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Surface roughness of beechwood following milling using modified cutters

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Abstract: *Surface roughness of beechwood following milling using modified cutters.* The paper presents results of measurements of selected roughness parameters of beech (*Fagus silvatica* L.) wood. Investigations were carried out on the surface obtained by milling carried out on a bottom-spindle milling machine. The tool used in experiments was a milling head with cutters covered with CrCN/CrN and TiAlN/TiN antiwear coatings. The performed experiments showed lower values of beechwood surface roughness parameters for cutters covered with antiwear coatings in comparison with cutters without such coatings and better results were found in the case of the CrCN/CrN coating.

Keywords: roughness, milling, wood, antiwear coatings, beech

INTRODUCTION

Wood surface quality is a very important aspect of wood processing and depends on many factors which are associated, among other things, with the processing method and parameters, employed tools, their condition, wear, durability etc. One of the surface quality determinants is its roughness described by various parameters, the most frequent among them are: arithmetic average height Ra and average peak to valley roughness Rz. Many investigations and experiments were carried out in recent years aiming at achieving the highest tool durability, while maintaining appropriate processing quality [1, 3, 8, 10]. Improvement of tool durability can be achieved employing a number of methods. Many studies were conducted to modify tools by spreading on the surface of cutters, with the assistance of different methods, e.g. PVD, of multilayered antiwear coatings [2, 4- 7, 14]. The application of antiwear coatings on tools, apart from increasing their durability, must also guarantee maintenance on an appropriate level of the surface roughness obtained after milling with these tools. Such analyses were also carried out for cutters with antiwear coatings [9]. This article presents research results of beechwood surface roughness following processing using cutters with multilayer CrCN/CrN and TiAlN/TiN antiwear coatings.

METHODOLOGY

Experiments were carried out on beechwood samples of 656 $kg \cdot m^{-3}$ mean density and 6.3% moisture content. Surfaces obtained after a milling process were investigated. The rotational velocity of the milling process amounted to 6000 min^{-1}, whereas the feed velocity was constant and equalled 12.5 $m \cdot min^{-1}$. The feed was realised by a three-roll feeding device type F38 of FELDER Co., and the milling process was conducted on a bottom-spindle milling machine type F900 of FELDER Co. (Fig. 1).

Fig. 1. Test stand of the bottom-spindle milling machine

A three-cutter, roll GOPOL Co., milling head was applied to carry out the milling process. Only one effectively milling cutter was used during the process, while the remaining cutters, appropriately configured, were used to ensure balancing of the head. The milling diameter amounted to 114 mm. Cutters manufactured from high-speed steel SW 18, of 45^{o} edge angle and antiwear coatings spread over their surface were applied in the milling head. Their characteristics are presented in Table 1. The antiwear coatings on cutters were spread using the method of cathodic arc evaporation at the Centre of Vacuous-Plasma Technology of the Institute of Mechatronics, Nanotechnology & Vacuum Technique of Koszalin University of Technology.

Investigations were carried out on samples obtained after milling. Cutters applied during the milling were designated as: I, II and III. Cutter I was covered with a CrCN/CrN coating, cutter II – with a TiAlN/TiN coating and cutter III did not have any antiwear coating.

Table 1. Types of antiwear coating used in experiments

Cutter	I	II
Type of coating	**CrCN/CrN**	**TiAlN/TiN**
Coating thickness [μm]	2,5	2,4 – 2,5
Number of layers	12	3
Coating hardness [GPa]	24	25

Multilayer CrCN/CrN coatings were made up of 6 modules and each module consisted of two layers making up the chromium cyanide (CrCN) and chromium nitride (CrN) layers. The thickness ratio of CrCN to CrN coatings in the module was 1:2. The thickness of each Λ module amounted to 400 nm.

