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Milling quality of sweet cherry (*Prunus avium L.)* wood on a CNC woodworking machine

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Abstract: *Milling quality of sweet cherry (Prunus avium L.) wood on a CNC woodworking machine*. The paper presents results of studies on surface roughness of sweet cherry wood. Cutting tests were performed on a Weeke-Venture 3 woodworking centre using a milling cutterhead with a ProfilCut knife clamping system by Leitz. Roughness parameters: mean arithmetic profile roughness parameter Ra and the mean peak-to-valley height Rz were recorded on the surface produced as a result of milling with a sharp knife. It results from the tests that values of roughness parameters increase with an increase in milling speed, while an increase in roughness depending on feed rate is observed at rotational speeds of 12000 and 14500 min^{-1}. Tests also showed that the application of climb way of cutting improves surface quality, with the best results obtained for rotational speed of 14500 min^{-1}.

Keywords: surface roughness, milling, sweet cherry

INTRODUCTION

Numerically controlled woodworking machines commonly used in wood industry have many advantages, including e.g. smooth regulation of woodworking parameters. Programming of woodworking machines makes it possible to arbitrarily set feed rate and rotational speed, on condition they are within the operational limits of the woodworking machine. From the point of view of machine efficiency it is best to use the maximum available values of these parameters, while the limiting factor for the application of maximum speed values may be connected with surface quality after woodworking. Tests in this respect were conducted in relation to many wood species [1, 2, 4, 5, 8, 10] and wood-based materials [9].

Among furniture industry representatives an increasing interest is observed in exotic wood species or native species with distinct grain, such as e.g. sweet cherry. Elements made from this wood species are frequently used in the production of ornamental elements e.g. solid edging, strips, wooden accessories, etc. Surface quality is a significant problem in the production of such elements. Visible fragments are subjected to finishing processes, in which they are coated e.g. with lacquer products. Their wear to a considerable degree is dependent on surface smoothness, thus surface roughness after woodworking should be as limited as possible. Most frequently studies are conducted on surface roughness after the last stage of mechanical woodworking, i.e. grinding [11], but also milling [3].

The aim of the study was to determine the effect of rotational speed of the tool and feed rate at cutting of sweet cherry wood on its surface quality after milling.

MATERIAL AND METHODS

For testing purposes samples were prepared from sweet cherry (*Prunus avium* L.) wood, in which milling operations were performed along the lateral surfaces. Three rotational speeds of the tool and three feed rates were applied. Samples were cut using sharp knives. A total of 3 samples were prepared for rotational speeds of 9500, 12000 and 14500 min^{-1}. On each sample three milling operations were performed with the climb and conventional ways of cutting for the feed rates of 2, 4 and 6 m/min. Maximum cutting diameter was 99 mm, while minimum cutting diameter was 78 mm. Two cutting knives were used.

Tests were conducted using tools by Leitz, i.e. a mandrel two-knife profile cutterhead with a ProfilCut knife clamping system. Woodworking operations were 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. Milled elements during machining were mounted under partial vacuum using suction nozzles facilitating machining of narrow elements. The numerical control centre and the tool used in these experiments are presented in Fig. 1, while the shape of ProfilCut profile knives is given in Fig. 2

