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Surface roughness aspects in machine cutting of medium density fibreboards (MDF) with modified cutters on a CNC woodworking machine

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Abstract: *Surface roughness aspects in machine cutting of medium density fibreboards (MDF) with modified cutters on a CNC woodworking machine.* The study presents measurement results of MDF surface roughness expressed by the Ra parameter. The narrow surface of the MDF was investigated following the process of machine cutting with a shank-type milling cutter on a CNC woodworking machine. The cutting edges used in experiments were made of cemented carbide HM modified with multilayer antiwear coatings. The impact of CrCN/CrN and TiAlN/TiN multilayer antiwear coatings on surface roughness was investigated. In comparison with cutting edges without a coating, blades modified with antiwear coatings exhibited lower values of the Ra parameter for the examined measurement pathways in places of different density of the MDF. The most advantageous effects regarding the Ra parameter were recorded for the cutting edge with the CrCN/CrN coating.

Keywords: roughness, milling, MDF, antiwear coatings

INTRODUCTION

The medium density fibreboard (MDF) is a product widely used in wood industry. Apart from its numerous advantages, it is also characterised by certain shortcomings of which its difficult workability is one of the most serious ones. In order to maintain relatively long durability of instruments used for processing of MDF, it is essential to employ tools with hard cutting edges and the most common ones comprise blades manufactured from cemented carbides HM or diamond blades. In recent years, investigations have been carried out aiming at increasing durability of instruments used in wood processing as well as other materials difficult to work. Numerous experiments are focused on improving tool durability by applying on their surfaces various coatings reducing their wear [2-5, 8-10, 11]. This field of investigations has been developing dynamically recently. The application of instruments with new coatings requires investigations on the quality of surfaces obtained after processing using these tools. Davim et al [1] examined the influence of different processing parameters on MDF surface roughness on a CNC woodworking machine for cemented carbide cutting edges without antiwear coatings. Many experiments were also conducted involving workability of MDF [6, 7]. This article presents results of investigations on the roughness of the narrow surface of MDF following the process of machine cutting using cemented carbide cutting edges modified by multilayered antiwear coatings.

METHODOLOGY

Experiments were carried out on single-side laminated MDF samples of 780kg $\cdot$ m^{-3} mean density. Roughness of the board narrow surface was investigated which was obtained after the process of machining on a three-axis, numerically controlled woodworking machine FLA16 CNC. The rotational velocity of the tool was 18 000 min^{-1} and the feed velocity was constant amounting to 5 m $\cdot$ min^{-1}.

Three measuring paths were marked out on the narrow surface of the MDF as shown in Fig. 1. Pathways I and III were situated on the near-surface layers of the experimental MDF and for them the mean density reached 900 kg · m^{-3}. The mean density of the board in the measuring pathway II amounted to 730 kg · m^{-3} and the mean moisture content of the MDF was determined at 5.3%.

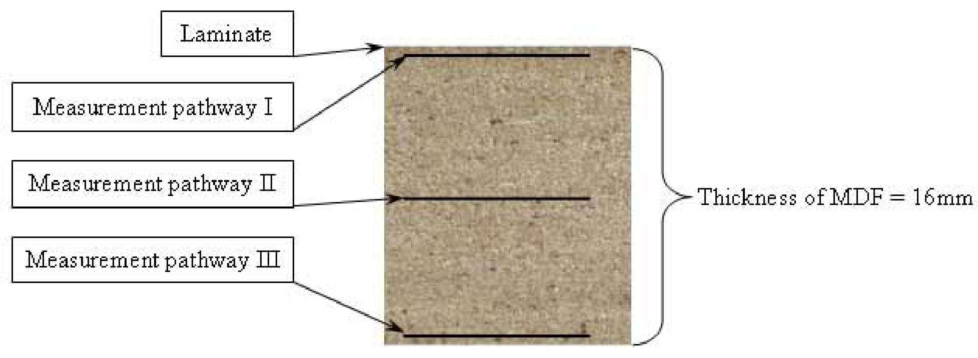


Fig. 1. Distribution of measuring pathways on the MDF

A two-blade shank-type milling cutter was used in experiments with only one of the blades utilised effectively in the course of investigations, while the second blade properly configured was used to guarantee correct balancing of the tool. The machine cutting diameter was 16 mm and the tool angle 55^{o}. The two-edge cutters (plates) employed in experiments were made of cemented carbide HM of SMG02 trade designation. The total of three types of cutters were investigated: without any antiwear coating and modified with two variants of antiwear coatings. Figure 2 shows an example of a cutter used in the trial.

