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Finishing Methods of Tools Functional Surfaces

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Abstract

Article shows the calculation of the stress in a rotating disc and the possibility of using proprietary forms of instruments for speed grinding. It presents the results of speed and efficient cutting tools in machining these materials alloyed with chromium. In addition, it notes the results of the influence of technological conditions on the quality of surfaces, the residual stress in the workpiece, resulting from the machining speed and the influence of technological conditions on the wear of grinding wheels. Finally, some options for the use of finishing techniques in practice are mentioned.

Introduction

Grinding is one of the machining methods to ensure the final quality of machined surface. The grinding tools are composed by fine abrasive grains together bonded by the bond material. Abrasive grains are statistically ordered as for the size, displacement, moreover differs in the geometry of cutting edge. Modifications of conventional grinding enable further sophisticated grinding methods. Cut level during creep-feed grinding (CFG) is removed by one feed stroke of the grinding wheel at low feed rate [9]. The high speed grinding (HSG) is a variety of grinding methods above the common cutting speed [2], [10]. Firstly, cutting speed for surface grinding is higher by rapid feed rate of the workpiece. The increase of the wheel speed is another technique, which is presented in the following paper. Integration of above mentioned grinding methods result in high efficiency deep grinding [10] (HEDG) and ultra high speed grinding [2] (UHSG), believed to be a step ahead as sintered carbides were in the past century.

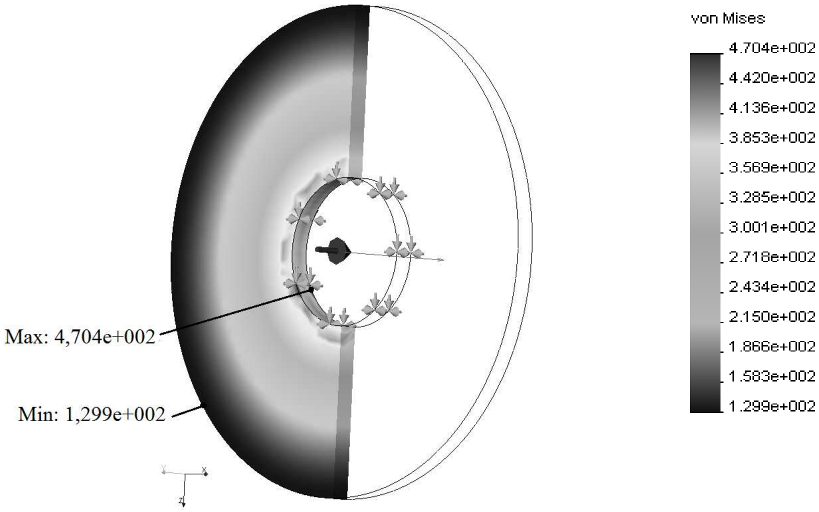

Fig. 1 Calculate distribution of von Misses stress for the grinding wheel [5]

One of the major problems of increasing cutting speed is the aspect of the grinding wheel strength, accompanied by the safety factor. The strength test of rotating grinding wheel is conducted until the wheel failure. The centrifugal force during the test is similar to the force under the tensile test. The increase of the cutting speed requires special grinding wheels with improved strength.
Ceramic bonding are one of the most preferable material, however comparing to other bonding materials has the lowest tensile strength.

Numerical model predicted von Misses stress σ' under critical wheel speed that is the magnitude of equivalent stress for principal axes with indexes 1, 2, 3 expressed as:

$$\sigma' = \frac{\sqrt{\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]}}{\sqrt{2}} \tag{1}$$

As expected, von Misses stress is greatest in the areas close to the inner hole, and with increasing radius over the profile stress decreases as is shown in the Fig.1. To verify previous presumption, a comparative model of straight grinding wheel was created [3], [4]. Acquired stress exceeded the ultimate strength of the material, since in the area of inner hole was enumerated von Misses stress as σ' = 452 MPa. Despite that fact, the straight grinding wheel cannot be used for high-speed cutting without geometric modifications.

