Proceedings of the 13th euspen International Conference – Berlin – May 2013

Dressing and Selfsharpening of Conventional Tools

C. Vogt[1], M. Rohrbacher[1], S. Sinzinger[2]
[1]*Hochschule für angewandte Wissenschaften, Deggendorf, Germany*
[2]*Technische Universität Ilmenau, Ilmenau, Germany*
christian.vogt@hdu-deggendorf.de

1 Abstract

Highly accurate pre-machining of optical parts using grinding processes is a challenge. A large range of parameters for optimisation is available, such as tool type, grit size, grit concentration, feed rate, cutting speed, depth of cut and grinding strategy. Several approaches for optimising and estimating grinding processes were developed - more or less successfully. A well known quantitative model for grinding processes is the average chipping thickness, described by several authors. The theoretical approach using this model is to calculate the chip height that a single grit would have to remove passing the contact layer between work piece and grinding tool. This model can be used to predict the characteristics of grinding processes - as long as tool wear is irrelevant. This goes especially for processes dealing with materials with lower hardness, e. g. BK7, and tools comprised of diamond grits and metal bonds. Grinding harder materials, such as ceramics, goes along with increased tool wear. It depends on the setup weather the average chipping model meets the reality. Research on active and passive dressing of grinding tools using a high resolution confocal microscope enabled the reconstruction of interactions, for a better understanding of the process. The gained data was used to develop a simple model for quantifying the sharpness of grinding tools. A procedure was developed to evaluate the condition of grinding tools. The results were verified by force measurements during grinding test runs. It was possible to monitore the wear process after dressing, until selfsharpening occurs in a periodical manner. A very interesting finding is the effect of different bond materials on the surface quality, as far as sub surface damages and roughness are concerned. The chipping process after active dressing and a certain tool wear has different characteristics. The bond material is involved in the chipping process, as soon as a certain level of tool wear is reached. Appropriate tool design enables the production of surface roughness from 200 nm Ra

down to 10 nm Ra or even simple smoothing tools for creating surfaces with 10 nm Ra and below. The developed model explains different effects using similar specified tools with different bonds, e. g. metal, resin (soft, hard) or even ELID supported processes. This opens a new point of view for optimizing grinding tools.

2 Introduction

Designing a grinding process means to take certain parameters into account, such as:

- type of grinding machine (rigidity, number of spindles, kinematics
- type of grinding process
- tool configuration (grit type and size, bond type and hardness) (1)
- machining parameters (2)

This offers a huge range of optimization for certain purposes - for example rough machining or low roughness finishing. One important point in grinding processes is the tool preparation. Object of the tool preparation is the creation of the desired macroscopic tool-shape and the micro structure. This can be achieved within two separate steps (dressing and truing) or within one step - depending on the requirements.

The most important questions with truing and dressing grinding tools are:

- Which are the indicators for a successful truing/dressing process?
- How often must a dressing procedure be conducted?
- What is needed to provide good self sharpening abilities within the machining process, in order to avoid the necessity of manual dressing?

Monitoring process forces is a common method to detect interactions between tool and sample (3). The theoretical approach is the assumption, that a change of process forces indicates an alteration of chipping conditions. This means as long as the forces remain constant, the chipping conditions and therefore the tool state remain constant as well. Increasing forces therefore would indicate tool wear. It used to be very complex to take a closer look at fine-grinding tools with grits of 20 µm in diameter and below. Scanning microscopy was often used for investigations on grinding tools, as this technology is capable to provide high resolution pictures within a range of several microns. A major disadvantage of this method is the effort during preparation of the samples and the limited sample size. Meanwhile the market offers confocal microscopes with nanometer accuracy. They can be used to take a closer look at fine grinding tools with grit sizes below 20µm. The analyses presented below were conducted with a confocal microscope. The effectivity of dressing processes and links between grinding forces and tool topography were investigated.

3 Experimental setup and procedure

For the experiments a sinthered silicon carbide sample was ground with meander tool path. The grinding tool with diameter 15 mm comprised of brass bond with a concentration of diamand grits of C70 (appr. 17 percent by volume) of the size D64 (64µm grit diameter). The aim was to figure out proportinality of process forces and tool micro structure. The grinder was dressed/trued and afterwards used for testruns on the mentioned silicon carbide sample. The testruns were interrupted several times to measure the tool's microstructure. During the testruns the forces where also captured using a dynamometer.

