RESEARCH ON THE QUALITY OF PROCESSING WITH A HORIZONTAL BANDSAW

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ABSTRACT

Experimental studies related to the influence of some factors on the quality of the resulting lumber were carried out. The venue of the research is the manufacturing conditions in Experimental and Training Forest Ranges in Barziya. As a work station a horizontal bandsaw for logs *Arsov 90 Ltd.* (Bulgaria) was used. The results were analyzed and compared to some earlier obtained with other machines of this type. They show that it is not advisable feed speed to exceed 16 $m.min^{-1}$– due to the risk of unacceptable size deviations. Some recommendations for a more efficient usage of this type machines were proposed.

Key words: horizontal bandsaw, logs cutting, surface roughness, quality of processing.

INTRODUCTION

The machined wood surfaces quality is a result of the interaction of different by their essence factors which influence during their reception. Some of them are anatomical structure of the cutting timber, the type, parameters and preparation of the cutting tool, geometrical and working precision of the machine, the depth of cutting, vibrations between the material, machine and cutting tool, practical skills of the workers, etc. Moreover, the kinematic nature of the cutting process influences as well (Barcíket al. 2009, Gochev 2005).

There are various definitions of surface quality in the literature. In the most cases, it's associated with the roughness. Some authors associate the quality of surfaces not only with this indicator. They define it as a result of macro and micro unevenness, i. e. as a result of the roughness, the accuracy of shape and dimensions (Bershadsky and Tsvetkova 1975, Ivanovsky et al. 1972, Kvietková et al. 2015).

To obtain lumber from logs sawing machines like gang saws, circular saws and bandsaws are primarily used. Due to the sharp decrease in processed raw material in our country, the use of gang saws is limited. The usage of circular machines (with 2 blades) is limited to the processing of logs with small diameters which produce materials with a square cross-section – on two passes through the machine. In recent years, for primary wood cutting bandsaw machines have been mainly used. In addition, mainly due to a number of advantages which they have, the modern horizontal bandsaws usage is growing. These machines are relatively new, however, there is a variety mainly in levels of mechanization of the different parts. In all cases, the feed movement is performed by the cutting mechanism which can be driven by motor or manually pushed by the machine operator (Atanasov 2014).

The purpose of this study is to determine the quality of processing by a horizontal bandsaw without mechanical feed. As quality criteria, the surface roughness and the dimensional accuracy are defined.

METHODOLOGY

To perform the experimental studies a horizontal bandsaw *Arsov 90 Ltd.* was used.

The scheme of its cutting mechanism can be seen in Fig. 1.

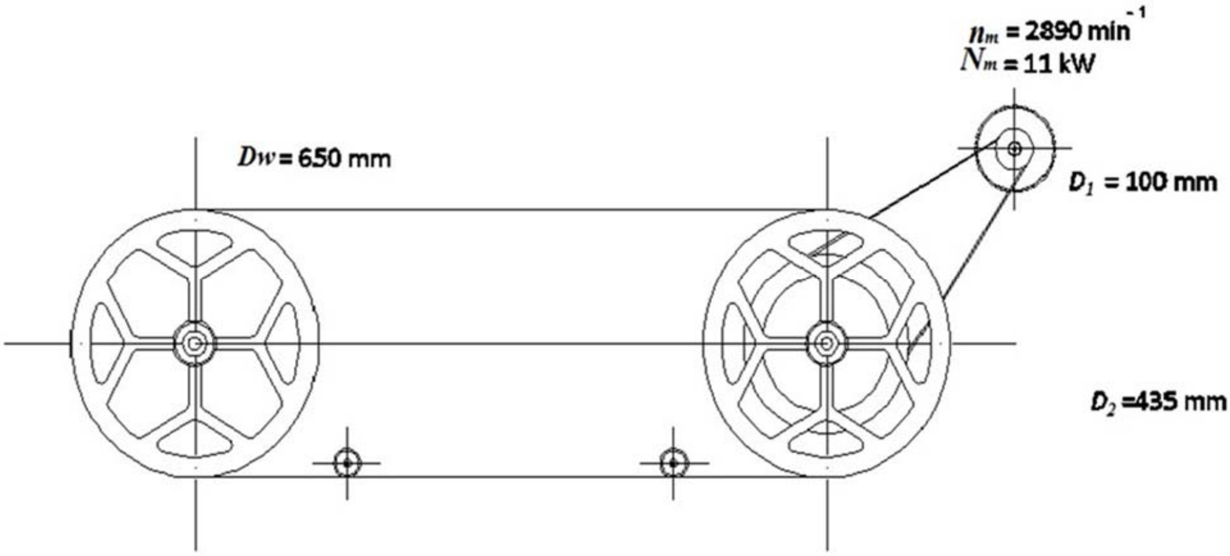

Figure 1: Horizontal bandsaw*Arsov 90 Ltd*

Some of more important technical features of the machine are:

