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EVALUATING THE GRINDING OF AISI 4340 INTERRUPTED WORKPIECES UNDER ABUNDANT COOLING METHOD, USING A CBN GRINDING WHEEL

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Abstract. The grinding is a machining process designated to obtain extremely precision dimension, usually in a micrometric scale. Following this approach, it has been done a study to verify the effects of the grinding process in interrupted workpieces. It was used three feed-rate (0.25, 0.50 and 0.75 mm/min), and four workpiece geometries, considering pieces with continuous geometry and with two, six and twelve grooves. A CBN wheel was applied on the tests. Roundness, Roughness, Acoustic Emission, Scanning Optical Microscopy and Grinding Wheel Wear were the Output parameters of evaluation. It was observed that increasing the feed-rate, the roughness increased too. An increasing trend of a worst roundness was obtained as a function of the feed-rate increasing. The feed-rate increasing also led to a higher level of grinding wheel wear considering all workpiece geometry, beyond provoking an elevation in the acoustic emission levels. Workpieces with interrupted geometry had a decreasing trend in the variations previously mentioned, as the number of grooves is increased, as function of more non-contact instants of interaction between the workpiece and the grinding wheel due to the interrupted geometry.

Keywords: *Interrupted grinding; CBN Grinding Wheel; Grinding Process.*

1. INTRODUCTION

Grinding Process is considered as a mechanical process in which occurs the chip removal of the grinded workpiece. During the process, the chip removal is accomplished in the contact surface between the piece and an abrasive tool named Grinding Wheel, performing in high speed spin, while the workpiece has a considerable lower speed.

During this work, a CBN grinding wheel was taken as the abrasive tool to perform the grinding process of discontinuous workpiece geometries. The interrupted cutting arises when is manufactured pieces in which the initial geometry is different than a cylindrical one (SANCHES, 2011).

Evaluating the impacts effects between the grinding wheel and the workpiece during the grinding process through an interrupted cutting, varying the number of pieces' grooves (an AISI 4340 Quenched and Tempered Steel) is the main goal of this paper. Therefore, it was possible to verify the resultant conditions of the process related to these output parameters: Grinding Wheel Wear, Roundness Errors, Workpiece's roughness.

2. MATERIALS AND METHODOLOGIES

Using AISI 4340 steel quenched and tempered as the workpiece's material, with a surface hardness around 58 HRc.

Treating about interrupted cutting tests, the workpieces was designed with grooves on its geometries. It was designed workpieces with 2, 6 and 12 grooves, beyond continuous workpieces.

Planning work was established to apply abundant cooling method, using 3 feed-rates (0.25, 0.50 and 0.75 mm/min) and for each of these conditions, it was used 4 different workpiece geometries, considering workpieces continuous and with 2, 6 and 12 grooves. For each workpiece design, 2 tests repetition were performed, totalizing 3 tests for each tested condition.

Following Bianchi (2013), the output parameters were evaluated: (a) roundness (b) roughness (c) acoustic emission (d) scanning optical miscrocopy and (e) Grinding Wheel Wear

3. RESULTS AND DISCUSSION

This chapter illustrates the obtained results of the output parameters after the grinding processo of the workpieces through the established testes conditions.

3.1 Roughness

Figure 1 illustrates the obtained results for Roughness (Ra) of the tested workpieces.

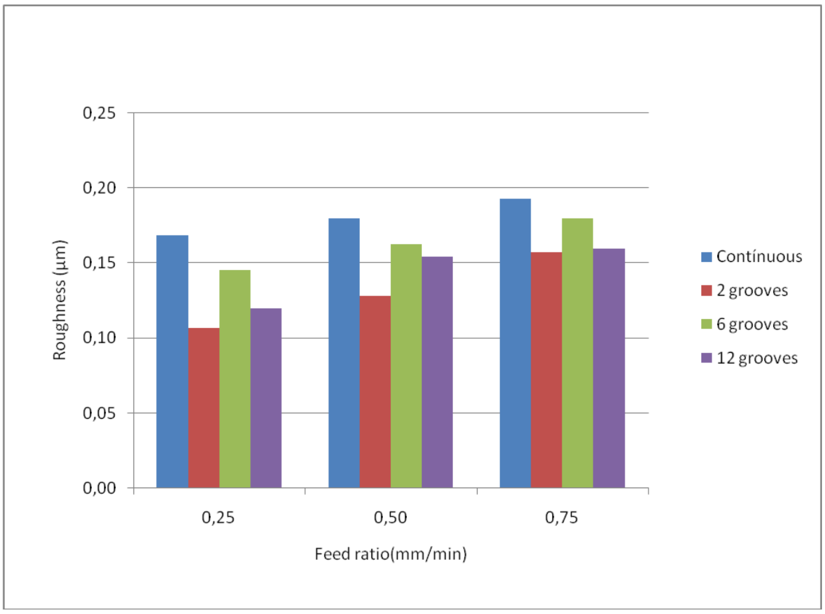

Figure 1. Relation between Roughness and Feed-Rate.

