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Impact of smoothing conditions on the rounding effect of cutting edges of cemented carbide machining blades

Wpływ warunków wygładzania na efekty zaokrąglania krawędzi skrawających ostrzy z węglików spiekanych

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The origin of rounding cutting edges of machining blades made out of cemented carbides is presented. Various methods of cutting edge smoothing and rounding measurement are described. The impact of smoothing conditions on the intensity and effects of edge rounding is specified.

KEYWORDS: cutting tools, edge rounding radius, smoothing

For several years, the rounding of the edges of the carbide cutting blades has been applied, which improves the durability of the tools. Therefore, many design solutions were developed for smoothing the abrasive edge [2, 8-9]. They have been described in more detail in [2, 12]. Many leading global tool companies have introduced this technology, mainly in reference to monolithic carbide burrs and milling cutters [5-6, 10].

An additional benefit associated with the smoothing of the edges is the reduction of the surface roughness not only of the blades themselves, but also of the tool bodies. This in turn contributes to a better evacuation of the chips from the cutting zone, as well as the impact on the more effective appearance of the entire tool.

A certain problem related to the smoothing of the edges can be the exact measurement of the radius of their rounding rn. A significant impediment to this measurement is the very small radius value, usually from several to several dozen micrometers [1-2, 4, 10, 13].

Metallographic samples made perpendicular to the edge can be used for the measurement. However, it is destructive and laborious.

Frequently, advanced optical microscopes are used to measure the radii of the edge. They are very expensive, but necessary to control the complex smoothing process, in which many factors influence the machining effect.

The aim of the work was to identify and assess the significance of factors that have the strongest influence on the geometric effects of smoothing and machining efficiency.

Test conditions and methodology

The tests were rounded off the edges of monolithic mandrel bits and cutters with diameters 6÷12 mm, made of CTS20D sintered carbide (Ceratizit) (fig. 1).

Fig. 1. Photo of the tools used in the research (KOMET URPOL)

The edges were rounded on a container smoothing machine with a non-rotating PARDUS 6H 30T 2S drum (fig. 2). The smoothing machine has one main spindle with satellite mounted four rotary heads with planetary motion. Each head has five handles rotating relative to its own axis. It is possible to set the tool spindles angular to the vertical in the range of 0÷20°. On the machine tool, you can automatically execute machining cycles with controlled speeds, times and directions of the main spindle and tool heads. One can also adjust the immersion depth of the tools in the abrasive charge.

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As abrasive coatings, minced shells of walnuts with a grain size of 0.8÷1.3 mm from OTEC (with the HSC 1/300 designation) and PD2i (with the designation MAHST 36 and LAPF 46) were used [8, 9].

The rounding of the cutting edges was measured using the ALICONA InfiniteFocus SL microscope (fig. 3). It has an optical three-axis measuring system that automatically measures the radius of the rounding of the edges. The IF-EdgeMasterModule6.1.1.1 module displays the three-dimensional edge image and gives the operator-specified number of fillet radius values for the individual points of the edge section measured and their averaged value.

a) *b*)

Fig. 2. PARDUS 6H 30T 2S container windrower: *a)* general view, *b)* mounting heads with one mounted tool

Fig. 3. Stand for measuring the radius of the rounding of cutting tool edges

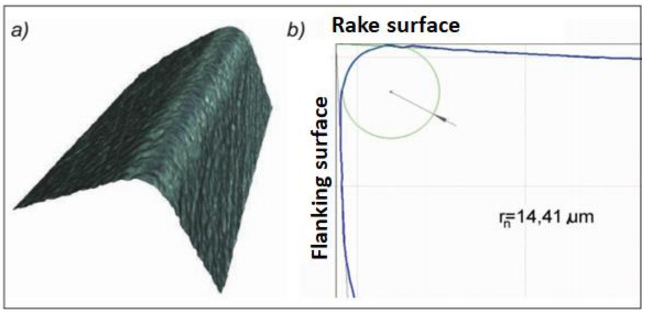

Fig. 4. Example of the measurement of the radius of the rounding of the cutting edge: a) cutting edge, b) cross-section of the edge

An example of a cutting edge image and a numerically defined cross-section of the blade are shown in fig. 4.