- $D_{w.}$=650 mm – saw wheel diameter;
- Lo=1660 mm – distance between the axis of the wheels;
- N_m=11 kW – power of the motor which drives the leading wheel;
- n_m=2890 min^{-1} – revolutions of the motor's shaft;
- D_1=100 mm – diameter of the electric motor pulley;
- D_2=435 mm – diameter of the wheel pulley;
- V=23 m.s^{-1} – cutting speed.

As a cutting tool, a bandsaw blade *SilverTip (Wood-mizer)* with hardened teethwas used. In addition, its width is greater than the most frequently used in our country – *DoubleHard* (*Wood-mizer*, 32 и 38 mm) and *Carl Röntgen* (40 mm). The main linear and angular parameters of the cutting tool are shown in the Table. 1.

Table 1: Parameters of the cutting tool

Manufacturer	Angular parameters: rake angle / clearance angle γ/α [°]	Pitch t and height of the teeth h', part-set size s' [mm]	Thickness s and width of the blade B [mm]	Type of the teeth
Wood-Mizer	10/30	22/5/0.6	1.14/50	Hardened

As experimental models three wood species are used: Scots pine (*Pinus sylvestris L.*), Spruce (*Picea abies (L.) Karst.*) and Douglas fir (*Pseudotsuga menziesii (Mirb.) Franco*). A part of the cutting materials can be seen in Fig. 2.

Figure 2: Logs of Scots pine (*Pinus sylvestris* L.), Spruce (*Picea abies* (L.) Karst.) and Douglas fir (*Pseudotsuga menziesii (Mirb.)* Franco)

Their density and humidity are determined by hygrometer (*Lignomat Tester* – Germany) and electronic scales (*RADWAG WLC 1/A2* – Poland). Furthermore, the temperature of the workplace was measured by using a multifunctional device (*MASTECH MS 6300*). It affects the process, especially in sub-zero temperatures.

Feed speed significantly affects the cutting quality. It depends on the variations in the width of the cutting and wood disadvantages and it's regulated by the operator and changing steplessly in the cutting process. In this study, its average value is determined by using a tape measure and a stopwatch by the following formula

$$U_{av.i} = \frac{L_{log}}{t_i}, \quad \textbf{(1)}$$

where L_{log} is length of the log, m;

t_i – the time to perform a cut when processing the log, min.

Besides feed speed, the wear of the teeth due to the volume of cutting wood, has a significant impact on the quality of processing as well. In the particular experimental studies, before making measurements, the quantity of cutting wood Q is defined in m^2

$$Q = hL_{log}, \quad \textbf{(2)}$$

where h is the cutting height, m.

The height of cut is determined with a tape measure in the middle of the sawn material.

Surface roughness is determined by an indicator gauge with measuring clock according to BDS 4622: 86. The measured indicator for roughness is $\bar{\bar{R}}_m$.

To measure the dimensional accuracy a caliper is used. The average feed speed for both crossings of which the board is cut was reported. The results obtained are compared with respective allowable thickness of the boards which are marked in BDS EN 1313-1:2010. In the present study, the resulting lumber are boards and beams with a thickness of 25 mm and 60 mm.

The measuring points for both indicators are 20 shown in Figure 3. To perform the analysis, the average results are calculated. For the dimensional accuracy, the absolute values are defined.

