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Research Article

ASSESSMENT OF THE PROCESSING ROUGHNESS OF BLACK ALDER SURFACES

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ABSTRACT

The objective of the study was to compare the surface quality of the processed samples made of black alder (*Alnus glutinosa* L.) wood when using two milling cutters endowed with different cutting plates. Defect free samples provided by a local company were used. They were processed by longitudinal milling under laboratory conditions when applying various cutting schedules. The surface quality of the resulted samples was expressed by the most relevant processing roughness parameters. The roughness of the specimens was measured with the help of a specific profilometer device of FRT type with white light. The results of this study showed that the two milling cutters generated smooth surfaces with no or low fuzzy grain and such quality of the processed surfaces can be obtained when using low feed speeds and light cutting depths. Findings of this work could help to use more efficiently the wood of black alder in the furniture sector.
Keywords: Black alder, cutting schedule, milling, roughness.

1. INTRODUCTION

Mechanical processing of wood represents those processes that can change the shape and dimensions of wood without changing its chemical composition. It is said that no cutting tool is more versatile than a milling cutter which can produce various and specific surfaces. Routers, machines for planing and straightening as well as for tenoning and vertical milling machines are widely used in the furniture sector. Various research studies performed during last decade have shown the pragmatic character of wood milling as regard to the most important factors that affect the quality of a processed surface, such as: wood species, type of milling, characteristics of milling cutter, and cutting schedule especially [1-9]. The feed speed and cutting depth have a high impact on the wood surface roughness. The higher the feed rate is, the rougher the processed surface becomes [10, 11]. Low feed speeds and light cutting depths were proved to generate smooth wood surfaces after milling [12, 13]. In order to obtain a superior quality of a wooden finished product different types of milling cutters with inserted plates are recommended. But common milling tools with brazed cutting plates are still used as well. Therefore the objective of the present study was to compare the surface quality of the processed samples made of black alder (*Alnus glutinosa* L.) wood when using two milling cutters of same diameter but endowed with

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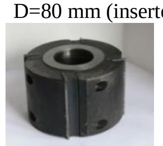
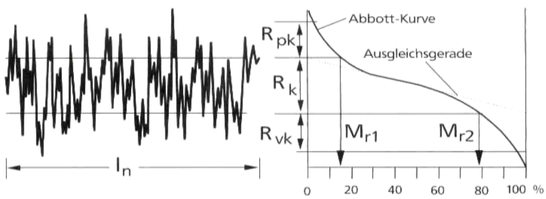
different cutting plates. It is expected that findings of this work could help to use more efficiently the wood of black alder in the furniture sector.

Table 1. Design of experiments, variables, parameters and equipment

<table>
<tr><td colspan="2">Processing direction / machine</td><td colspan="3">Longitudinal milling / MNF 10 vertical machine</td><td colspan="3"></td></tr>
<tr><td colspan="2">Number of samples</td><td colspan="6">20 specimens / each milling process and rotation speed</td></tr>
<tr><td colspan="2">Milling cutters</td><td colspan="3">D=80 mm (brazed carbide)
</td><td colspan="3">D=80 mm (inserted carbide)
</td></tr>
<tr><td rowspan="4">Cutting schedule</td><td>Rotation speed, rpm</td><td colspan="6">6620 and 9732</td></tr>
<tr><td>Feed speed, m/min</td><td>4.5</td><td>9</td><td>13.5</td><td>18</td><td colspan="2">22.5</td></tr>
<tr><td>Cutting depth, mm</td><td>1</td><td>2</td><td>3</td><td>4</td><td colspan="2">5</td></tr>
<tr><td>Cutting width, mm</td><td>20</td><td>25</td><td>30</td><td>35</td><td colspan="2">40</td></tr>
<tr><td rowspan="2">Roughness parameters</td><td>R_k, µm</td><td colspan="6" rowspan="2">

R_k=Parameter for the processing roughness evaluation
R_{pk}, R_{vk}=Parameters for the fuzzy grain and anatomical roughness evaluation, respectively</td></tr>
<tr><td>R_{pk}, R_{vk}, µm</td></tr>
<tr><td rowspan="2">Scanning parameters</td><td>Scanning mode</td><td>Scanning speed</td><td>Points per line</td><td>Evaluation length</td><td>Sampling length</td><td colspan="2">Resolution</td></tr>
<tr><td>2D</td><td>750 µm/s</td><td>10000</td><td>50 mm</td><td>2.5 mm</td><td colspan="2">5 µm</td></tr>
<tr><td>Roughness measurement</td><td colspan="3">Along the processing direction</td><td colspan="4" rowspan="2"></td></tr>
<tr><td>Roughness device</td><td colspan="3">MicroProf FRT Optical Device</td></tr>
</table>

