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CUTTING EDGE PREPARATION FOR TWISTED DRILLS

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Abstract: *To obtain better results for tool life, researchers have improved the microgeometry of the cutting edge. Through cutting edge preparation, a defined rounding and a reduced chipping of the cutting edge can be achieved. For this paper, twisted drills with the K factors: 0.5; 1 and 1.4 were used. The preparation process to obtain the K factors above was micro abrasive jet machining and drag finishing.*

Key words: *Drill, K Factor, Cutting edge, Micro geometry, Surface integrity*

1. INTRODUCTION

The increasing demand of products for the engineering industries requires the highest possible productivity products and continuous improvements to satisfy the customer's needs. New materials appearing are increasingly harder to work with, thus requiring more attention from the manufacturer. Therefore, an important factor in the final price of the product is affected by the price of the tool. A third of the price of the crankshaft for the 3.0-liter TDI Audi comes from the price of the manufacturer's cutting tools [3]. The primary objectives of cutting tools are to achieve high performance, excellent durability, low wear, but also a better surface quality. To achieve those, researchers wanted a change in the material their tools are made from, a redesign of the cutting geometry, relying largely on a new microgeometry of the edge. During the cutting process, large thermic and mechanical loading are the results of cutting tool wear [5]. Moreover, the surface quality is affected by the shape of the chips on the cutting edge [7]. The researchers found that preparing the cutting edges of tools, will not cause craters as easily, chipping of the cutting edge and increase wear resistance. To achieve optimum cutting edge, certain factors must be taken into account: the cutting material, cutting conditions, and material of the cutting tool [7]. In the papers [2, 4] the cutting edges are divided into different categories: rounded edge: single radius, trumpet form, and waterfall; sharp edge; chamfered edge: chamfer, protective chamfer (land) and double chamfer and the last category is combination edge: chamfer and rounded edge. To achieve special micro geometries at the cutting edges, different manufacturing technologies can be applied depending on the productivity, precision, and final micro geometry. Sharp edges with cutting edge radius $r_\beta < 5$ μm are generated by grinding the rake face. Grinding is also applied for the preparation of complex geometries, chamfers and the removal of a larger material quantity at the cutting edge. Intermediary edge radii, 5 μm $< r_\beta <$ 20 μm, can be prepared through abrasive blasting of the flank and rake faces. Brushing produces larger edge radii, with $r_\beta > 20$ μm. Blasting and brushing of the tool edge require less investment. If financially viable, magnet finish or laser blasting can also be applied. In this case, the radii are in the range of 30–50 μm [2, 4]. There are studies which show the influence of the factor K. Regarding drills, a good example is [10], which tests for the drill with a diameter 8.5 mm different K-factors: 0.6; 1 and 1.4 with different cutting parameters.

This paper shows that in almost all tests, an increase of the K-factors leads to a decrease of the tool wear and of the force F_f. Exceptions were made when using the v_c=110 m/min and f=0,3 mm parameters. Using the K factors: K=0.6 and K=1.4 obtained the best roughness. More studies with different K-factors have been done for the milling and turning process. An excellent study, testing more K factors is in the paper [11], where the K-factors 0.5; 0.6; 1; 1.6; and 2 were used. A milling cutter with a diameter of 80 mm was tested. The minimum tool wear VB were caused using the K factors K=0.5 and K=0.6, and the maximum tool wear were caused by using K=1.6 and K=2. The best roughness R_a was obtained when the cutting tools with K factors K=0.5 and K=0.6 were used. Following this research, we can say that the tools that were used pads amovible best results were when they use inserts with a K factor smaller than 1. Other studies for the milling process are in the papers [6, 10]. For the turning process the only tested K-factors are 0.5; 1; and 2 [9, 12]. In regards to the passive force F_p and feed force F_f,, it has been found that the smallest forces are recorded from the inserts with the sharp edge and with the chamfered edge. In case of the inserts were was used K factors is seen that when the K factors decrease the forces increase. The main cutting force F_c, is influenced mostly by a plate that has a factor of K=0.5 and K=1. At the opposite pole lies plate which has sharp edge and the factor K=2. The smallest tool wear is found by the insert with a single chamfer that has followed from the sharp edge.

By the inserts were was prepared different K factors has been observed that with the decrease of the K factors increase the wear [12]. This paper presents the preparation method of the carbide drill RT100HF with a diameter of 6.8 mm 5xD to obtain the K factors K=0.5; K=1 and K=1.4.