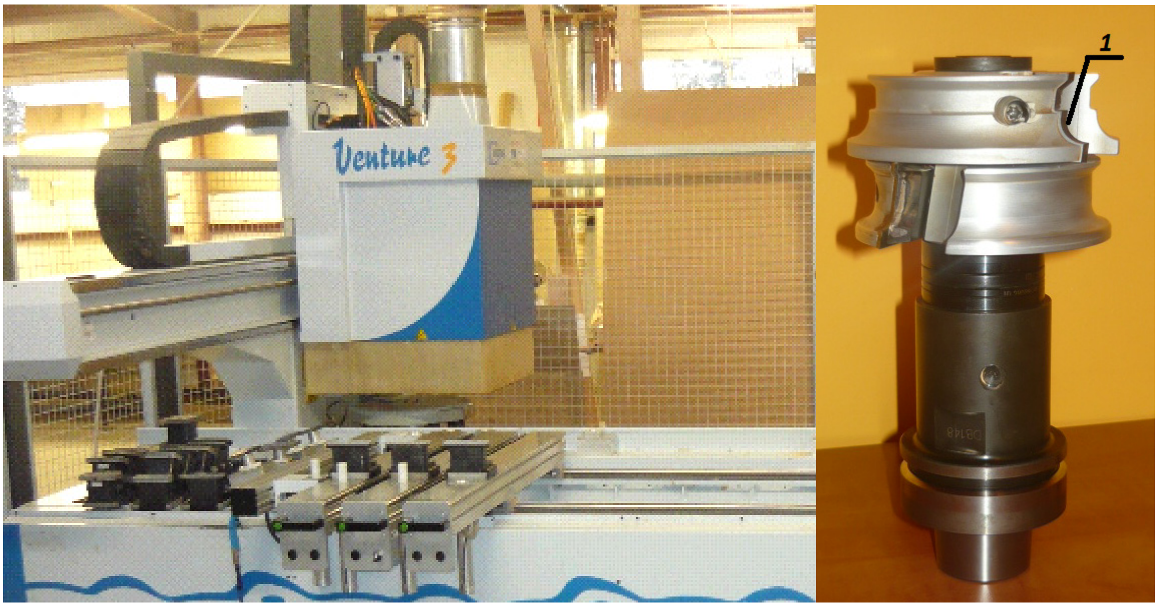

Fig. 1 A CNC Weeke Venture 3 woodworking machine and a ProfilCut cutterhead;
1 - knife used in tests

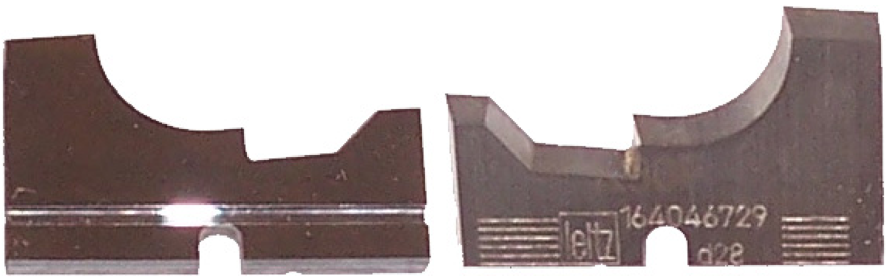

Fig. 2 Shape of ProfilCut profile knives

Moisture content of samples for tests was 8%. Roughness was analysed for surfaces cut along the grain, with the tested surface being perpendicular to the axis of the tool rotation. Locations of measurement sites are given in Fig. 3.

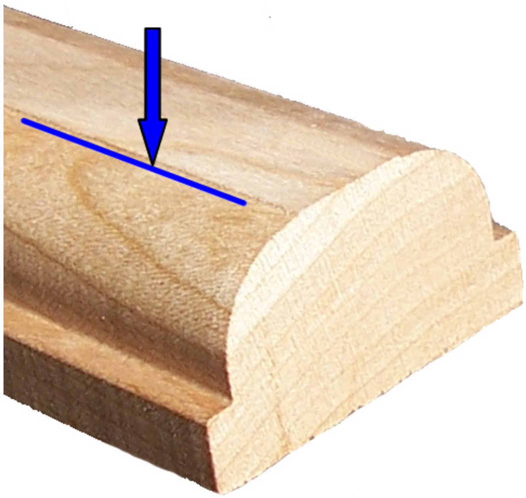

Fig. 3 Location of roughness measurement sites

Profile surface was recorded using a modified Carl Zeiss ME-10 profile gauging graphometer, equipped with a gauging attachment with a corner radius of 10 μm and apex angle of 90°. Feed speed during profile recorded was set at 200 $\mu m \cdot s^{-1}$. Recorded data were filtered according to the standards PN-EN ISO 11562:1998 [7]. Mean arithmetic profile roughness parameter Ra and the mean peak-to-valley height Rz were adopted as the index of surface roughness in accordance with the standard PN EN ISO 4287-1998 [6].

RESULTS AND DISCUSSION

Calculated values of roughness parameters Ra and Rz for the rotational speed of 9500 min^{-1} are presented in Fig. 4. In the case of parameters Ra and Rz no significant changes were observed depending on the rate or type of feed.