2. MATERIAL AND METHOD

Commercially flat sawn timber of black alder (*Alnus glutinosa* L. Gaertn.) wood supplied by a local company in Buzau County, Romania was used in this study. A total of 80 defect free samples were cut at 1000 mm length. Table 1 presents the complete design of experiment, variables, parameters and equipment. All specimens were processed on their longitudinal edges on the vertical milling machine of MNF 10 type under laboratory conditions by employing a mechanical feed device [10]. Two milling cutters of 80 mm diameter endowed with cutting plates made of brazed and inserted sintered carbide were used for the milling process. The factorial experiment with three variables (feed speed, cutting depth, cutting width) was applied per each milling and rotation speed. Such algorithm enables various cutting schedules with only 20 samples per process. The moisture content of all samples prior to processing was 8%.

2.1. Roughness measurements

In this study a specific roughness device of MicroProf FRT type was used for roughness measurement. The scanning parameters and roughness parameters under evaluation are presented in Table 1. Two out of three parameters of R_k family (R_k, R_{vk} and R_{pk}) were selected, namely R_k and R_{pk} according to ISO 13565 2 standard [14]. In this study R_{vk} was excluded because the anatomical roughness was not removed. The roughness core depth, R_k, is considered by far the most representative processing roughness indicator [15]. A Gaussian filter was automatically applied.

2.2. Data processing

Specific software programs have been used for data processing, such as *Visual Basic*, *DataFit* and *Delphi*. A non-linear regression was applied by respecting an equation of 2nd degree type with three variables, expressed by Eq. (1).

$$Y = a + bx_1 + cx_2 + dx_3 + ex_1x_2 + fx_1x_3 + gx_2x_3 + hx_1^2 + ix_2^2 + jx_3^2 \quad (1)$$

in which Y is the roughness (R_k and R_{pk}) and the three variables x_1, x_2, and x_3 were the feed speed (u), cutting depth (h) and cutting width (b), respectively. The real experiment did not benefited by enough representation values and thus some extreme values have been removed from the analysis. The cutting width has relevance for the dynamic elements only and it does not influence the surface quality. Therefore in this study three feed speeds (9, 13.5 and 18 m/min) and three representative cutting depths (1, 2 and 3 mm) were evaluated along the cutting width of 30 mm.

3. RESULTS AND DISCUSSIONS

The software used in this study provided 3D response surfaces representing the variation of the two roughness parameters under evaluation for all the processed surfaces as a function of cutting schedule. Figure 1 presents the variation of roughness parameter, R_k, as a function of all three cutting variables after the longitudinal milling when using the inserted carbide milling cutter at 9732 rpm rotation speed. Figures 2 and 3 present the variation of roughness (R_k) depending on the variable cutting schedules for a cutting width of 30 mm after the longitudinal milling when using two types of milling cutters at 6620 and 9732 rpm rotation speeds, respectively. For both types of milling processes performed with the two milling cutters at the rotation speed of 6620 rpm the R_k roughness values gradually increased once the feed speed and cutting depth increased.