2. Definition of the cutting edge micro geometry

Cutting edge preparation is an important factor for tool life. To improve the tool life of the cutting tools, researchers have improved the microgeometry of the cutting edge. Looking at Fig.1 we could say that it is sufficient to characterize the cutting edge radius by determining the r_β. This cutting edge rounding is not enough to characterize the shape of the cutting edge [8]. Microgeometry is characterized by parameters: K, S_α, S_γ, φ, and Δr – which are presented in Fig. 1. The distance between the intersection point of the flank and rake face tangents, as well as the point of detachment of the respective tangent from the cutting edge profile defines the parameters S_α and S_γ. The relation $K=S_\gamma/S_\alpha$ determines the tendency of the edge to the flank face (K < 1) or to the rake face (K > 1) [8]. One can distinguish three types of K-factors, namely K <1 describes slope toward the flank face, K = 1 shows a symmetrical edge and K> 1 indicates a slope toward the rake face. Asymmetric edges are characterized by the following parameters: S_γ, S_α and K. Average rounding cutting edges are defined by size $\bar{S} = (S_\gamma + S_\alpha)/2$ [8]. Δr quantifies the edge sharpness; a low Δr denotes a sharp edge, while a high Δr means that the radius resembles a chamfer. The angle φ between the rake face and Δr describes the localization of the highest point of the edge [7].

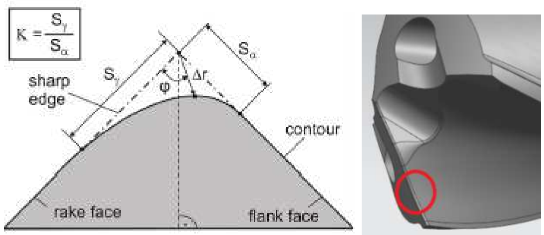


Fig. 1 Microgeometry of a cutting edge [7]

3. Cutting edge preparation processes

The cutting edge preparation processes can be divided into three types of preparation categories: mechanical, thermal, and chemical. In this paper, for the development of the cutting edge were used two mechanical preparation processes. The first process is micro abrasive jet machining (Fig. 2) and it is one of the most effective methods for achieving microgeometries. It's a process in which a granular medium is accelerated in the equipment of various systems and is brought to the surface of the workpiece desired to be processed. We can further classify this process into two categories: dry micro abrasive jet machining and wet micro abrasive jet machining. The advantages of wet micro abrasive jet machining are the absence of thermally induced distortions on the machined surface, and it also suppresses dust formations. The main aim of jet machining is to achieve the desired cutting tool microgeometry. The functioning principle of wet micro abrasive jet machining is simple. The abrasive medium is mixed with water and then with compressed air into the nozzle. Turning on the nozzle produces a fine jet, forming a cone aimed at striking the cutting edge. The results are small deformations on the cutting edge. At the beginning of the process the cutting edge was perfectly sharp, but after the blasting, the cutting edge will have a round edge or it will have a chamfered edge. [8]