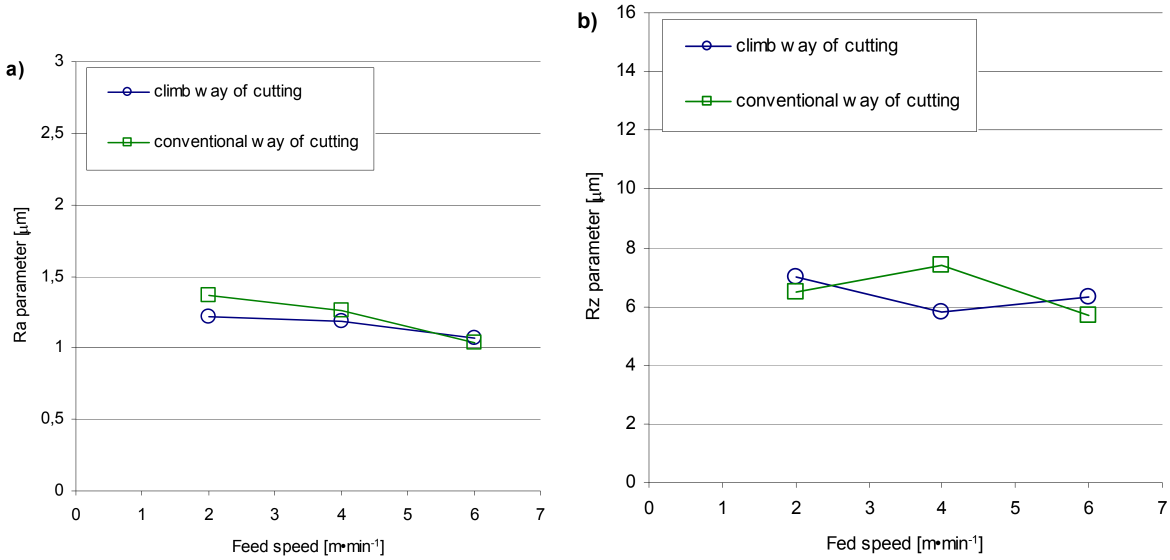

Fig. 4. Roughness for rotational speed of 9500 min^{-1} depending on the rate and type of feed; a) Ra parameter b)Rz parameter

Figure 5 presents parameters Ra and Rz for the rotational speed of 12000 min^{-1}. At this rotational speed with an increase in feed rate a limited upward trend is observed for roughness, while lower roughness values are obtained for the conventional way of cutting.

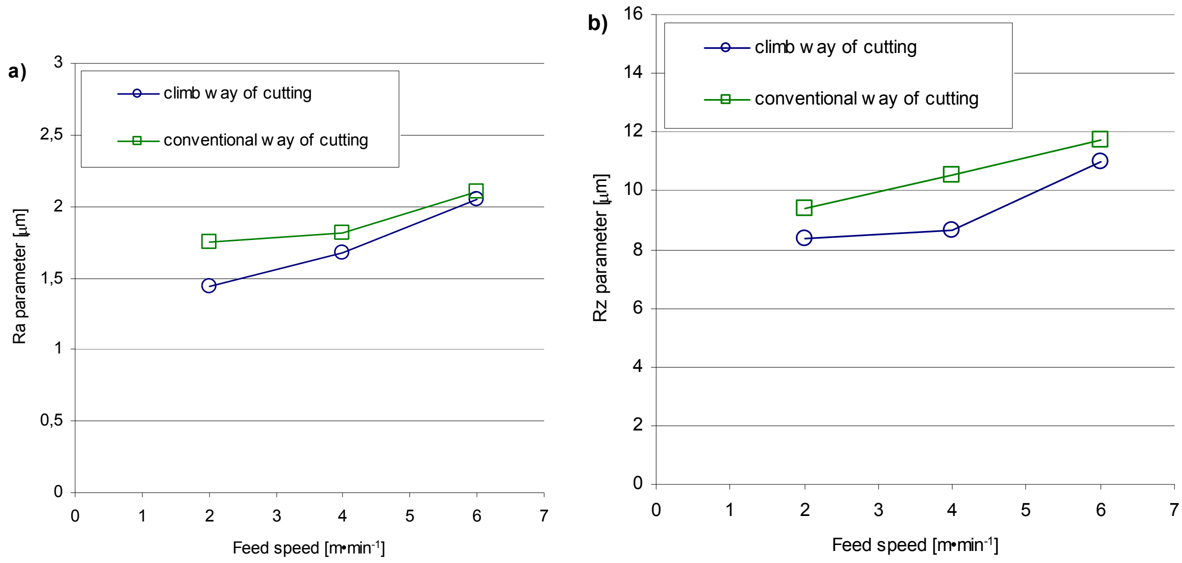

Fig. 5 Roughness for rotational speed of 12000min^{-1} depending on speed and type of feed; a) Ra parameter b)Rz parameter.