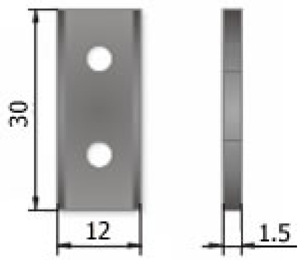


Fig. 2. Two-edge cutter blade used in experiments

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.

Cutters employed in the course of the milling process were designated as: I, II and III. Cutter I was covered with a CrCN/CrN coating, cutter II – with a TiAlN/TiN coating whereas cutter III did not have any antiwear coating.

The multilayer CrCN/CrN coating was 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 thickness of the entire coating amounted to 2.5 µm, while its hardness – 24 GPa.

The coating on the TiAlN base was a three-layer structure which consisted of a two-layer TiAlN/TiN coating and a TiAlN ⇒ TiN transitory layer. The thicknesses of individual layers were as follows: 1.25 µm TiAlN, 0.5 µm TiAlN+TiN, 0.75µm TiN. The thickness of each Λ module amounted to 400 nm. The thickness of the entire coating amounted to 2.5 µm, while its hardness – 25 GPa. Figure 3 presents an enlarged image of wear of the CrCN/CrN and TiAlN/TiN coatings obtained when examining the thickness of coatings with the assistance of Callote's method.