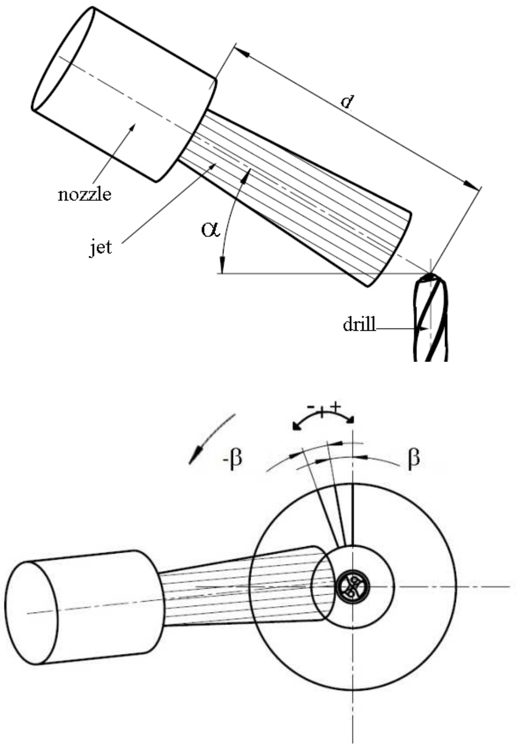


Fig. 2 Wet micro abrasive jet machining scheme

Parameters influencing results are; positioning of the nozzle to the cutting tool (d), the inclination angle of the nozzle (α), the number of revolutions of the tool, cutting tool number of swinging, angle of the swinging (β) and jet pressure (p). Jet pressure has a significant influence on the removal of material. Due to the high environmental pressure abrasive grit increases its speed and kinetic energy. As a consequence, it increases the cutting edge rounding, but it can also destroy the cutting edge if pressure is raised. Setting the inclination angle of the nozzle affects the removed material along the cutting edge in a direction of the flank face or from the rake face. With so many varied parameters, wet micro abrasive jet machining can achieve a variety of microgeometries of cutting edges.

Drag finishing (Fig. 3) is a simple cutting edge preparation process with a geometrically undefined cutting edge. The drill is fixed in a chuck which can rotate around the axis counter wise or clockwise. The chuck together with the drill goes down in the drum with an abrasive medium which also can be rotated around the axis counter wise or clockwise until more than the half of cutting length of the drill is inside of the abrasive medium. At the drag finished process the surface of the drill will have a better quality, the micro asperity will become smoother, so the friction between the drill and the cutting material and chips will be smaller. Another thing about the drag finishing is that after the process, the cutting edge rounding (r_β) will be smaller with a few µm. In addition to improving the appearance of the drill surface, polishing also improves the physical properties of the surface. For example, a polished chip flute gives higher maximum cutting speeds.

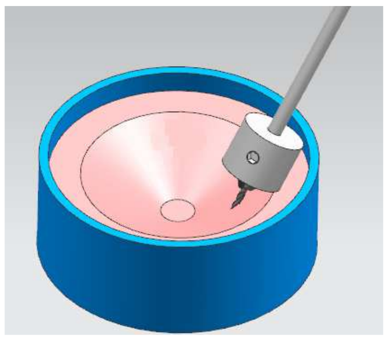


Fig. 3 Drag finishing scheme

4. EXPERIMENTAL SETUP AND RESULTS

For this experiment, 54 drills were prepared, which means for each K-factor 18 tools were prepared. The drill RT100HF with the diameter 6.8 mm and the carbide of which it’s made is

K30/K40. The properties of the solid carbide are: 90% WC, 10%Co; the grain size of WC is 0.5 μm. The density is $14.45 g/cm^3$ with a Vickers hardness HV_{30} of 1620. For achieving different values of K-factors, some parameters for the wet micro abrasive jet machining must change, such as: the inclination angle of the nozzle, the pressure of the nozzle jet, the rotations and the oscillations of the cutting tool. For the start were prepared drills with K-factors K=1, because K=1 is the standard value for the K factor, that means that the parameters were known from other experiments. After each prepared drill, the cutting edge of the tool (both cutting edge of the drill) was measured on the GFM MicroCAD (Fig. 4). On each measurement, an interval (between the two vertical lines) was selected, and the interval has 100 measurements for the K-factor to see how the K-factors on the cutting edge vary. After that was made the average K factor for the cutting edge. The results for the both cutting edges of the drill were similar, and the obtained values were in the range of K=1±0.1. At some drills, the difference between the two cutting edges for the K factor value was big, but with the rest of them, they had similar values. In this case the jet hit equal the rake and the flank face. Later on, drills with K-factors near K=1 were prepared, which meant K=1.4±0.1, because the angle of the nozzle has a value near the standard angle of K=1. In contrast to the values of the drills with K factor K=1, in this case, the values for the both cutting edges were very similar. In this case the jet hit more the rake face. Lastly, the drills with K-factor K=0.5±0.1 were prepared. In this case, the inclination angle of the nozzle for K=0.5 was bigger than the inclination angle for K=1. For K=0.5 the value of S_γ must be two times greater than S_α the abrasive medium must hit very much the flank face. After all the drills were prepared with wet abrasive jet machining, the tools were prepared with drag finishing, and identical parameters were used for all the drills.

With the help of the REM microscope, the surfaces of the cutting edge could be analyzed after the wet micro abrasive jet machining and drag finishing. In the images below is shown the topography of the three types of K-factors of the cutting edge after each preparation type process (Fig. 5).