Figure 6 presents parameters Ra and Rz for the rotational speed of 14500 min^{-1}. In this case comparable values are found for the feed rates of 2 and 4 m·min^{-1}, while at the feed rate of 6 m·min^{-1} an increase in roughness is observed. At the rotational speed of 14500 min^{-1} a significant effect of feed is found on the values of surface roughness values. The application of the climb way of cutting markedly improves quality of the woodworked surface. This is most evident at the feed rate of 6 m·min^{-1}.

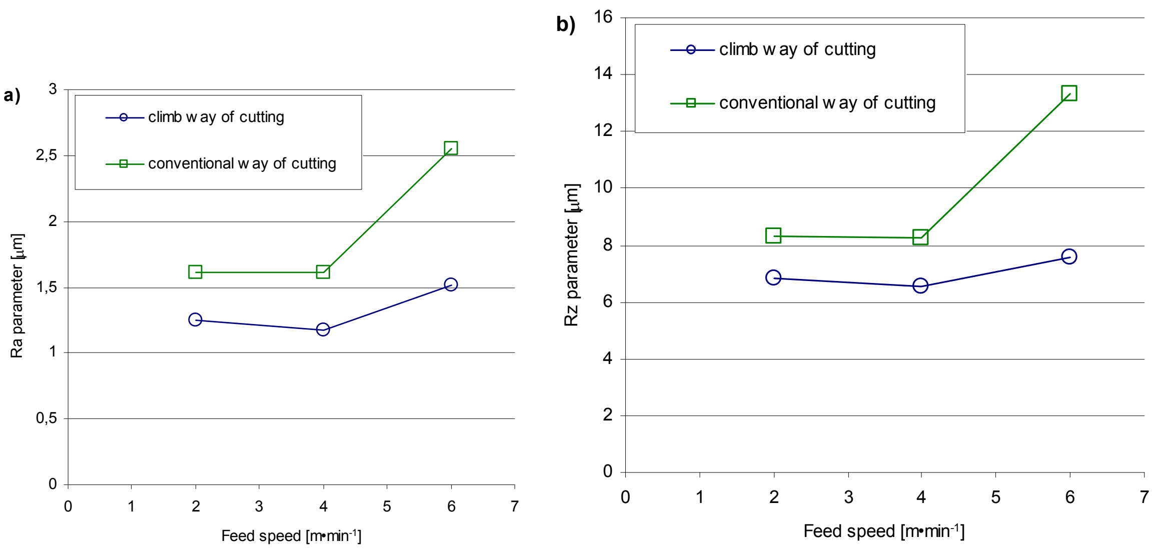

Fig. 6 Roughness for rotational speed of 14500min^{-1} depending on the rate and type of feed; a) Ra parameter b)Rz parameter

CONCLUSIONS

It results from the conducted tests that values of roughness parameters increase with an increase in rotational speed, while an increase in roughness depending on feed rate is observed at rotational speeds of 12000 and 14500 min^{-1}. Moreover, with an increase in rotational speed of the tool we may observe a greater difference between surface roughness produced at the climb and conventional ways of cutting.

Conducted tests showed that the use of the climb way of cutting improves surface quality. This is most evident at the maximum applied rotational speed. At milling along the grain at the climb way of cutting the so-called cleavage is not formed, which has a decisive effect on the improvement of surface roughness in sweet cherry wood. In this case fibres are cut, not split, as it may happen at cutting along the grain by conventional way of cutting.

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Streszczenie: *Jakość frezowania profilowego drewna czereśni (Prunus avium L.) na obrabiarce CNC.* W pracy zaprezentowano wyniki badań chropowatości powierzchni drewna czereśni. Badania skrawania wykonano na centrum obróbkowym Weeke-Venture 3 z zastosowaniem głowicy frezowej profilowej z mocowaniem noży typu ProfilCut firmy Leitz. Parametry chropowatości: średnie arytmetyczne odchylenie profilu Ra oraz największą wysokość profilu Rz wyznaczono na powierzchni uzyskanej w wyniku frezowania nożem ostrym. Z przeprowadzonych badań wynika, że wraz ze wzrostem prędkości skrawania wzrastają również wartości parametrów chropowatości, natomiast wzrost chropowatości w zależności od prędkości posuwu następuje przy prędkościach obrotowych wynoszących 12000 oraz 14500 min^{-1}. Przeprowadzone badania wykazały ponadto, że zastosowanie posuwu współbieżnego poprawia jakość powierzchni, przy czym najlepsze efekty uzyskano dla prędkości obrotowej 14500 min^{-1}.

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