The best surface quality expressed by the processing roughness parameter (R_k) using both types of milling cutters was obtained for the longitudinal milling at the rotation speed of 6620 rpm, for a feed speed of 9 m/min and a cutting depth of 1 mm, while at the rotation speed of 9732 rpm, it was obtained for the same feed speed of 9 m/min but the cutting depth of 3 mm. The processing roughness values ranged between 14.13 to 20.32 µm in case of processing with the brazed carbide milling cutter and from 16.33 to 22.7 µm in case of using the inserted carbide milling cutter. For both types of milling at the rotation speed of 9732 rpm a slow increase of the processing roughness (R_k) with the increase of feed speed at a constant cutting depth was noticed, while at same feed speed for an increase of cutting depth, the roughness values slowly decreased. The most reduced value for the fuzzy grain roughness parameter (R_{pk}) of about 6.35 µm was determined in case of using the brazed carbide milling cutter at a rotation speed of 9732 rpm and a feed speed of 9 m/min for a cutting depth of 3 mm. A similar value for such fuzzy grain expression of about 6.43 µm was determined using the inserted carbide milling cutter at the rotation speed of 6220 rpm and same feed speed of 9 m/min but for a light cutting depth of 1 mm. In this respect it is worth to mention that all samples presented either no or less fuzzy grain given the low values of the specific roughness parameter, R_{pk}, ranging from 6 to 9 µm, as presented in Figure 4. Both milling cutters generated by processing fine surfaces which indicated how smooth the milling process run. But based on the criteria of minimum roughness parameters which express the surface quality after processing, it can be concluded that for low feed speeds and light cutting depths, the inserted carbide tool is recommended for a rotation speed of 6620 rpm while the brazed carbide tool generates the best surface quality for a rotation speed of 9732 rpm. Such findings are in accordance with the specialty literature (Sogutlu, 2010).

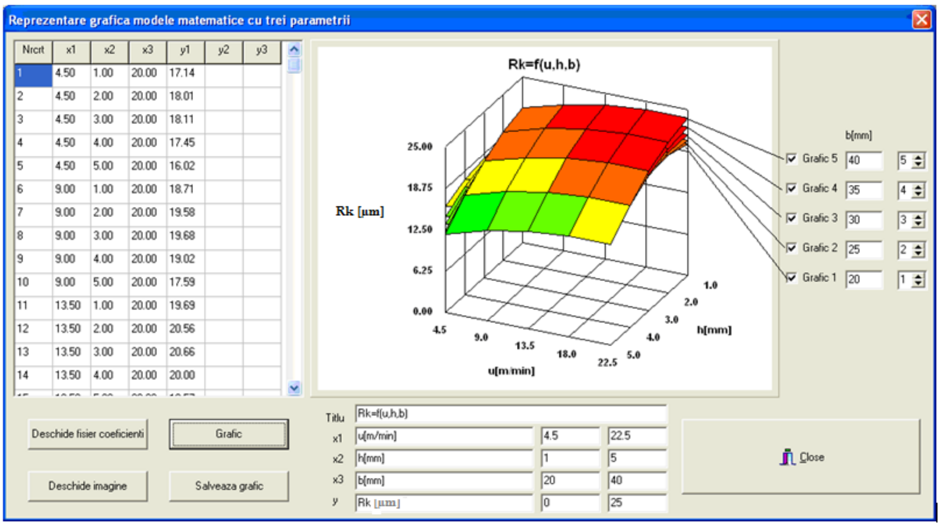


Figure 1. 3D Surfaces - Variation of roughness (R_k) depending on feed speed (u), cutting depth (h) and cutting width (b) after the longitudinal milling by using the inserted carbide milling cutter at 9732 rpm rotation speed

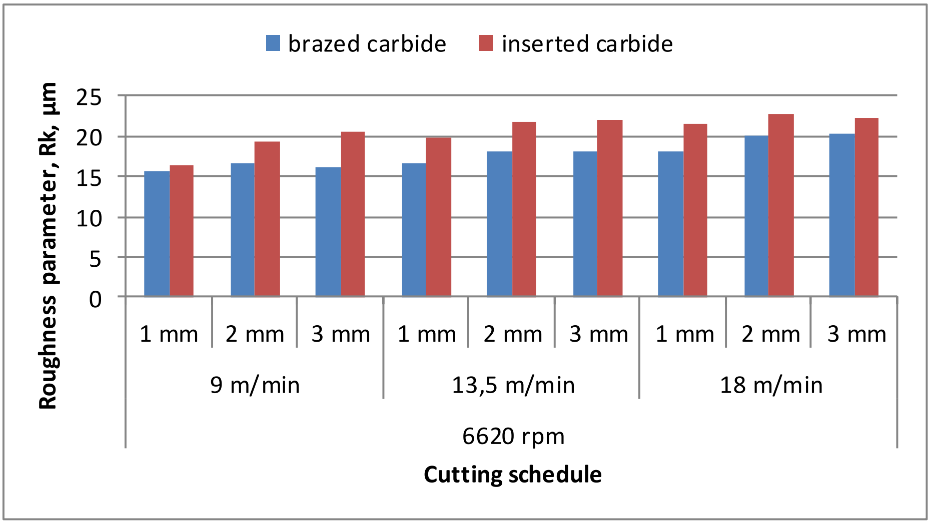


Figure 2. Variation of roughness (R_k) depending on the cutting schedule for 30 mm as cutting width after the longitudinal milling by using two types of milling cutters at 6620 rpm rotation speed