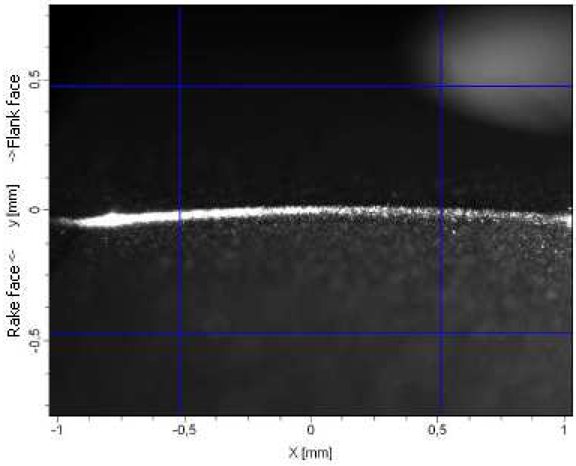


Fig. 4 GFM MicroCAD measurement

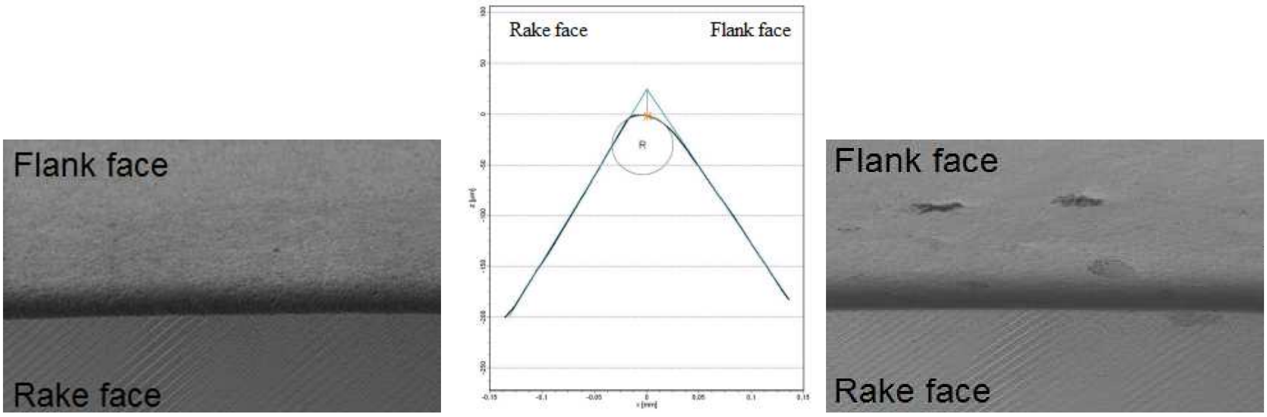
In the first set of images is shown the cutting edge of the drill with K-factor K=0.5. In the first image, we see the topography of the cutting edge after the drill has been prepared with wet micro abrasive jet machining. On the flank face we could see a high quality of the surface in comparison with the rake face. On the rake face we see some striations, from grinding of the macrogeometry. If we look at the section of the cutting edge, we understand what's happening. Because of the high angle of the nozzle jet, the abrasive medium hits the flank face much more, so in the end, there's no complete radius of the cutting edge. After the drag finishing the surfaces of the drills are improved. The next set of images represents the topography of the cutting edge with K=1. In this case, we see the symmetry of the flank and the rake face, meaning $S_\gamma=S_\alpha$. By looking at the topography of the surface, we can determine that the quality is poor. The reason for the poor quality of the surface is because the pressure of the nozzle jet was bigger in comparison with the nozzle jet pressure for K=0.5. After the tools were prepared with drag finishing, an improvement of the surfaces was shown. The last set of images illustrates the topography of the cutting edge drill with K-factor K=1.4. This K-factor indicates a slope towards the rake face, as seen in the last image.

