_{o.}$). Moreover, the band with normal teeth „Professional“ shouldn’t be included in determining the influence of this factor because it has proved unsuitable for cutting frozen wood. Figure 7 also shows that with increasing feed speed ($U_{av.}$) the measured roughness values ($\bar{R}_m$) increase. Exceptions to this are possible depending on the presence of various defects in the wood.

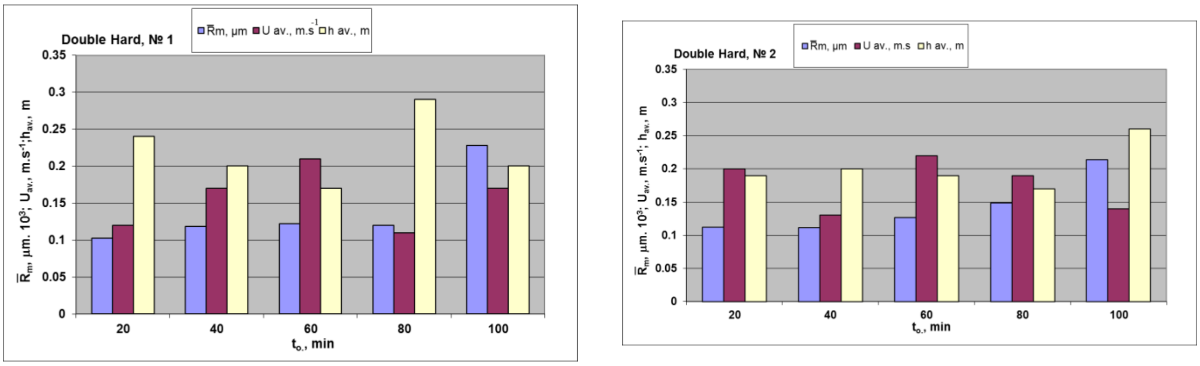

Figure 7: Effect of feed speed ($U_{av.}$) and cutting height ($h_{av.}$) on the roughness of the resulting surfaces ($\bar{R}_m$)

Concerning the accuracy was found that the type of the band doesn't affect it and the real and nominal dimensions differ in the range from 0,38 to 0,57 mm (Table 3) which is within limits. This may be due to defects or wear of the mechanism for vertical direction moving of the cutting unit. Possible deflection of cantilever beam where the cutting unit is mounted can also be a reason for the discrepancy in dimensions.

Table 3: Results of the measurements for dimensional accuracy

Nominal thickness size of the lumber [mm]	25	50	60	100
Average deviations from the nominal size [mm]	0,41	0,38	0,47	0,57

CONCLUSION

The following conclusions and recommendations can be made based on the results of the study:

1. Band saw blade type "Professional" without hardened teeth is not suitable for winter conditions. Partially frozen moisture in the wood and the presence of ice on the bark of logs has a strong abrasive wear effect on the teeth.
2. When cutting logs in winter conditions is more appropriate to use bands with hardened teeth and less front angle of cutting (γ). The results show that the time they maintain their performance is twice longer than those with normal teeth and an increased front angle of cutting.
3. During machine operation was found that the height of the cutting doesn't affect significantly the feed speed. Consequently, the engine isn’t loaded optimally and part of the production capacity of the machine is lost. To a large extent this is due to insufficient knowledge of the cutting process kinematics by the operator.
4. In case of deviation from thickness accuracy it should be compensated by the operator when the size of the lumber is set.
5. Further research on the accuracy of the processed material shape is needed for this type of machines.

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