The coating on the TiAlN base was a three-layer structure which consisted of a two-layer TiAlN/TiN coating and a TiAlN $\Rightarrow$ TiN transitory layer. The thicknesses of individual layers were as follows: 1.25 μm TiAlN, 0.5 μm TiAlN+TiN, 0.75μm TiN. Figure 2 presents calotest friction track of the CrCN/CrN and TiAlN/TiN.

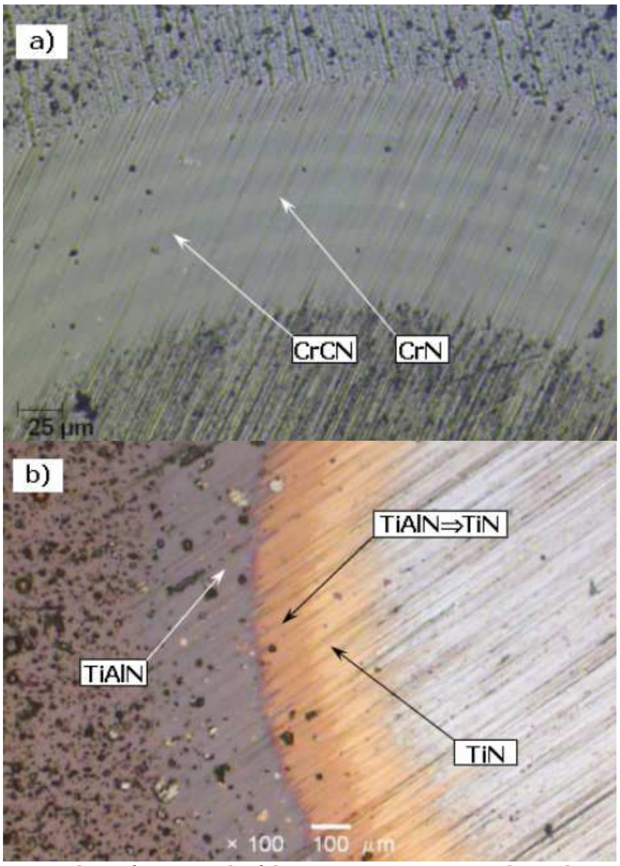

Fig. 2. Calotest friction track of the coatings: a) CrCN/CrN, b) TiAlN/TiN

Sample roughness was assessed after milling of the following distances: 1, 100, 500, 1000, 2000, 3000, 4000, 5000 and 6000 running metres.

Wood surface roughness parameters were determined using for this purpose a Carl Zeiss Jena surface analyser equipped in a measuring tip of 10±2.5 µm nose radius and nose angle of 90^o. The applied feed rate during measurements amounted to 100 $\mu m \cdot s^{-1}$. The obtained results were filtered in accordance with the PN-EN ISO 13565-1:1999 [12] and PN-EN ISO 11562:1998 [11] standards and the applied cut-off length during filtration amounted to 0.8 mm. As recommended by the PN-EN ISO 4287:1998 [13] standard, two basic roughness parameters were determined: arithmetic average height Ra and average peak to valley roughness Rz.

RESULTS

Figure 3 presents arithmetic average height Ra of the profile depending on the realised distance of milling for two cutters covered with antiwear coating and for one cutter without any coating. This dependence exhibited an increasing trend for the cutter without any coating and for the cutter with a TiAlN/TiN coating, though the cutter with the TiAlN/TiN coating showed a slightly lower values of the roughness parameters. The roughness parameters determined for the surface of beechwood milled with a CrCN/CrN-coated cutter exhibited a slightly declining trend.

The highest value of the determination coefficient r^2 was obtained for the cutter without any coating, whereas for cutters with coatings, the value of this coefficient was lower and amounted to 0.57 for the cutter with the CrCN/CrN coating and to 0.52 for the cutter with the TiAlN/TiN coating.

