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Milling quality of Norway maple *(Acer platanoides L.)* wood

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Abstract: *Milling quality of Norway maple (Acer platanoides L.) wood.* The paper presents results of roughness studies of Norway maple wood. Samples were prepared on a Weeke-Venture 3 woodworking centre using a ProfilCut knife clamping system by Leitz. Samples were cut using a sharp and a worn knife. Two roughness parameters Ra and Rz were determined. These tests showed that values of roughness parameters decrease with an increase in feed rate for most analysed values of feed rate and rotational speed. Analyses also showed that for the sharp knife the climb cutting reduces values of surface roughness.

Keywords: surface roughness, profile milling, Norway maple

INTRODUCTION

Norway maple (*Acer platanoides L.*) is a wood species with applications in different branches of industry. Thanks to its attractive wood pattern it is used to produce veneers as well as lumber for the production of furniture strips. In the furniture industry maple wood is used to manufacture solid wood elements and board elements with natural veneer. Apart from the above mentioned applications maple wood is used to produce decorative objects, toys, handles, etc. This species is also used by luthiers to produce various elements of musical instruments.

Numerically controlled woodworking machines, commonly used in wood industry plants, ensure smooth regulation of woodworking parameters such as rotational speed and feed rate. Obviously from the point of view of woodworking efficiency potentially maximum values of these parameters should be applied. However, the primary limitation is connected with the effect of woodworking manifested in the condition of the surface after milling. Numerous studies have been conducted on this subject concerning various wood species [1-3,5].

The aim of this study was to investigate the effect of feed rate and rotational speed of a sharp and a worn tool on surface roughness after a milling operation performed on a numerically controlled woodworking machine.

MATERIAL AND METHODS

Tests were conducted on samples of Norway maple (*Acer platanoides L.*) wood, which was moulded along the grain. Four samples were prepared. On three samples three milling operations were performed on both sides of the sample using climb and conventional ways of cutting, as shown in Fig. 1. Feed rates were 2, 4 and 6 $m \cdot min^{-1}$. Samples were cut with a sharp knife at rotational speeds of 9500, 12000 and 14500 min^{-1}. The fourth sample was prepared and cut with a worn knife (before it was replaced with a new knife) at a rotational speed of 12000 min^{-1}. Minimum and maximum cutting diameters were 78 mm and 99 mm, respectively.

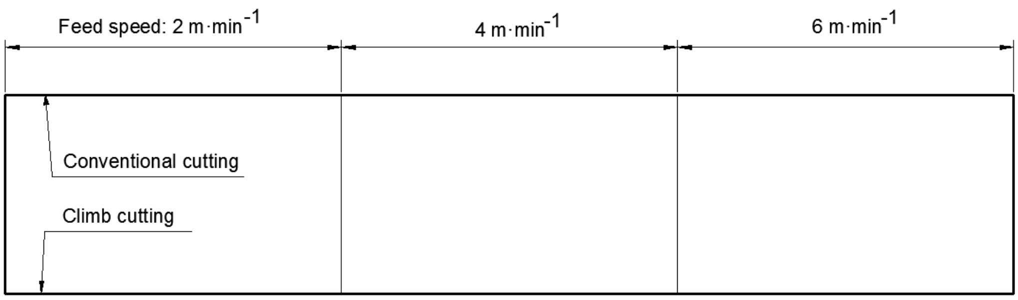

Fig. 1. A diagram of cutting zone distribution in individual samples

Cutting was performed using a mandrel two-knife profile cutterhead with a ProfilCut knife clamping system. Machining was performed on a Weeke–Venture 3 woodworking centre. The cutterhead was mounted in the machining assembly of the woodworking machine using an HSK tool holder. The shape of ProfilCut cutterheads used in the tests is presented in Fig. 2.

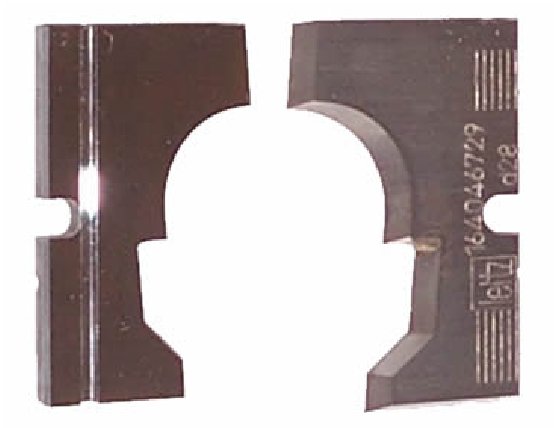

Fig. 2. Shapes of knives used in studies

Moisture content of tested samples was approx. 8%. Roughness was examined on surfaces cut along the grain, with the examined surface located perpendicular to the axis of rotation of the tool. The measurement path is presented in Fig. 3.