Influence of smoothing parameters on the radius of rounding of cutting edges

Variable parameters in the tests were: main spindle and tool spindle speeds, machining cycle times, the immersion depth of the tools in the abrasive feed, the machining time, and the type of abrasive feed. All tests were repeated three times, and their results, as average values, are shown in the graphs (figs. 5-9).

Before the smoothing, the radius of the edge rounding was measured. For all edges after the sharpening operation it ranged between 3 and 4.3 µm.

The research was carried out with fixed parameters of the central point (table). Only the values of this parameter, which was currently analyzed, were changed. Parameters changes are given in the graphs of test results.

A constant value of the inclination of the tool spindles in relation to the vertical has been kept: -20°. Its best value was determined based on previous studies.

TABLE. Values of the central point parameters of the test plan

Cycle time, s	120
Main spindle rotation speed, rev/min	25
Rotational speed of heads, rev/min	60
Depth of tool immersion in the abrasive batch, mm	70

Fig. 5 shows the influence of the spindle speed of the main smoothing machine on the radius of rounding of the cutting edge. The data shows that it is irrelevant.

Theoretically, the "resistance" of an abrasive load should increase with the square of the speed, and thus its abrasive effect should significantly depend on the spindle rotation. However, on the vector of the speed of movement of the batch relative to the tool, resulting from the main spindle rotation, a relative velocity vector is applied to the rotation of the tool spindles, because the tools perform complex planetary movements additionally disturbed by the angle of inclination of the tool spindles. The vectors of both these speeds - depending on the angle of rotation and angular position of the tool - can add up or subtract in a rather complicated way. This should be explained by the low intensity of the main spindle rotation on edge formation.

The influence of the rotational speed of the tool spindle on the intensity of edge rounding is shown in fig. 6. It is also ambiguous. For one of the tools grows linearly, and for the other - it is irrelevant. This is probably due to similar reasons as in the case of the rotational speed of the main spindle of the smoothing machine, i.e. the complexity of the planetary movements of the rotating spindles. Hence the conclusion that this factor is not suitable for controlling the process.

Fig. 7 shows the influence of the machining time on the value of the radius of the edge rounding. The presented data show that it is clearly growing with a slightly decreasing intensity. The reduction in the intensity of the smoothing time effect is due to the fact that as the radius of the edge rounding increases, the increasing volume of material must be removed to obtain the radius increase by the same amount.

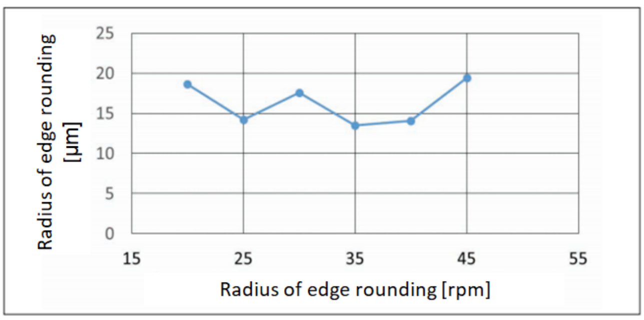

Fig. 5. Influence of rotational speed of the main spindle on the radius of rounding of the cutting edge

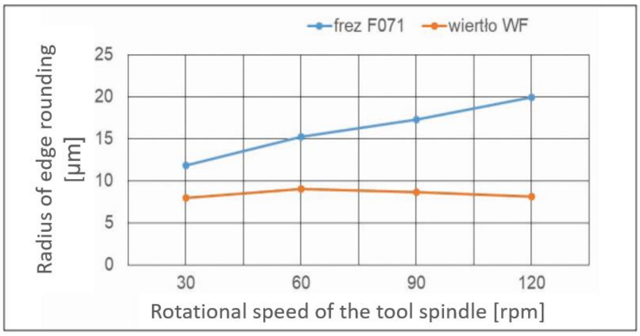

Fig. 6. Influence of rotational speed of the tool spindle on the radius of rounding of the cutting edge

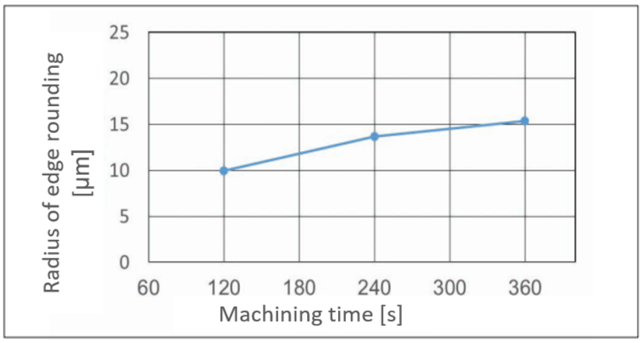

Fig. 7. Influence of machining time on the value of the radius of the cutting edge rounding

Thus, the machining time factor is a good parameter for controlling the process because it is unambiguous and reproducible. However, it should be taken into account that extending the machining time reduces the efficiency of the process and raises its costs.