Based on figure 1 datas, it is possible to observe that the increasing of feed-rate influences in the finishing quality of the workpiece. Similar results was obtained by Alves et al. (2008), when considered that the material removal rate is higher when the feed-rate increases, what means a more severe process.

3.2 Roundness error

Figure 2 illustrated the obtained roundness results for the tested workpieces.

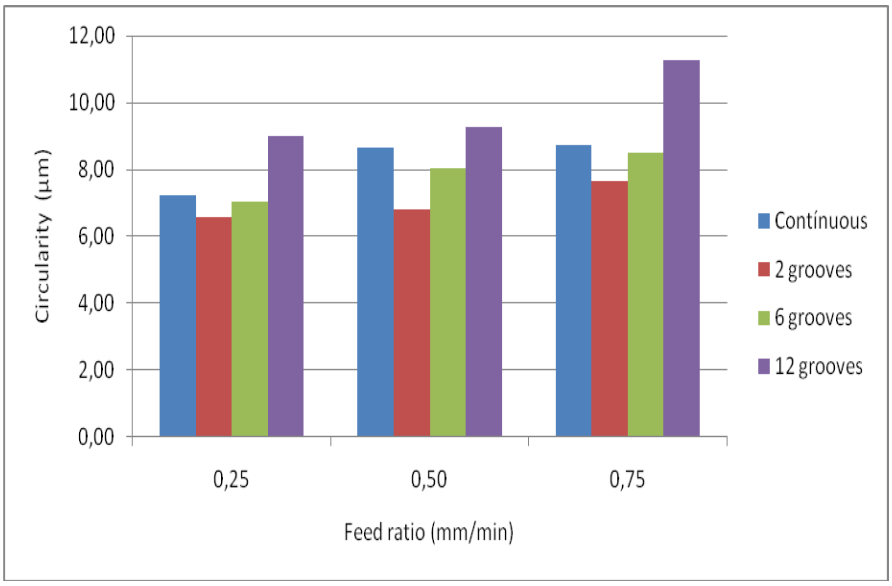

Figure 2. Relation between Roundness and Feed-Rate.

It is possible to observe in the figure 2 a trend of increasing the roundness errors when the feed-rate is higher. Mello et al. (2015) explain that this effect is because when the feed-rate is increased, the grinded workpiece is under higher compression rates, intensifying the residual stresses and consequently, promoting higher roundness error trend.

3.3 Grinding Wheel Wear

Based on Figure 3, it is possible to note that the feed-rate showed a negative interaction related to the grinding wheel wear.

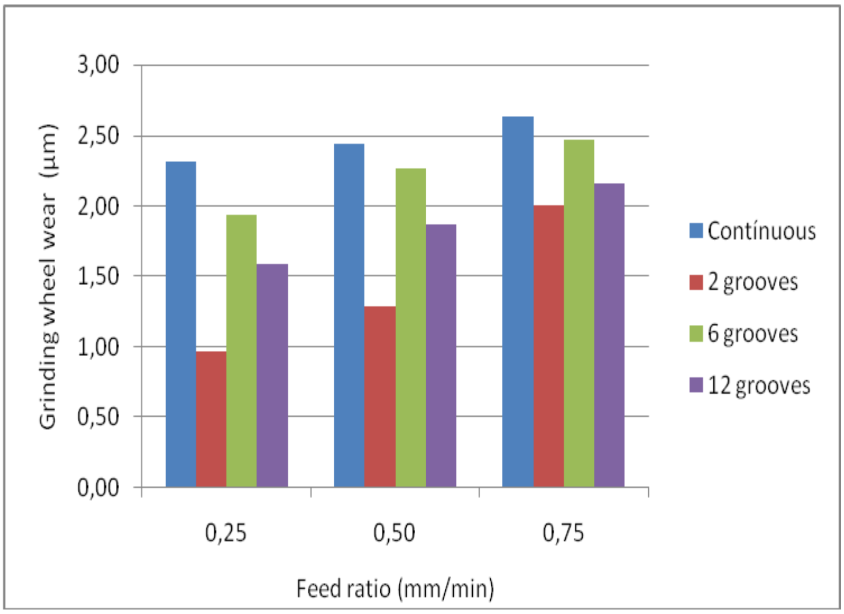

Figura 3. Interação entre velocidade de mergulho e desgaste do rebolo.

Winter et al. (2015) evaluating the CBN grinding wheel wear operating during grinding process with different feed-rate, they observed relation between the increasing of the feed-rate and the tool wear, which means that this effect, exposed by the authors, due to the higher material removal rate in these conditions.

3.4 Acoustic Emission

Observing the Figure 4, its is possible to note that the acoustic emission values results as function of the increasing in the feed-rate during grinding process of the workpiece with four different tested geometries.