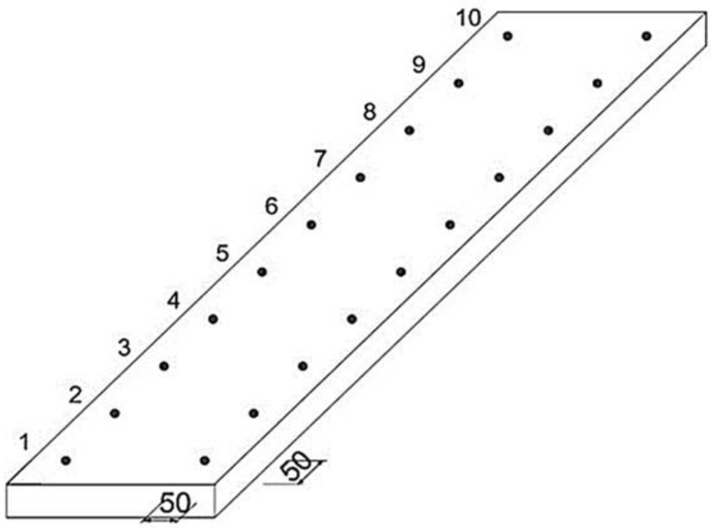

Figure 3: Scheme for the determination of surface roughness and dimensional accuracy

RESULTS AND ANALYSIS

The results for the measured density, wood moisture content and the temperature of the working area during the experimental studies are presented in Table 2. The table shows that temperatures in the workplace does not adversely affect the process of cutting.

Table 2: Results of the measurements of density, moisture content and temperature to conduct the experimental studies

Scots pine	Spruce	Douglas fir
	Wood density, $kg.m^{-3}$	
550	420	460
	Wood moisture content, %	
38.4	29.5	25.2
	Temperature of the working area during the experimental studies, ^{0} C	
26.1	25.6	25.2

The results of the feed speed effect measurement over the surface roughness are graphically presented in Figure 4. As can be seen it varies from class III to VI. To receive the highest grade of roughness the feed speed should not exceed 10 $m.min^{-1}$ as well.

The values obtained for the wood of spruce have the greatest variation. For example, a feed speed of 24 $m.min^{-1}$ roughness 305 and 356.5 µm was obtained. But in the first case, the values were measured after 19.8 m^2, and in the second after 88.7 m^2 sawn wood. Moreover, only in this tree species III^{-rd} class of roughness was reached – in feed speed of 30.5 $m.min^{-1}$, after cutting of 40.1 m^2 wood.

Results for Douglas fir show that the function curve describing the roughness of this wood species exceeds the rest in its larger part. Furthermore, the least amount of wood is being cut from this wood species. Consequently, the cutting tool has not reached the wear rate as other types of woods.

It is seen that on reaching the feed speed over 14.29 $m.min^{-1}$, the class of roughness decreases in IV^{-th}, ie bumps are more than 320 µm. As a reason for this, the anatomical characteristics of this tree species can be identified.