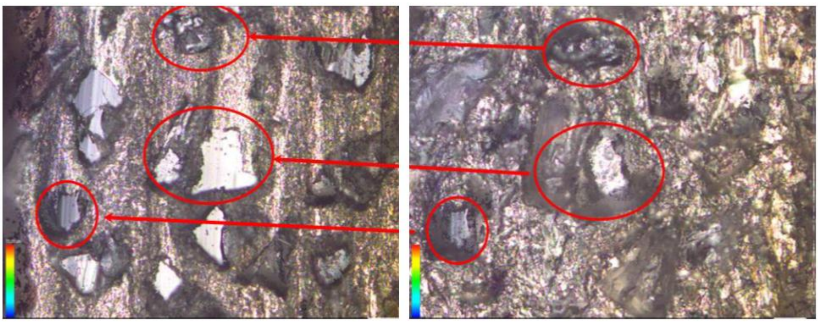

Fig. 1: Microscope image of tool topography before and after dressing

Fig. 1 shows the tool's topography before and after dressing. It was possible to identify the same grits before and after dressing (marked with red circles). This gives an idea of the dressing process's mechanisms.

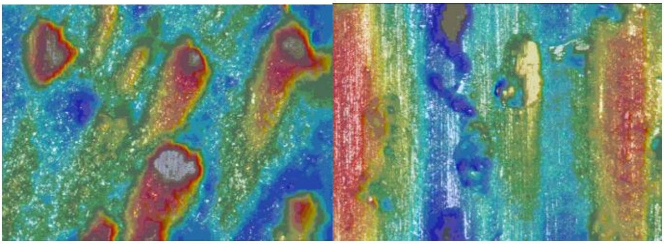

Fig. 2: Confocal measured tool-topography after dressing (left) and after 20 passes on the silicon carbide sample (right)

Fig. 2 shows confocal measurements of the tool after dressing and after 20 passes on the silicon carbide sample. Fig. 3 shows the corresponding growth of the perpendicular grinding force with increasing tool wear.

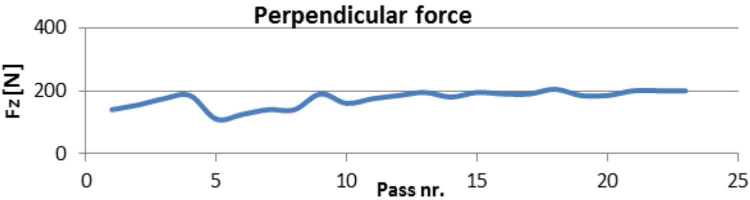

Fig. 3: Perpendicular force vs. pass nr.

Discussion and conclusions

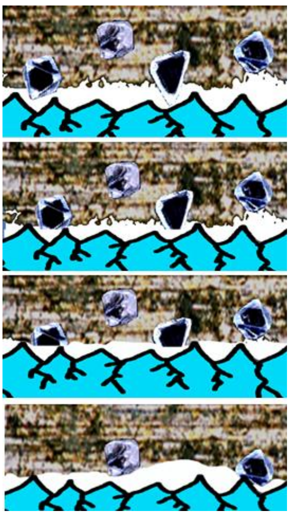

Fig. 4: Principle of toolwear

Fig. 2 shows bond structure and grit protrusion before and after a material removal of appr. 0.5 ccm.. The bond hat a different structure after 20 passes, compared to its state after dressing. The graph also shows a high increase- and decreasement within the first 5 runs. The reason for this effect is a different type of tool wear within the first passes. Experts know the influence of the type of bond on the grinding process well. This results give an idea, how the material removal is affected by the type of bond, as it obviosly takes part in the chipping process. This means the classic model of chips generated by single grits is not appropriate. The development of the process forces in Fig. 3 show an assymptotic approach to appr. 190 N at pass nr. 13 - it seems to be a steady state of self dressing, which is verified by the topography measurements.

The measurments gave an idea of the different states of tool wear (see Fig.4). The average chipping model deals with constant chipping space. The chipping space changes during grinding in selfsharpening mode due to toolwear. The bond affects the chipping process significant, as it takes part in the chipping process via direct contact to the workpiece and its properties are critical for the grit protrusion. It has turned out, that the average chipping model is oversimplified for processes dealing with selfsharpening effects. But it is still suitable for the description of operating points for different types of grinding tools.

References:

1. **E.-S. Lee, S.-Y. Baek.** A study on optimum grinding factors for aspheric convex surface micro-lens using design of experiments. *International Journal of Machine Tool & Manufacture.* 2007, Vols. pp 509-520, 47.
2. **J. E. Mayer Jr., G.-P. Fang, Texas A&M University, USA.** Effect of Grinding Parameters on Surface Finish of Ground Ceramics. *CIRP Annals - Manufacturing Technology.* 1995, Volume 44, Issue 1, Pages 297-282.
3. **H. K. Tönshoff, T. Friermuth, J. C. Becker.** Institute of Production Engineering and Machine Tools, University of Hannover, Germany. *CIRP Annals, Manufacturing Technology.* 2002, Volume 51, Issue 2, Pages 551-571.