Experiment

The results of theoretical considerations and experiment show, that the roughness of work surfaces to a large extent determines the lifetime of the products. A big attention to mathematical and experimental determination of before mentioned characteristic is devoted for modeling of the technological process in literature [1], [7]. Experimental grinding especially at high speed at recess grinding of chromium steels have been carried out for confirmation of the theoretical models. Experiments show that with increasing cutting speed decreases the value of the mean arithmetic roughness thus improves the quality of the cut surfaces. This value changes significantly at lower cutting speeds and is stabilized in the area of particularly high cutting speeds (Fig. 2).

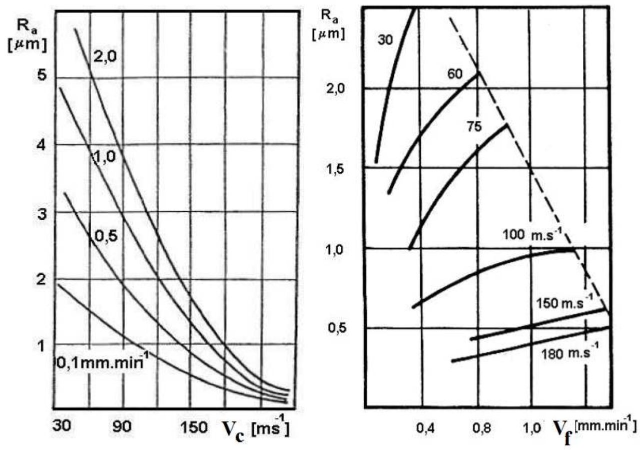

Fig. 2 Influence of changes of technological conditions to the roughness [6]

To determination of the influence of the cutting speed and the other cutting conditions to the dimensional accuracy of the workpiece was devoted to an increased attention during the evaluation of the experimental results.

With careful measurement of the ground surface shape we could find a distinctive shape deviations on this surface very, called the waviness. Waviness of the cylindrical surface is considered as a geometric deviation of circularity which is harmoniously repeated along the perimeter of the workpiece. The cause of waviness during the grinding can be regard to the reciprocal oscillating movement of the workpiece and grinding wheel, induced by self-excited vibration and changes of stiffness [6], [8].

The waviness of the ground surface decreases with increasing cutting speed, assuming constant cutting conditions. This decrease is more significant, if the infeed is greater. The stabilization of the shape changes occurs in the area of cutting speeds higher than 130 ms^{-1}, as is depicted in the Fig. 4. Subsequently increase of the cutting speed improves the waviness only slightly [5].

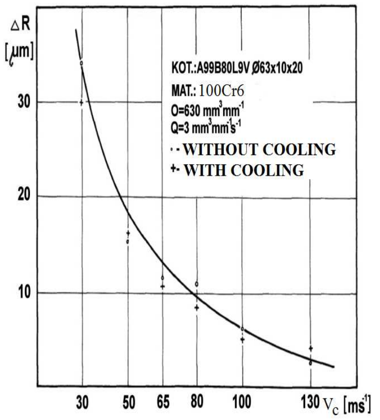

Fig. 3 Influence of cutting speed to wear of grinding wheel [6]

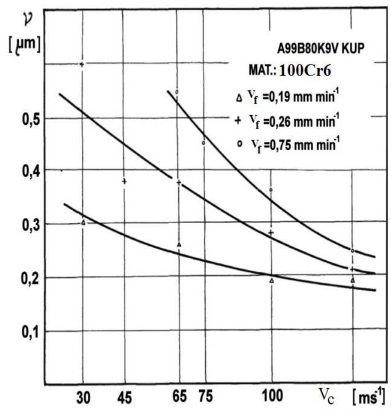

Fig. 4 Influence of cutting speed to waviness of ground surface [6]

The rate of wear significantly affects the economical characteristics of the technological process. The duration of the process when the cutting edge of the tool is capable to operation is called as lifetime. It is a time, during which the edge of tool can effectively perform the required functions. The influence of the forces and temperatures in the cutting zone during the grinding leads to the wear of grinding wheels. The rate of wear is reduced when the cutting speed is higher, especially in the area of higher cutting speeds and cut depth. In the area of particularly high cutting speeds and cut depth is only a small decrease of the wear rate, because the wear rate is almost constant (Fig. 6).

