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WEAR MANAGEMENT OF ABRASIVE WHEELS IN CNC GRINDING. COMPARATIVE ANALYSIS OF THE PERFORMANCE OF SHARPENED ABRASIVE WHEELS

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Abstract: *The objective of the work is to conduct experimental research to correctly manage the phenomenon of abrasive stone wear in the grinding process of bearings on CNC machines, through their correct and efficient sharpening. To this end, the quality of the ground surfaces with different sharpening regimes is evaluated to identify those optimal working conditions.*

Keywords: *grinding, abrasive wheel, dressing, dress rate, roughness*

1. INTRODUCTION

Truing and dressing are equally important for efficient and accurate grinding, but this article highlights the influence of the wheel sharpening process on the roughness of machined surfaces. Dressing is the process of controlling the grinding wheel surface to reshape the wheel if it has lost its original shape due to wear.

The working scheme of grinding processing (Figure 1) is like to that of milling, with the differences induced by the following particularities: the abrasive grains are made arbitrarily, compared to the teeth of the milling cutter, the work is done with very different clearance angles ɤ, generally negative, and with very high cutting speeds. In Figure 1, the following are revealed: 1 – workpiece; 2 – abrasive tool; 3 – abrasive grain and in Figure 2 is shown the grinding of the bearing raceway.

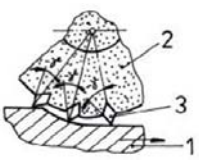


Figure 1. Rectification work scheme

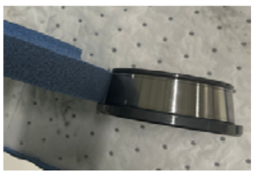


Figure 2. The grinding of the bearing raceway

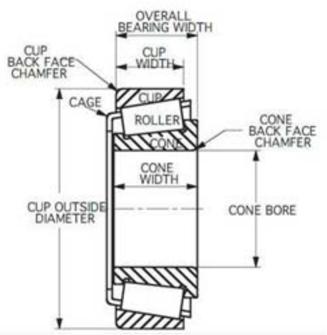


Figure 3. Taper roller bearing (the workpiece)

Figure 3 shows the workpiece, a taper roller bearing, whose raceway has been ground for experimental research.

For a correct grinding, the characteristics of the abrasive body (for example, the nature of the bond, the nature of the abrasive material, hardness, grain size, structure) must be chosen, depending on the material of the part, the shape of the surfaces to be ground, the surface roughness, the dimensional accuracy to be obtained, and previous processing processes. If the bond of the abrasive body is too soft, the abrasive grains come off without being blunted and as such, the abrasive body wears out too quickly. When the bond is too hard, the blunt grains do not come off, and the body, being polished, requires a restoration of the active surface by resharpening.

Also, to avoid overheating of the part and to be able to obtain high precision, intense cooling is recommended, using emulsions with low concentrations as cutting fluids.

Grinding is used especially in the final stages of mechanical processing, when parts must meet high precision and finish requirements. It is applied to a wide range of materials, including hardened steels, carbides, ceramics and non-ferrous alloys.

2. MATERIALS, DEVICES, INSTALLATIONS AND METHODS USED

The experiments were carried out by machining cylindrical and conical parts made of 100Cr6 steel (SAE 52100) on a computer numerically controlled (CNC) machine tool.

The measurements were carried out using a coordinate measuring machine (CMM) with an accuracy of up to ±0.5 µm or even ±0.3 µm.

To assess the sharpening status of abrasive wheels, specific wear monitoring techniques were used, which allow the detection of the phenomenon of fracturing of abrasive grains or clogging of the stone with material.

Subsequently, the roughness measurement of the machined surfaces was carried out using a Taylor Hobson Surtronic 5+ roughness meter, equipped with a high precision profilometric sensor, to reveal the roughness profiles related to each evaluated surface.

3. EXPERIMENTAL RESEARCH

Two types of grinding wheels used will be presented comparatively, analyzing them both descriptively, with reference to their characteristics and working parameters, and in terms of the quality of the processed surfaces, the roughness (Ra).

The experimental studies were carried out on CNC machines for cylindrical grinding, machines that present multiple advantages compared to traditional methods, namely: precision and repeatability, automation, flexibility and reduction of production times. Although the machine operates automatically, the operator is responsible for continuous monitoring of the process and for the interventions that are required such as: adjusting the position of the part, adjusting the rotation speed of the abrasive wheel or the cooling system, depending on the evolution of the grinding process and possible changes in the machining conditions. In addition, the machining accuracy must be constantly controlled, using diagnostic devices and precise measuring instruments. to comply with the required dimensional tolerances and surface roughness.

On these machines, the parts are fixed on supports (adjusted with great precision to ensure the stability of the parts during the process), which allows them to rotate. The abrasive stone processes the entire circumference of the part, ensuring a uniform finish. Choosing the appropriate type of wheel is essential to obtain quality finishes and to prevent premature wear.

Abrasive wheel wear can lead to changes in machining conditions and must be carefully monitored. The grinding machine operator must effectively apply abrasive wheel wear management techniques, considering the following aspects: prolonged use of a wheel can affect both the quality of the machining and the efficiency of the process; process optimization involves minimizing the machining time without compromising quality; sharpening the stone in order to restore the geometry and obtain an optimal finish is very important, as is the tool used for sharpening (the dresser) and the technological parameters used in the sharpening process, such as the feed rate of the dresser/tool in relation to the stone (dress rate). Proper sharpening of the wheel will lead to a quality of the machined surface and a dimensional accuracy according to the required technical specifications.

Surfaces machined with different speeds of movement of the sharpening tool were comparatively analyzed, both for sharpening a conventional abrasive wheel (CubitronTM II) and for sharpening a CBN (Cubic Boron Nitride) abrasive wheel, to study the influence of this parameter (dresser feed rate) on the roughness parameter Ra. Table 1 presents a comparative analysis of their characteristics.