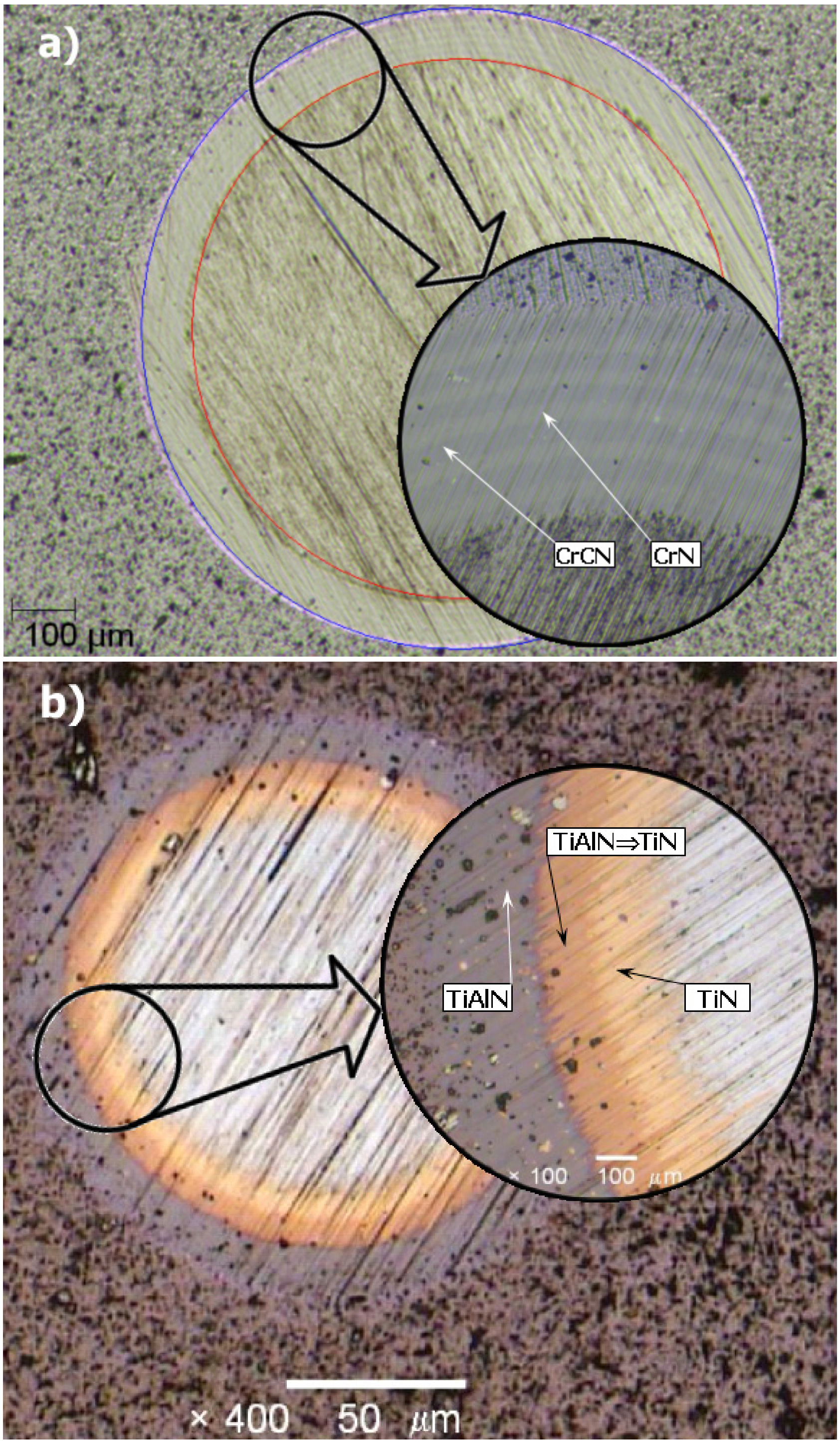


Fig. 3. Calotest friction track of the coatings: a) CrCN/CrN, b) TiAlN/TiN

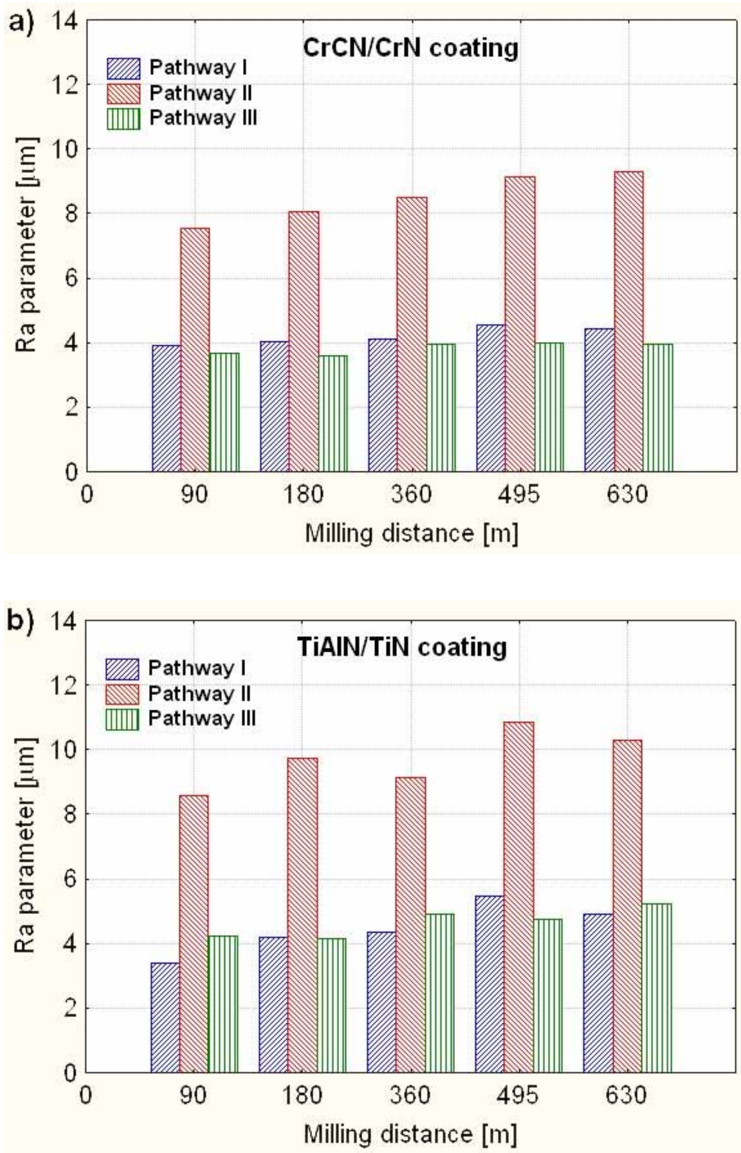
Sample roughness was assessed after milling of the following distances: 90, 180, 360, 495 and 630 metres.