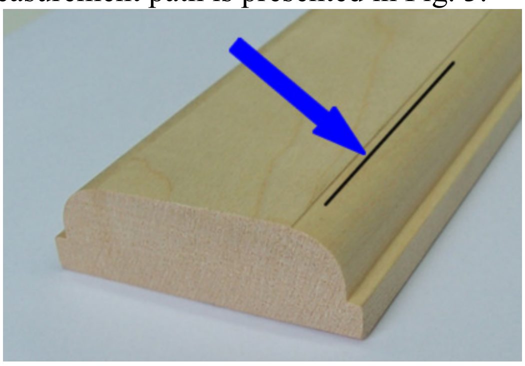

Fig. 3. Location of roughness measurement path

Surface roughness was measured using a Carl Zeiss ME-10 profile gauging profilometer. The stylus radius of the gauging attachment was 10 μm and the apex angle was 90^{o}. Two vertical roughness parameters were determined in accordance with the standard PN-EN ISO 4287-1999 [4], i.e. Ra and Rz.

RESULTS AND DISCUSSION

Roughness parameters Ra and Rz recorded for the surface produced at rotational speed of 9500 min^{-1} are presented in Fig. 4. Values of both parameters decreased with an increase in feed rate, with lesser roughness observed for climb cutting.

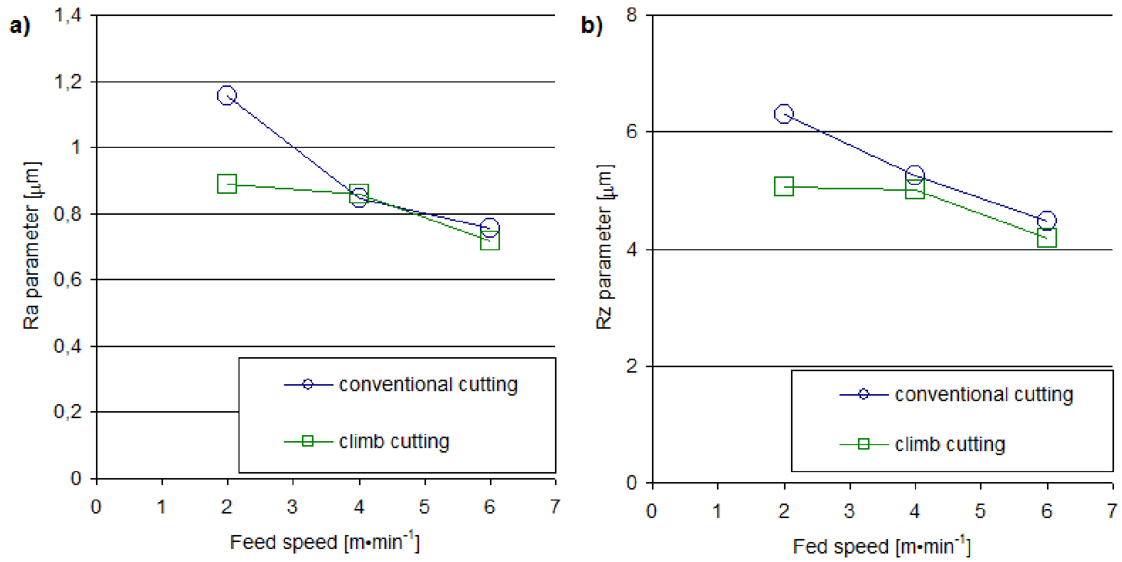

Fig. 4. Surface roughness for rotational speed of 9500min^{-1} depending on speed and type of cutting: a) parameter Ra, b) parameter Rz

Figure 5 presents parameters Ra and Rz for rotational speed of 12000min^{-1}. In the case of parameter Ra for both types of cutting and for parameter Rz for conventional cutting a trend was observed for roughness to decrease with an increase in feed rate. Parameter Rz for climb cutting does not show an oriented trend.