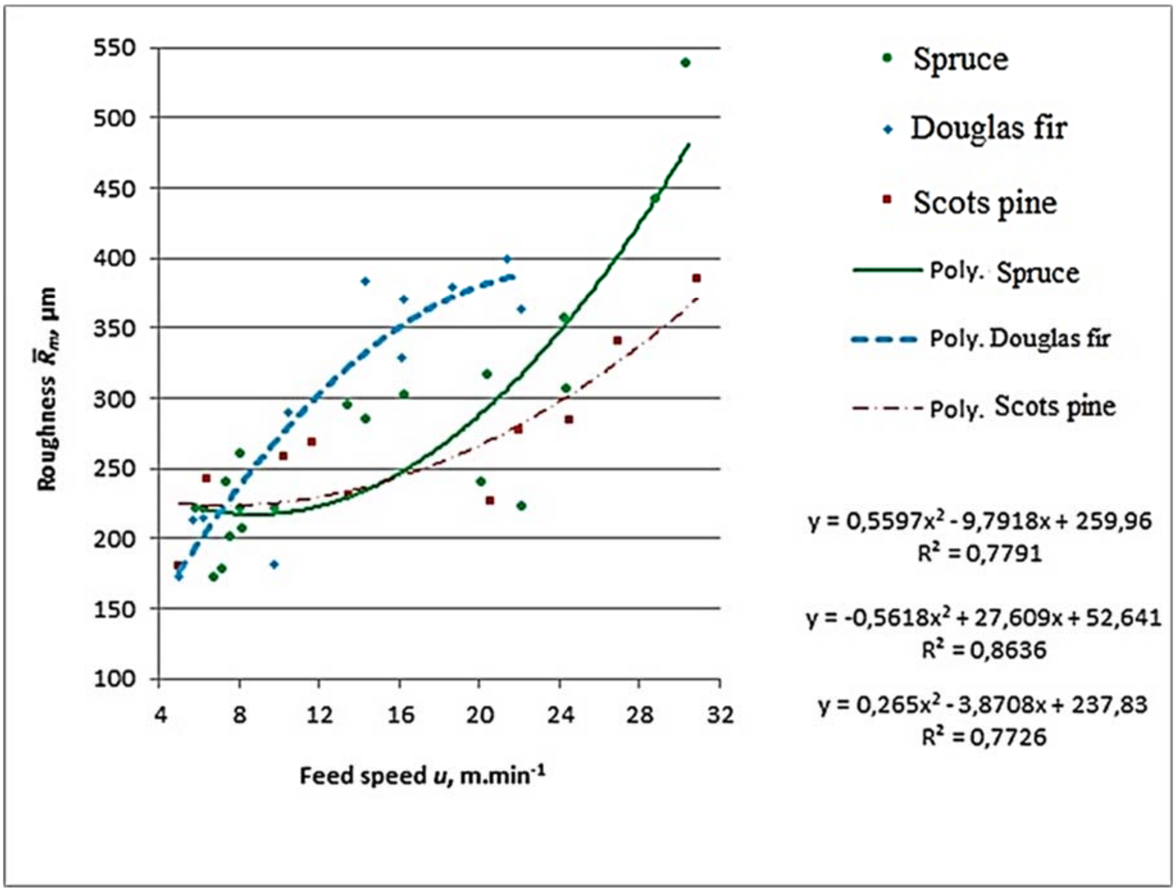

Figure 4: Results of measurements about surface roughness

Fig. 4 shows that with regard to this indicator, the best results are obtained by cutting of Scots pine. The main reason for this is the fact that the majority of results for higher feed speeds were accounted for in the beginning of measurement – at sharp teeth of the cutting tool. However, in excess of the feed speed of 27 m.min^{-1} IV^{-th} class of roughness was reached.

The results of research on the deviations from the nominal dimensions are shown in Fig. 5. In this case they do not exceed 3 mm in all wood species. The main part of the resulting lumber has a thickness of over 60 mm. According to the standard BDS EN 1313-1:2010, the tolerance in sizes over 32 mm is 4 mm in plus and 2 mm in minus. This means that the results can be described as satisfactory. On the other hand, the standard affects timber with a moisture content of 20%. In this case, the measured moisture content is higher, i.e., the dimensions will decrease further in the drying process. However, it's not recommended when cutting Scots pine and Douglas fir feed speed to exceed more than 17 m.min^{-1}, since it increases the risk of exceeding the limits in the dimensions.

The best results in this indicator are obtained by cutting spruce. It can be seen that below feed speed of 16.82 m.min^{-1}, the discrepancy with nominal dimensions don't exceed 1 mm, regardless of the amount sawn wood. The resulting function curves for the other two wood species are approximately equal. About the Douglas fir, the resulting dimensions coincide almost completely with the nominal feed speed of 5.5 m.min^{-1}.

When comparing the results for the roughness with the previously obtained it was noted that at approximately the same feed speed for the two experiments, those obtained with a mobile horizontal bandsaw (Atanasov 2014) were better. On the other hand, the values in the current study are reported in greater quantity of sawn wood. In this study better results in terms of dimensional accuracy were obtained. As a reason for this a bigger bandwidth 50 mm may be indicated. As is known from the equation for the critical force of Bershadsky (Gochev 2008), where in the saw losing transverse resistance, increasing the bandwidth increases its resistance as well. This is confirmed by experimental studies with a vertical bandsaw with carriage feeding, working with a wide bandsaw. Moreover, the results for the roughness in this measurements are significantly better. For example, at a feed speed of 33 $m.min^{-1}$ the derived values for roughness are 208 µm (Trichkov 2006).