MDF 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°. The applied feed rate during measurements amounted to 100 µm · 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, one basic roughness parameter were determined: arithmetic mean value Ra of the profile.

RESULTS

Figure 4 presents values of the Ra parameter for the three analysed cutting edges depending on the machining distance and the position of the measuring pathway.



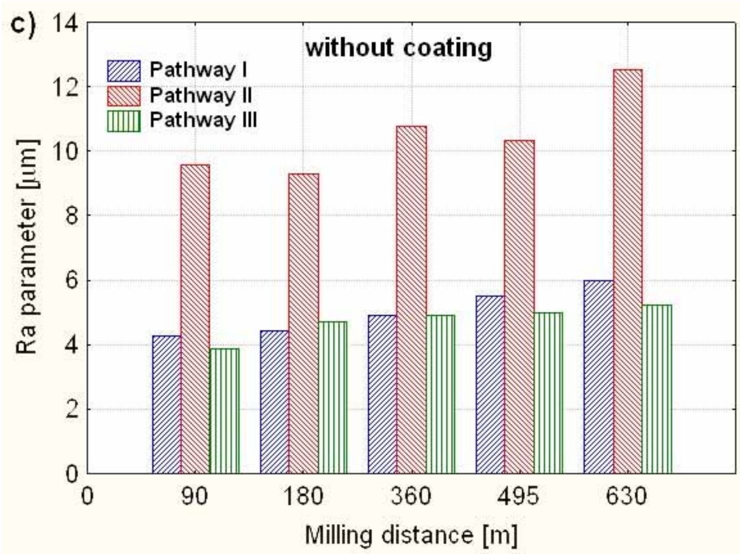


Fig. 4. Relationship between Ra parameter and machining distance for three measuring pathways for cutter edges: a) with CrCN/CrN coating, b) with TiAlN/TiN coating, c) without a coating

It is evident from the Figures that the highest values of the Ra parameter were registered for the II^{nd} measuring pathway which was situated half through the MDF thickness, i.e. at a place of its lowest density. These values ranged from 7.5 µm for the cutter covered with the CrCN/CrN coating at the shortest machining distance to 12.5 µm – for the cutter without any antiwear coating at the maximal machining distance. For measuring pathways I and III, where the board density was the highest, the Ra parameter value fluctuated at a similar level ranging from 3.41 µm – for the cutter with the TiAlN/TiN coating and the machining distance of 90 m to 5.97 µm for the cutter without a coating and for the maximum machining distance. The comparison of the Ra parameter values for the analysed measuring pathways revealed over a twofold surface roughness increase when the MDF density changed from the value of 900 kg · m^{-3} to that of 730 kg · m^{-3}.

Figure 5 presents the correlation between the Ra parameter and the machining distance for the examined three measuring pathways.