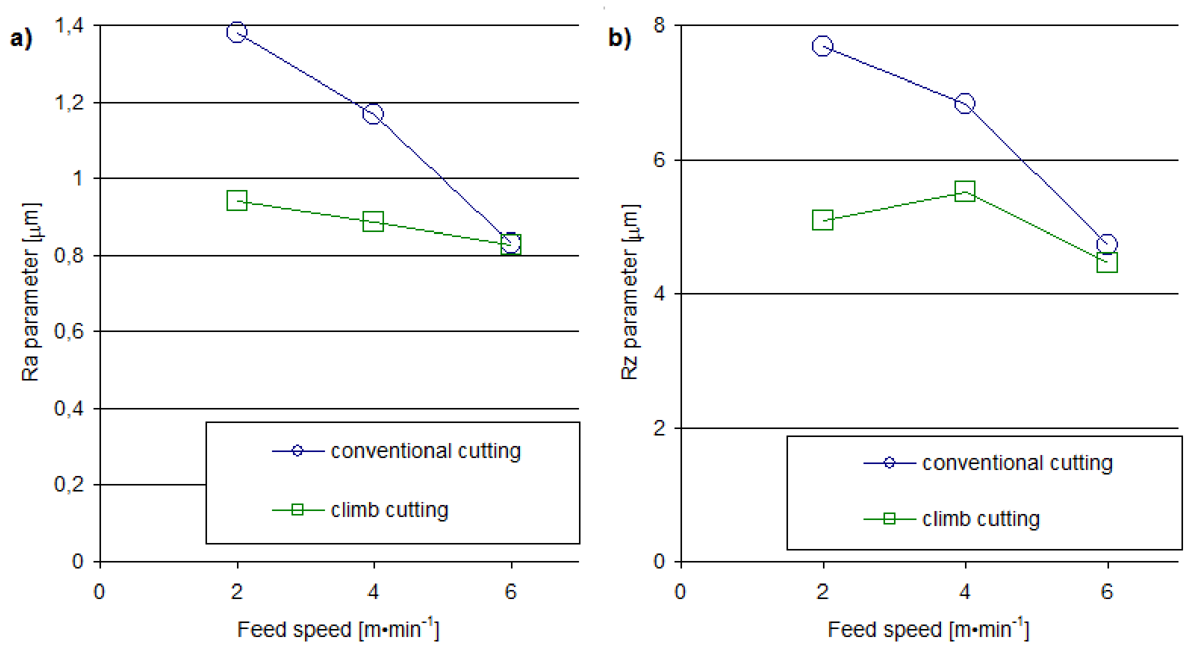

Fig. 5. Surface roughness for rotational speed of 12000min^{-1} depending on speed and type of cutting: a) parameter Ra, b) parameter Rz

For rotational speed of 14500min^{-1} an identical dependence was found for parameters Ra and Rz, which is presented in Fig. 6. At conventional cutting an increase in feed rate resulted in an increased roughness, while an opposite dependence was observed for climb cutting.

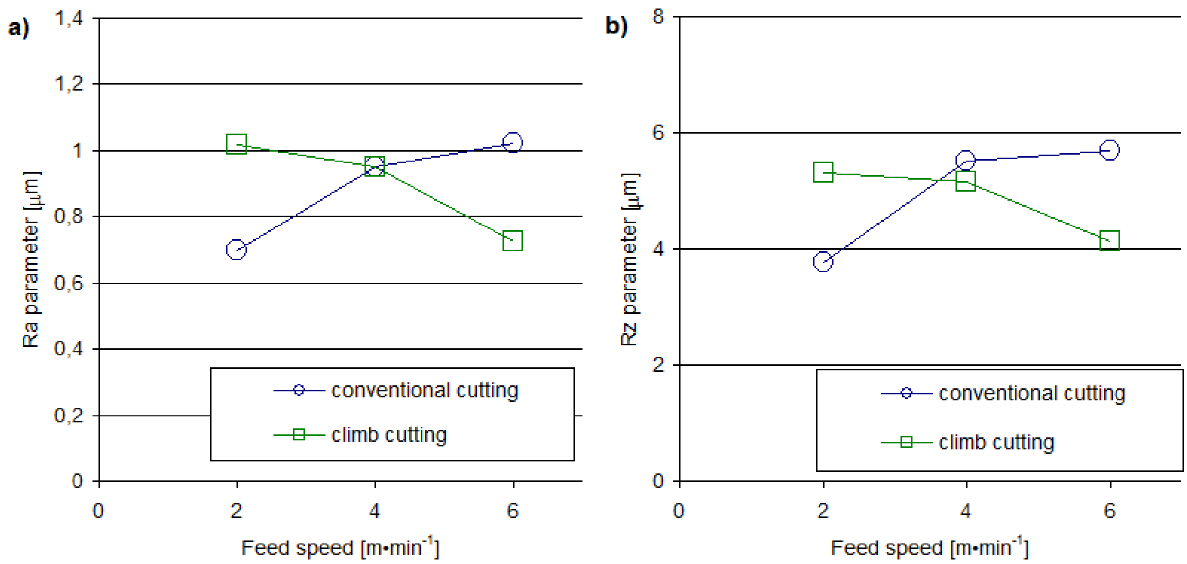

Fig. 6. Surface roughness for rotational speed of 14500min^{-1} depending on speed and type of cutting: a) parameter Ra, b) parameter Rz

Figure 7 presents values of parameter Ra depending on feed rate and wear (bluntness) of the cutting knife at the tool rotational speed of 12000 min^{-1}. For the sharp knife, irrespective of the type of cutting, values of parameter Ra decreased with an increase in feed rate. In the case of the worn (blunt) knife an increase in feed rate resulted in an increase in Ra values. This was particularly evident for climb cutting.

