THE IMMERSION DEPTH INFLUENCES ON CUTTING EDGE RADIUS DURING DRAG FINISHING

Ondřej Hronek, Miroslav Zetek & Tomáš Bakša

This Publication has to be referred as: Hronek, O[ndrej]; Zetek, M[iroslav] & Baksa, T[omas] (2017). The Immersion Depth Influences on Cutting Edge Radius During Drag Finishing, Proceedings of the 28th DAAAM International Symposium, pp.1030-1036, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-11-2, ISSN 1726-9679, Vienna, Austria
DOI: 10.2507/28th.daaam.proceedings.143

Abstract

The article deals with the intensity of the preparation of a cutting edge during the drag finishing process. The cutting edge radius of a milling tool is investigated because it is a very important element of cutting tool behaviour during machining. The intensity of the process was evaluated relative to the immersion depths of samples during drag finishing. The aim of this experiment is to confirm the idea that a greater depth in the working container causes a higher intensity of the process. A DF – 3 drag finishing machine was used for the experiment. An Alicona IFM G4 microscope was used to measure the microgeometry of the cutting edges. Cutting edges were always measured before and after the modification. The main goal of this article is to find the dependence between cutting edge modification intensity and immersion depth.

Keywords: Drag finishing; Process conditions; Immersion depth; Cutting edge modification

1. Introduction

Drag finishing is one of four types of mass finishing. Rotors and holders make the main rotary movements. There are multiple combinations of rotary motions. The samples are attached in the holders for finishing. The holder and rotors can make counter-clockwise and clockwise motions. The holders also make a vertical movement in the working container. The container does not move. High circumferential speeds and great depth of immersion cause high pressure between the media and the parts. [1] [2]

In mechanical engineering this method is mainly used for finishing milling and drilling tools. It is especially used in the cutting edge preparation of cutting tools. Cutting edges do not have a high quality after grinding. [3] Defects can be seen on the cutting edge under a microscope. For example, the flank and rake surfaces are badly shaped, there are small areas on the main edges where the cutting edge is missing, or there is a variable size of the radius. Most defects on the cutting edges are removed by drag finishing, which creates a higher quality cutting edge. The cutting edge has a better surface roughness and a modified microgeometry with a precise value of the radius. [4] Also the cutting edge radius affects cutting tool wear. [8] The influence of cutting edge microgeometry was proved when milling super-alloy Inconel 718 during a practical experiment with different cutting edge radii (15 μm ; 20 μm ; 25 μm). [9]

In many cases other experiments are performed after drag finishing. These experiments monitor the cutting tools in the process of machining. [5] [6] Drag finishing is a common process prior to the deposition of thin coatings on cutting tools. This type of machining improves the adhesive properties of the tools. This technology can create a barrier on the surface which prevents the development of cracks or other defects, so this is a big advantage. Different radius sizes cause changes to the effect and the size of the cutting forces. In many cases, drag finishing causes longer tool life. [7]

1.1. Problem statement

Cutting tool microgeometry is a topical issue. As microgeometry affects cutting tool life and efficiency, research and development need to continue and look for new possibilities for improving cutting tool quality. Therefore, this article is concerned with cutting tool microgeometry modification. The effects of the drag finishing process parameters are investigated on the cutting edge radius. The cutting edge radius is one of the most important parameters on a cutting tool. This article investigates the effect of the immersion depth on the cutting edge radius. We investigated how the immersion depth affects the intensity of the microgeometry modification. The research is also focused on the positive or negative impact of immersion depth on the shape and quality of the cutting tool wedge microgeometry.

2. The apparatus used in the experiment

The IFM G4 microscope is a 3D optical / scanning measuring device which works on the principle of changing focal lengths. It is used for measuring surface characteristics, analysis and also for actual dimensions. The accuracy of the device is in nanometers. It is also suitable for cutting edge measurement.

Fig. 1. IFM G4 Microscope

A DF – 3 drag finishing machine is used for preparing the edges of the tools for machining. The main movement is a planetary rotary motion made by the holders and the rotors. This movement causes pressure between the media and the workpieces. 16 workpieces can be clamped into the DF – 3 at the same time. A big advantage is the simplicity of the drag finishing machine. The drag finishing machine has five main parts: the frame, the control panel, the process container, the rotor and the holders.

Fig. 2. Drag finishing machine

HSC 1/300 medium was used for experiment. The medium consists of two components: walnut shells and silicon carbide. It is a dry type of abrasive. It is used only for drag and stream finishing. HSC 1/300 is used mostly for finishing cutting tool microgeometry. For an efficient drag finishing process with a short time by using HSC 1/300, the maximum value of the cutting edge radius is 20 μm .

Fig. 3. Process media HSC 1/300

3. Experiment

The tool diameter is 8 mm and the length is 55 mm. Sintered carbide milling tools were used for the experiment and evaluating the cutting tool microgeometry. Twelve end mill tools were used and six tests were prepared. There were two samples for different immersion depths (Table 1.).

Fig. 4. Modified cutting tool

Before the experiment, it was necessary to select the appropriate finishing parameters. The DF – 3 drag finishing machine has six parameter settings. The aim is to find out the relationship between the intensity and the immersion depth of drag finishing. The Table 1. shows that the only variable parameter is the immersion depth. Other parameters are constant during the experiment.