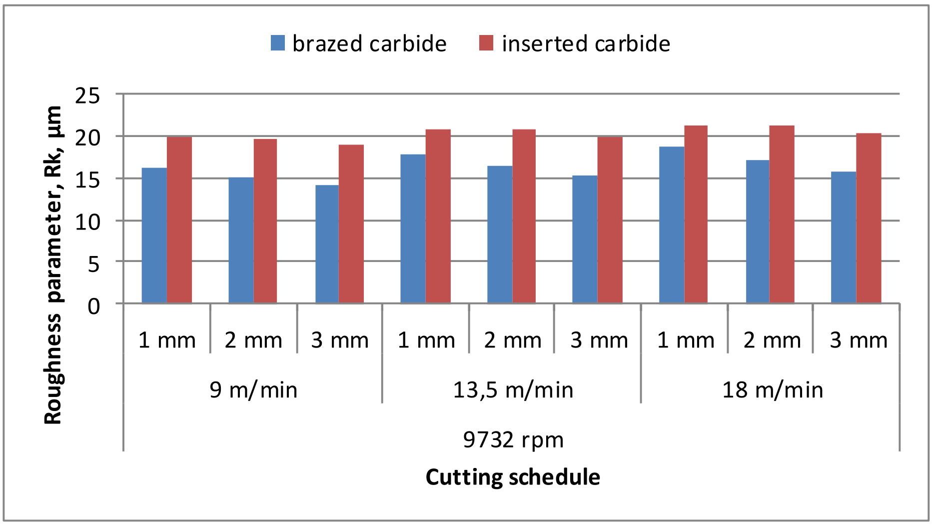


Figure 3. Variation of roughness (R_k) depending on the cutting schedule for 30 mm as cutting width after the longitudinal milling by using two types of milling cutters at 9732 rpm rotation speed

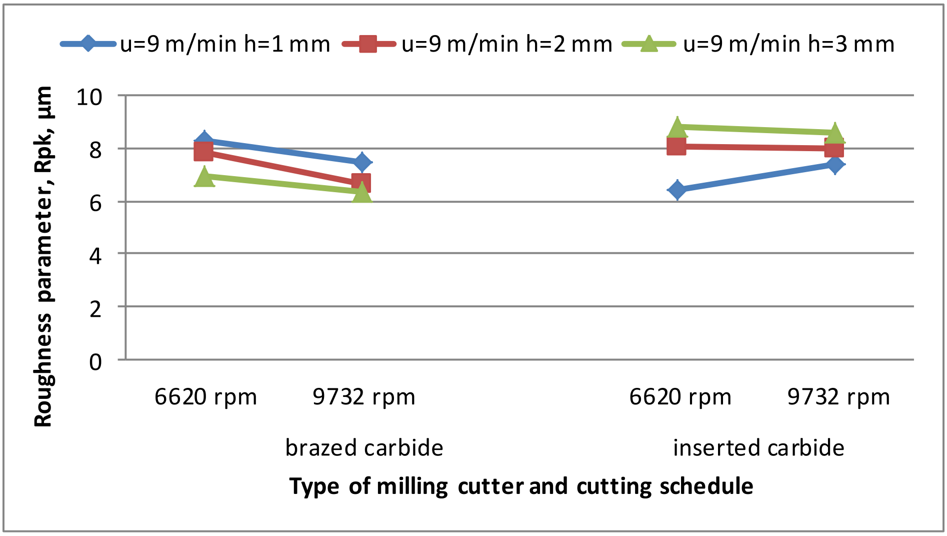


Figure 4. Variation of roughness (R_{pk}) as a function of different cutting schedules for two milling cutters

4. CONCLUSIONS

The results of this study showed that the two milling cutters generated smooth surfaces with no or low fuzzy grain and such quality of the processed surfaces can be obtained when using low feed speeds and light cutting depths. Findings of this work could help to use more efficiently the wood of black alder in the furniture sector.

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