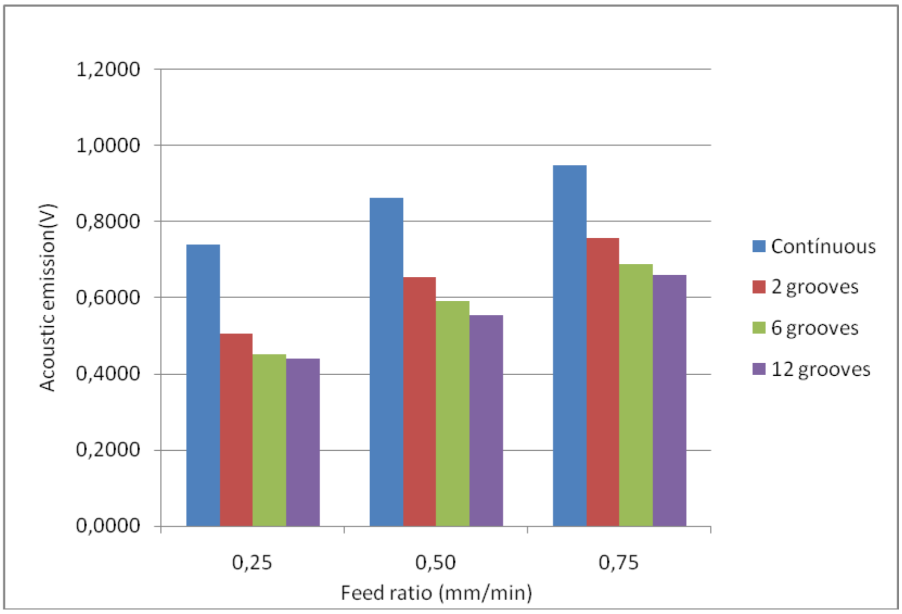

Figure 4. Relation between Acoustic Emission and Feed-Rate

Observing the Figure 4, it can be seen that there is a relation between the increasing in the feed-rate with the magnification of the acoustic emission levels during the grinding process. Moia et al. (2015) explain that occurs a phenomenon of changing the structure of the grinding wheel abrasive grains as machining occurs, what means this effect influences in the increasing of the acoustic emission. Complementing it, Javakumar et al. (2005) quotes that a direct relation between the obtained acoustic emission signals during the grinding process with the generated deformations in the workpiece.

3.5 Optical Microscopy

It is possible to observed in the Figure 5 the obtaine results through optical microscopy after grinding process tests of the workpiece with 12 grooves under 0.75 mm/min feed-rate.

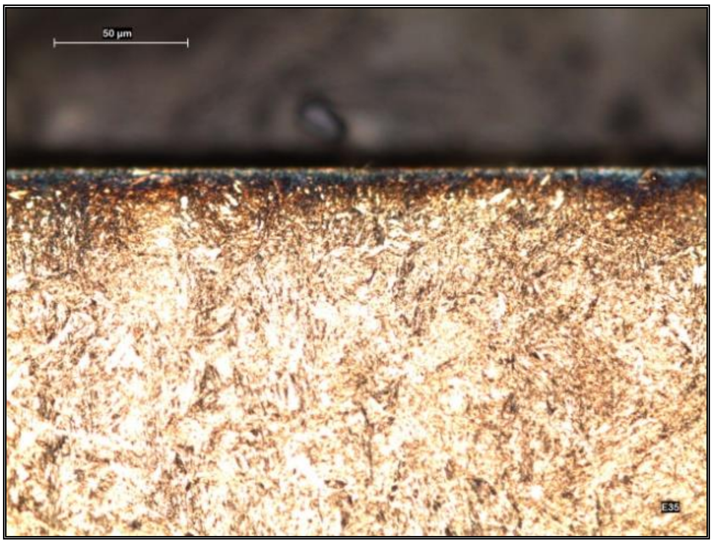

Figure 5. Optical Microscopy of the workpiece with 12 grooves under a feed-rate of 0.75mm/min.

Based on the Figure 5, it is possible to observed that thermal damages didn´t happened in the grinded workpieces surfaces of the workpieces illustrated in this figure, which indicates to favor the microstructural quality, as well as mechanical resistance of the machined material. Bianchi et al. (2000) explain that the burning limit of the workpiece corresponds to the temperature limit of the material austenitization.

Following this approach, during the grinding process, because the workpiece surface is exposed to high temperatures for long time, microstructural changings can occur, and this effect can be reduced with adequate cooling conditions (SILVA, 2014).

4. CONCLUSIONS

A conclusion can be taken that the increasing of the feed-rate compromised the grinded workpiece quality, considering the roughness and roundness error, beyond promoting higher grinding wheel wear.

It was observed that higher the grooves' number increased the grinding wheel wear levels and roundness error of the workpiece, due to the constants impacts between the borders of the grooves in the interrupted workpiece geometries and the surface of the tool. However, the thermal damages of the pieces were not influenced by the increasing in the grooves' number, what can be seen in the optical microscopy analysis.

It was possible to verify that the acoustic emission levels tends to increase as the feed-rate increases.

5. ACKNOWLEDGEMENTS

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