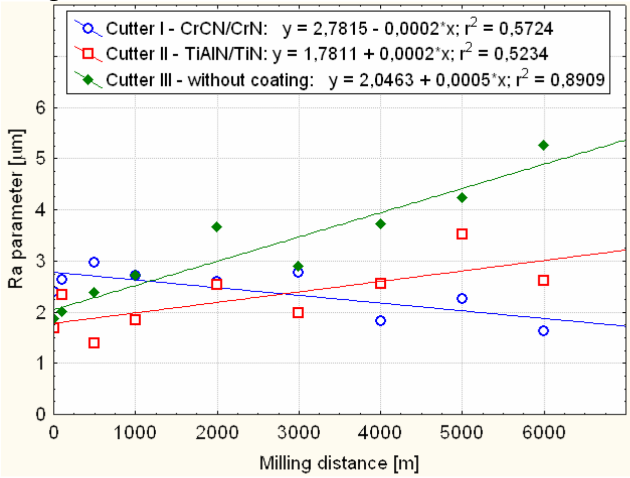

Fig. 3. Dependence of the arithmetic mean height Ra of the profile in the function of the milling distance for the examined cutters

Figure 4 presents the dependence of the parameter of the profile Rz roughness height on the milling distance. Characteristics of this dependence are identical with the Ra parameter, although the values of the determination coefficient differ slightly from those which were observed for the Ra parameter.

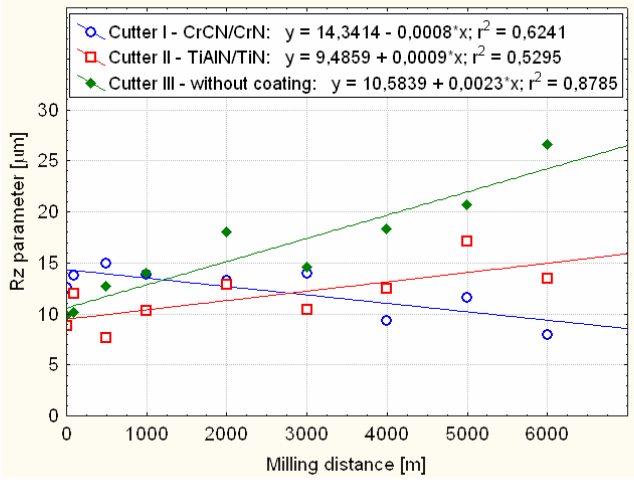

Fig. 4. Dependence of the average peak to valley roughness Rz in the function of the milling distance for the examined cutters

All in all, it should be emphasised that, in comparison with a crude cutter, surface roughness obtained after processing using the cutter with a TiAlN/TiN coating was characterised by a lower increase of the two analysed surface roughness parameters, namely Ra and Rz, whereas the surface obtained following processing with the cutter covered with the CrCN/CrN coating revealed a tendency for a slight drop of these parameters together with the increase of the milling distance.

CONCLUSIONS

The performed investigations on surface roughness obtained following beechwood milling using antiwear CrCN/CrN and TiAlN/TiN coatings spread over high-speed steel cutters revealed a decrease of roughness parameter values in comparison with wood surface after processing with a cutter without an antiwear coating. Positive effects in this regard were determined for both analysed antiwear coatings, although better results were observed in the case of the CrCN/CrN coating.

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Streszczenie: *Chropowatość powierzchni drewna bukowego po frezowaniu nożami modyfikowanymi*. W pracy przedstawiono wyniki pomiarów wybranych parametrów chropowatości powierzchni drewna buka (Fagus silvatica L.). Badaniu poddano powierzchnię uzyskaną poprzez frezowanie, zrealizowane na frezarce dolnowrzecionowej. Narzędziem zastosowanym w badaniach była głowica frezowa nasadzana z nożami pokrytymi powłokami przeciwzużyciowymi CrCN/CrN oraz TiAlN/TiN. Badania wykazały niższe wartości parametrów chropowatości powierzchni drewna buka dla noży z powłokami przeciwzużyciowymi w porównaniu do noża bez powłoki, z tym, że lepsze efekty stwierdzono dla powłoki CrCN/CrN.

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