During the finishing of the functional surfaces of tools arise a residual stress in the surface layer, which has a significant impact on lifetime and functionality of the machined surfaces. These residual stresses arise due to the effect of the accompanying phenomena of machining and still act in the part without external load. The influence of cutting forces, temperature and phase transformation of workpiece material leads to non-uniformity of plastic deformation which is the reason for arise of the residual stresses under the surface of part. Evaluation of the residual stress has a significant importance especially at finishing operations, which mostly affect the lifetime of the products.

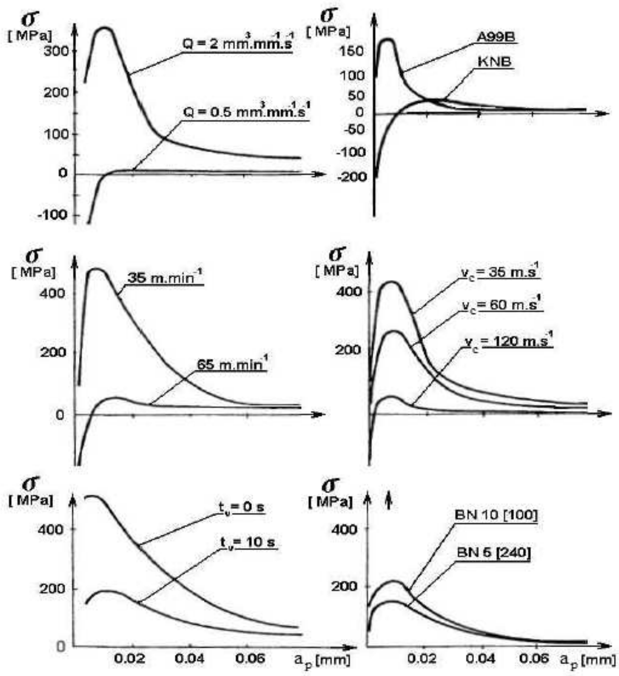

Fig. 5 Influence of technological conditions on the residual stress during the grinding [6]

The results of experiment are interesting when the ratio between feed speed and cut speed remain constant. In the Fig. 6 is shown, that the dependencies have the minimum at q=60 or at n-times of this value [5].

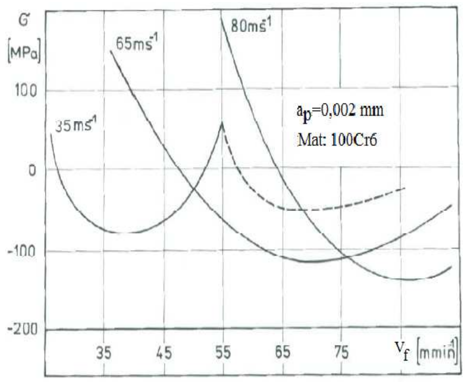

Fig. 6 Influence of technological conditions on the residual stress [6]

Conclusion

Analyses and results of experiment show possibilities of the escalation of tool strength under station by constructional adaptation of grinding wheel. The article mentions possibilities of the shape improvement and quality material for grinding combining newly developer firmer adhesives, if needed all-metal grinding tools, enables safety application of cutting speed markedly excessing $100ms^{-1}$ and thus, productivity improvement of grinding operation.

Experimental results show that increasing the cutting speed has considerable technical and economic benefits. It improves the quality of the machined surfaces, reduces the deformation of the technological system improves the waviness and reduces the wear of grinding wheel. This technology allows to remove added time.

The significant benefit is the possibility to optimize the technological conditions and thus reduction of the residual stress and increase of the product lifetime.

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