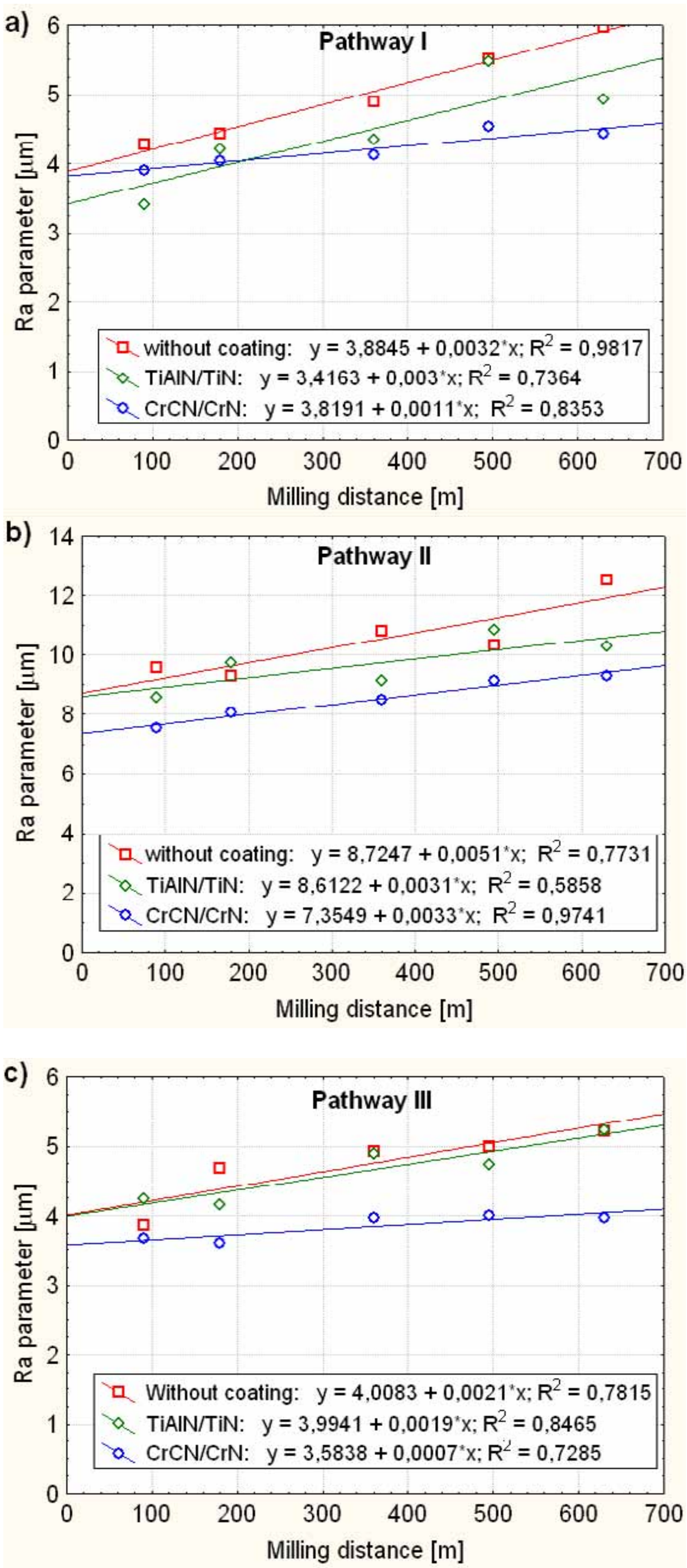


Fig. 5. Relationship between Ra parameter and the machining distance for the measuring pathway: a) I, b) II and c) III

When analyzing the Ra parameter along individual measuring pathways shown in Fig. 5, it was observed that irrespective of the measuring pathway, the parameter assumed the highest values in the case of the cutter without any antiwear coating. Slightly lower Ra values were recorded for the cutter covered with the TiAlN/TiN antiwear coating, while the lowest – for the cutter with the CrCN/CrN coating.

On the basis of the presented diagrams (Fig. 5), it can be said that the most favourable values of the Ra parameter were obtained for the measuring pathway III for the cutter with the CrCN/CrN coating.

CONCLUSIONS

MDF milling using cutters made of cemented carbide (HM) modified by multilayer antiwear coatings caused that, together with the increase of the machine cutting distance, also the surface roughness of the worked board increased.

The antiwear coatings applied onto cutting edges of cutters in the described investigations reduced surface roughness expressed by the Ra parameter in the case of all the examined measuring pathways. The greatest advantages were gained for the CrCN/CrN coating.

Surface roughness was found to increase twofold when the MDF density changed from the value of 900 kg · m^{-3} to the value of 730 kg · m^{-3} within areas of the adopted measurement pathways.

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Streszczenie: *Skrawanie płyty MDF nożami modyfikowanymi na frezarce CNC w aspekcie chropowatości powierzchni*. W pracy przedstawiono wyniki pomiarów chropowatości powierzchni płyty MDF (medium density fiberboard) wyrażonej parametrem Ra. Badano wąską powierzchnię płyty po obróbce skrawaniem frezem trzpieniowym na obrabiarce CNC. Zastosowano ostrza wykonane z węglika spiekanego zmodyfikowane wielowarstwowymi powłokami przeciwzużyciowymi. Badano wpływ powłok przeciwzużyciowych CrCN/CrN i TiAlN/TiN na chropowatość powierzchni. W porównaniu do noża bez powłoki, noże modyfikowane powłokami przeciwzużyciowymi wykazały niższe wartości parametru Ra dla badanych ścieżek pomiarowych usytuowanych w miejscach o różnej gęstości płyty MDF. Najkorzystniejsze efekty w zakresie parametru Ra, uzyskano dla noża z powłoką CrCN/CrN.

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