The influence of the immersion depth of the tool in the abrasive bed on the edge rounding intensity is shown in fig. 8. It shows that initially increasing the tool cavity in the abrasive bed increases the edge rounding intensity, then the effect decreases and decreases with extremely high immersion values .

It is difficult to clearly explain the reason for such a change in the smoothing effect. Probably a deeper immersion of the tool, in the extreme case including the part of the frame, performing complex circular movements, causes a greater loosening (loosening) of the batch, and this may weaken its impact on the edges of the tool. Therefore, it is necessary to choose the immersion depth of the tool in the batch to obtain the highest machining efficiency. In addition, the intensity of smoothing can vary depending on the number of simultaneously machined tools.

The type of abrasive used in the blasting machine play a very important role in shaping the surface, especially the tool edges [1, 8, 9, 12].

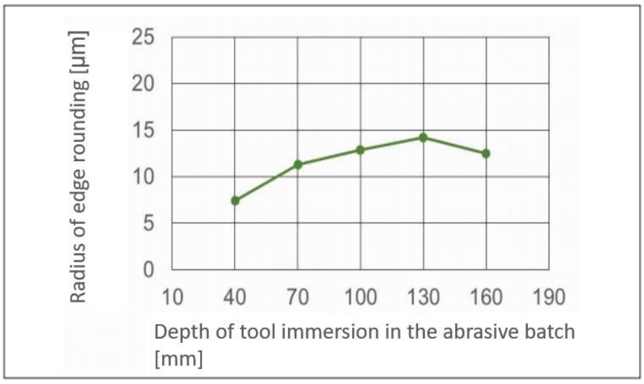

Fig. 8. Influence of the immersion depth of the tool in the abrasive charge on the radius of rounding of the cutting edge

It is not entirely clear what has a greater impact on the durability of the blade: the radius of rounding the edges or reducing its jaggedness. When choosing an abrasive batch, one must look for a compromise between efficient abrasives with good abrasive properties and those that allow to obtain a low roughness of smoothed surfaces.

Three types of batches were used in the research. The results of the research are presented in fig. 9.

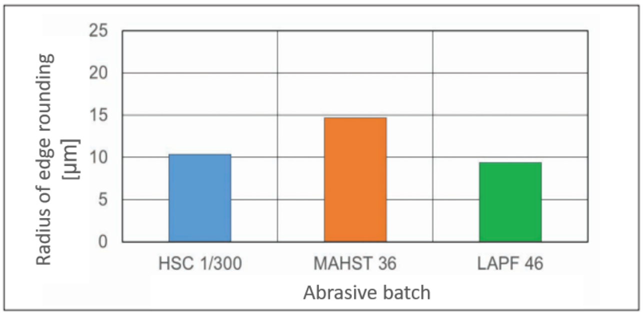

Fig. 9. Influence of the type of abrasive sanding pad on the radius of rounding of the edges of carbide blades

The abrasive MAHST 36 abrasively interacts with the tested batches. The remaining two batches have a similar intensity of impact, less by approx. 33%.

Conclusions

Smoothing of the cutting edges of the blades - which originated in the polishing of chip flutes to improve chip evacuation - caused a rounding effect on the cutting edges. It turned out that this small rounding, and at the same time a significant reduction in the edge's jaggedness, significantly contributes to extending tool life. Hence the rapid development and implementation of this technology in the tool industry. There is still insufficient knowledge to allow quick applications of these modern methods that bring about a real increase in the quality of tools and the efficiency of their use.

The research illustrates the complexity of factors affecting the effects of rounding the cutting edges of tools. It is mainly determined by the complex kinematics of overlapping planetary movements around three rotating spindle axes, tool heads and the tools themselves.

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