5. CONCLUSION

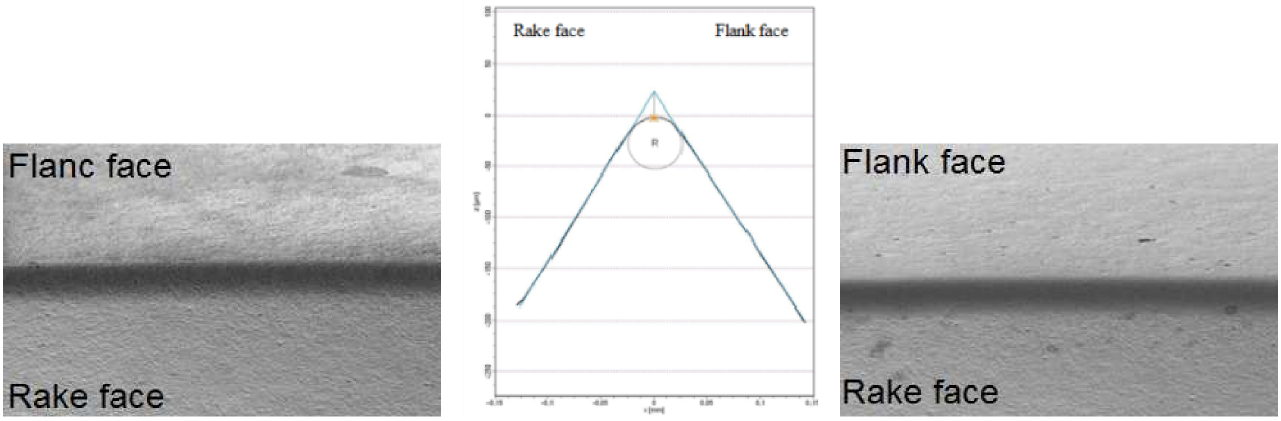
relation to K-factor K=1, we can find some similarities but also differences. First of all, we can say that in both cases there is a slope on a face (flank face or rake face) of the cutting edge. The qualities of the surfaces are different: in the case of K=0.5 the quality is better than in

In conclusion we make a comparison between the cutting edge from K=0.5 and K=1.4 in the case of K=1.4, which is similar with K=1, because the nozzle jet pressure was the same. Another difference is that in the case of K=1.4 we don't have striations on the surface, as it is for the cutting edge with K-factor K=0.5.

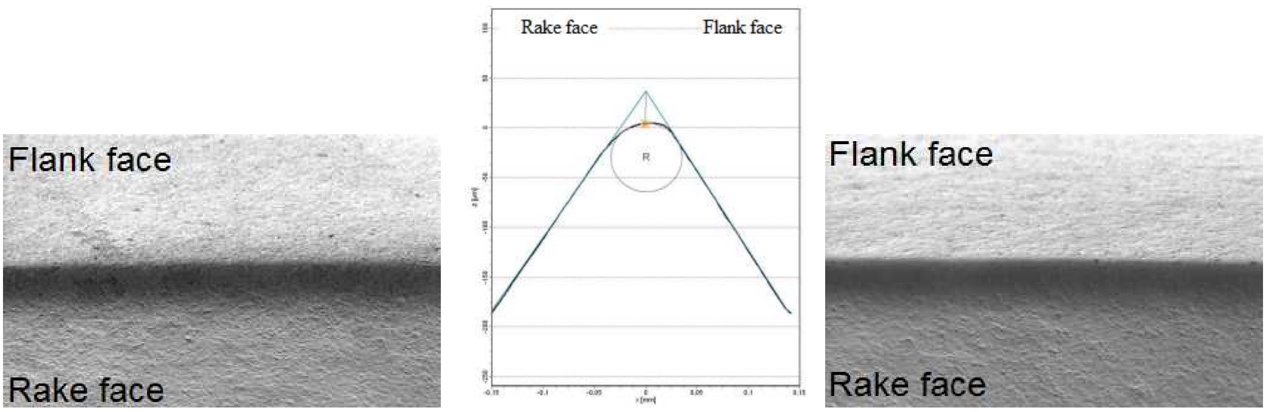
K factor K=0.5



K factor K=1



K factor K=1.4



Cutting edge after wet abrasive jet machining

Cutting edge after drag finishing

Fig. 5 Topography of twisted drills with different K factors

6. ACKNOWLEDGMENT

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Prepararea muchiilor aşchietoare pentru burghie spiralizate

Pentru obținerea unor rezultate bune a durabilității sculelor, cercetătorii au îmbunătățit microgeometria sculelor aşchietoare. Prin prepararea muchiilor aşchietoare, o rotunjire definită şi o reducere a ciobirii muchiei aşchietoare poate fi obținută. În această lucrare, burghie spiralizate cu K factori : 0.5; 1 şi 1.4 au fost utilizați. Procesele de prepararea muchiilor aşchietoare pentru obținerea acestor K factorii amintiți mai sus au fost sablarea umedă şi şlefuirea în granulat abraziv.

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