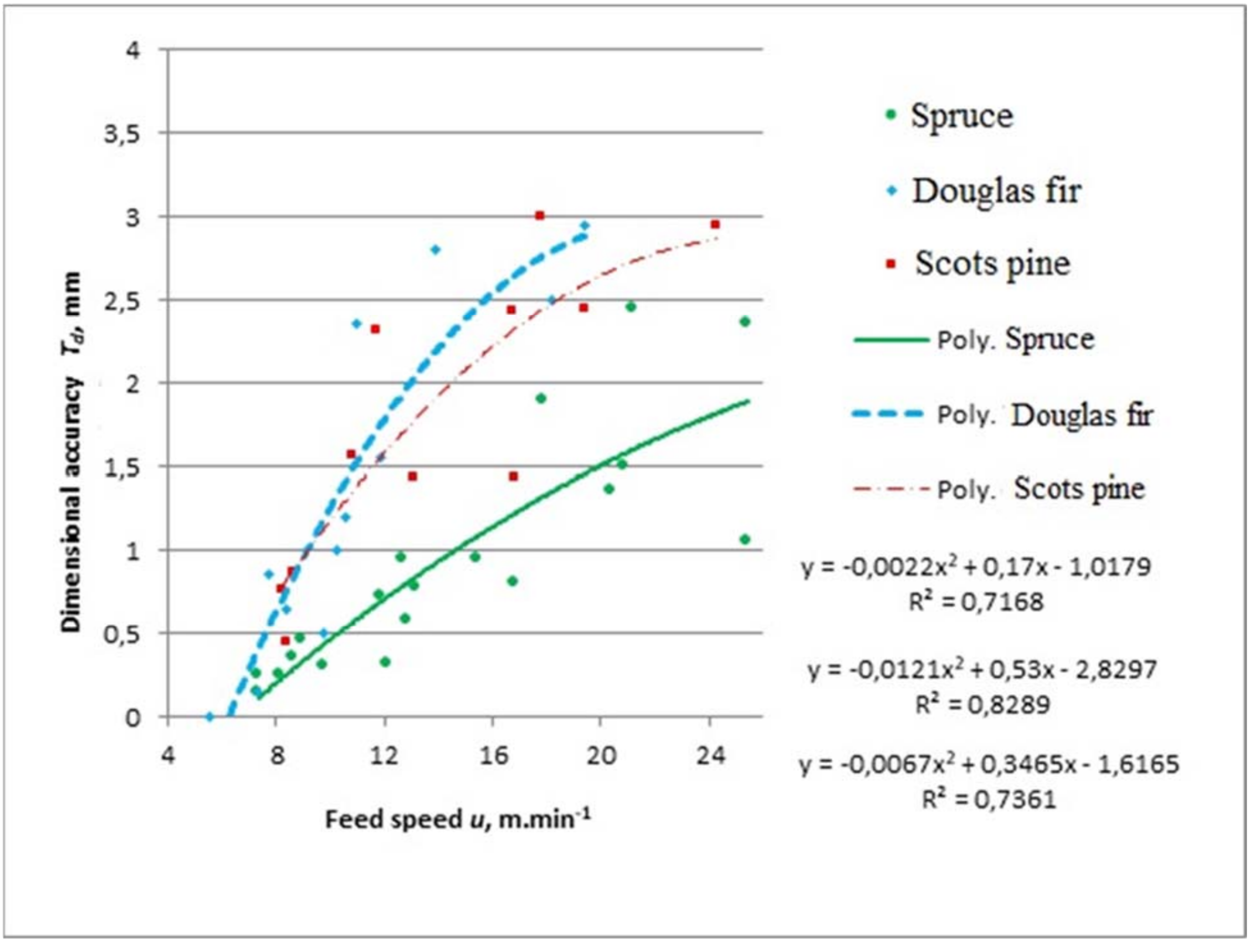

Figure 5: Results of measurements about dimensional accuracy (deviation from nominal)

CONCLUSIONS AND RECOMMENDATIONS

1. The main part of roughness results shows that most of them correspond to the V^{-th} class. After exceeding the feed speed of more than 20 $m.min^{-1}$ the class of roughness significantly decreased.
2. The tested band saw shows good results about the dimensions accuracy of the lumber thickness. Even at high feed speed, the upper limit of +3 or +4 mm (depending on the thickness) is not exceeded.
3. From the viewpoint of dimensional accuracy it is not advisable to apply a feed speed exceeding 16 $m.min^{-1}$ because of the danger of exceeding the permissible variations.

4. The horizontal bandsaw with manual feed has significantly worse results about the roughness compared to the vertical and horizontal bandsaw with mechanical feed. However, these results can be considered as satisfactory, since the roughness is not a priority in the primary cutting of wood.
5. In the future it is necessary to be made more comprehensive studies including the straightness of the cut, the influence of the type of cutting tool – type of teeth, its linear, angular parameters, etc.

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CONTENTS