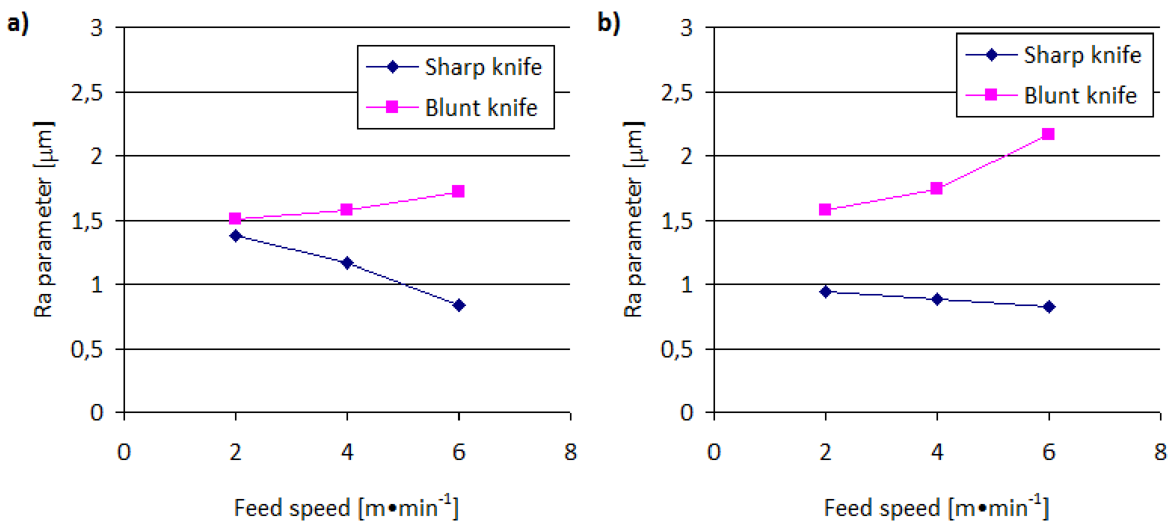

Fig. 7. Roughness Ra for rotational speed of 12000min^{-1} for a sharp and a blunt knife depending on feed rate; a) conventional cutting b) climb cutting

CONCLUSIONS

It results from the conducted analyses that in the case of the sharp knife for most analysed cases values of parameters Ra and Rz decreased with an increase in feed rate, irrespective of the applied cutting method, i.e. climb vs. conventional cutting. An exception from this dependence was the variant for conventional cutting at feed rate of 14500 min^{-1}.

Analysed roughness variants for surfaces milled using a sharp and a worn knife showed opposite dependencies, i.e. for the sharp knife roughness decreased at an increase in feed rate, while for the blunt knife roughness increased with an increase in feed rate.

It also results from the investigations that climb cutting in milling of maple wood with a sharp knife generally improves surface quality.

Tests showed that in terms of surface quality in the analysed cases optimal cutting parameters are feed rate of 6 $m \cdot min^{-1}$, rotational speed of 9500 min^{-1} and climb cutting.

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Streszczenie: *Jakość frezowania profilowego drewna klonu zwyczajnego (Acer platanoides L.).* W pracy przedstawiono wyniki badań chropowatości powierzchni drewna klonu zwyczajnego. Próbki przygotowano na centrum obróbkowym Weeke-Venture 3 z wykorzystaniem głowicy frezowej profilowej firmy Leitz typu ProfilCut. Próbki skrawano nożem ostrym oraz zużytym. Wyznaczono dwa parametry chropowatości Ra oraz Rz. Z przeprowadzonych badań wynika, że wraz ze wzrostem prędkości posuwu maleją wartości parametrów chropowatości, dla większości analizowanych wariantów wartości prędkości posuwu i prędkości obrotowej. Przeprowadzone badania wykazały ponadto, że dla noża ostrego, zastosowanie posuwu współbieżnego obniża wartości parametrów chropowatości powierzchni.

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