Table 1. The characteristics of the abrasive stones

Abrasive wheel characteristic	Conventional wheel 3M	CBN wheel
Granule type	93DA (precision triangular granules)	CBN (synthetic or natural diamond)
Grit size	120 (0,1 mm)	B151 (0,06 inch ~ 1,5 mm)
Fineness	120 (fine)	90
Hardness	H (low hardness)	P-R (medium-high hardness)
Structure	15 (open structure)	4-6 (medium to open structure)
Binder type	V (vitrified)	VZ125 (vitrified, concentration 125)
Porosity	P (high induced porosity)	High porosity (favors cooling and evacuation)
Color	blue	black
Maximum peripheral speed	63 m/s	63 m/s

The characteristics of abrasive wheels influence their performance in the grinding process, as follows.

Grit refers to the size of the abrasive particles in the composition of the wheel. A larger grit (e.g. 60 or 80) is more abrasive and can remove more material, being suitable for roughing grinding. Smaller grits (e.g. 100 or 200) are used for fine finishing, having a more delicate action and creating less roughness on the part.

The hardness of the grinding wheel refers to how tightly the abrasive particles are bonded to the wheel matrix. A harder wheel is more suitable for hard materials, while a softer wheel will be used for softer materials. Hardness affects both the cutting speed and the life of the wheel.

The bond or binder is the material that holds the abrasive particles together. There are several types of bonds, such as: vitrified (glass) bond, resin bond, or metal bond. The type of bond influences the behavior of the abrasive wheel and can affect aspects such as cooling, durability, and performance when machining hard materials.

The dressing process is the process by which dull abrasive particles and the bonding material accumulated on the surface of the abrasive stone are removed, thus exposing new sharp particles. This process restores the shape and cutting capacity of the stone, ensuring quality finishes and increased efficiency in processing.

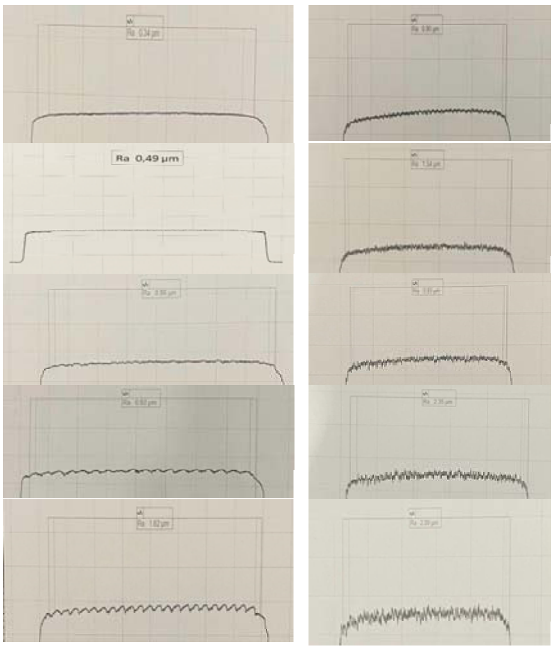
For dress rate values between 0.5 and 2.5, the values of the roughness parameter Ra were measured for surfaces ground with sharp abrasive wheels with these feed values and are presented in Table 2. Table 3 presents the roughness profiles for the eight surfaces machined with abrasive stones that were sharpened with different feeds. four surfaces were ground with the CBN wheel and four were ground with the conventional 3M wheel.

Table 2. The Ra Roughness values for surfaces ground with CBN stone and 3M stone

Dress rate [m/min]	2,5	2	1,5	1	0,5
Ra1 (CBN)	1,62	0,92	0,56	0,49	0,34
Ra2 (3M)	2,99	2,35	1,93	1,54	0,90

Table 3. The roughness profiles of finished surfaced

Ra1 (CBN) Ra2 (3M) Dress rate [m/min]



0.5

1.0

1.5

2.0

2.5

The diagram in Figure 4 shows a decrease in the roughness parameter Ra, an improvement in the quality of surfaces processed with abrasive wheels, where sharpening was done with lower feed rate values.

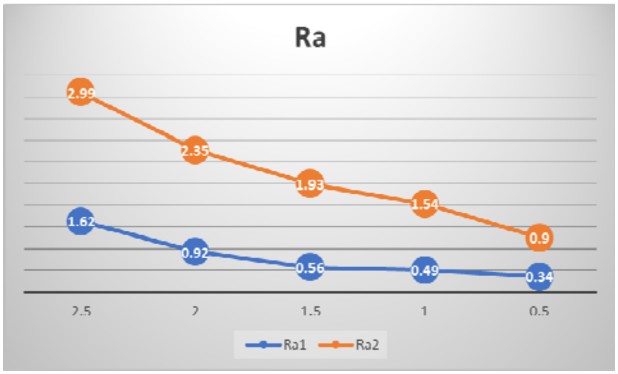


Figure 4. Influence of stone dress rate on roughness Ra

4. CONCLUSION

A decrease in the values of the roughness parameter Ra and an increase in the quality of the finished surface are observed at a lower speed of sharpening the wheel surface.

Therefore, for a better finish, regardless of the type of wheel chosen, a slower, controlled sharpening is recommended, at the limit of decreasing productivity and, implicitly, the efficiency of the processing.

On the other hand, the lower values of the roughness parameter Ra confirm the advantage of using the CBN wheel for high-precision processing, for materials that are more difficult to process, recommending it for fine and semi-fine grinding operations, due to its wear resistance and high thermal stability. This can achieve increased productivity and reduce costs in the long term.

In conclusion, the quality of dressing has a direct impact on the roughness of the machined surfaces.

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