Overall time [min]	CCW [min]	CW [min]	Rotor speed [min ⁻¹]	Holder speed [min ⁻¹]	Immersion depth [mm]
6	3	3	40/-40	65/-65	330
6	3	3	40/-40	65/-65	350
6	3	3	40/-40	65/-65	370
6	3	3	40/-40	65/-65	390
6	3	3	40/-40	65/-65	410
6	3	3	40/-40	65/-65	430

Table 1. Process parameters for drag finishing

All 12 samples were measured by IFM before finishing. The most important parameter was the radius of the cutting edge. The left and right edges were measured separately. The scanning area was 2 mm from the tip of the milling tool.

Sample number	Left radius edge [μm]	Right radius edge [μm]
1	1.31	1.73
2	1.55	1.39
3	1.66	1.27
4	1.33	1.61
5	1.26	1.83
6	1.66	1.23
7	1.47	1.51
8	1.30	1.36
9	1.90	1.39
10	1.24	1.26
11	1.66	1.54
12	1.48	1.36

Table 2. Values of cutting edge radius before drag finishing

Fig. 5. shows the cutting edge of the sample. This edge was created by grinding. It is magnified 20x by an Alicona IFM microscope. At this magnification it is easy to identify the marks created by the grindstone. Moreover, the radius of the cutting edge is also evident, even though it is only about 1.47 microns. Despite the fact, that the cutting tool is much sharper after grinding, the cutting edge is brittle and prone to chipping and also to deformation.

Fig. 5. Cutting edge microgeometry before drag finishing

4. Results

Twelve samples were finished at six different depths. The depth was changed after every second process. The immersion depth increased in 20 mm intervals. The difference between the initial and the final depth was 100 mm. Every cutting edge was measured by IFM after drag finishing. The left and right radii of the cutting edge were measured at the same location as before drag finishing. The measuring point was on the edge, 2 mm from the tip (Fig. 6.).

Fig. 6. Example of measuring area on cutting edge

The smallest measured radius was 8.1 microns on the sample with 330 mm immersion. The biggest radius was achieved at the bottom of the process container (430 mm). This was 14.6 microns. So, with a distance of 100 mm, the intensity of finishing the radius increases by 6.5 microns. At an immersion depth of 430 mm, the radius of the sample was 44% larger than the sample at a depth of 330mm with the same entry condition. Fig. 7. shows the increase in the size of the radius by drag finishing. The values of the radius increase gradually. The biggest increase of the intensity is between depths of 390 and 410 mm. The increase of the cutting edge was more than 2 microns at this point. The curves on the graph have relatively the same shape. The radius sizes for the left and right milling edges are approximately the same. The biggest difference was measured at a depth of 410 mm. The difference between the left and right cutting edges was 0.74 microns.

Fig. 7. Results of experiment

Fig. 8. shows the development of the cutting edge before and after finishing at depths of 330 mm and 430 mm. There is a gradual enlarging of the cutting edge radius. There is also a difference in the flank and rake surfaces. The quality of these surfaces improved with greater depth.

Fig. 8. Cutting edge microgeometry after modification; immersion depth 330 mm and 430 mm

Differential analysis was used to make an interesting comparison between the cutting edge before and after finishing. Differential analysis is based on the color spectrum and provides the user with quick and clear information. Fig. 9. shows the edge which was finished at 330 mm. The radius of the cutting edge is 8.1 microns.

Fig. 9. Differential analysis; immersion depth 330 mm

The cutting edge in Fig. 10. is finished at an immersion depth of 430 mm. The radius of the edge is 14.1 microns. Compared with Fig. 9., it is evident that the radius has increased. Additionally, the finishing at 430 mm gives better surface quality, because there are fewer tracks from the grindstone.

Fig. 10. Cutting edge microgeometry; immersion depth 430 mm

5. Conclusion

The main focus of this experiment was to verify the influences of the immersion depth on the cutting edge radius of an end mill tool. Therefore, an experiment was proposed in which the drag finishing immersion depth was changed. Walnut shells with SiC were used as the medium for the experiment. Immersion depths of 330 mm; 350 mm; 370 mm; 390 mm; 410 mm and 430 mm were selected. By evaluating the measured values, the relationship was found between the cutting edge radius and the immersion depth during the drag finishing process. The smallest radius, 8.1 microns, was measured at a depth of 330 mm, whereas at the depth of 430 mm, the value of the radius increased by 44%, to 14.6 microns.

Besides from the fact, that a deeper immersion depth causes a higher intensity of cutting edge modification, marks after grindstone disappear from flank and rake face. Another advantage is that the symmetry of cutting edge is achieved after drag finishing. Functional areas of the cutting tool with higher qualities are necessary not just for cutting process, but also for a coating process. It exists many cases, where cutting edge modification has brought a cutting tool life increasing, for example during machining stainless steel. But it is important to realize, that materials with toughness, such as Al and Cu alloys can't be machined by tools with high value of cutting edge radius. So it is necessary to understand a system, cutting tool – microgeometry – cutting material – workpiece material for proper cutting edge modification.

In the near future, these tools will be tested. This is necessary in order to obtain relevant information about the potential influence of microgeometry on the durability of the cutting tool. At the same time, cutting forces will be measured during the experiment. This will provide additional information and the relationships between the cutting tool microgeometry and the cutting process. This article is one of the tests that are designed to increase the quality of monolithic carbide end mill cutters.

6. Acknowledgments

This paper includes results created within the project SGS-2016-005.

7. References

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