Parameter Analysis in ELID-Grinding of Cermets

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Abstract

Electrolytic in-process dressing (ELID-)grinding can keep cast-iron bonded (CIB) wheels sharp for long grinding cycles to avoid glazing effects and especially in case of even harder materials. This paper describes the latest results of research on ELID-grinding of a cermet. In the roughing step, ELID-grinding and conventional grinding with 46µm diamond grits CIB wheels are preferable to resin-bonded grinding which is characterized by low G-ratios. With ELID stable grinding can be achieved without the need for dressing operations. The maximal material removal rate (MRR) in 'ELID-roughing' on the used surface grinder is measured to be 1 mm^3/s. A thorough parameter analysis is more important during 'ELID-finishing' because this step is prone to chattering. To avoid these effects it is advisable to limit the normal force by lowering the axial feed and by maximizing the duty ratio of the ELID power supply.

1 Introduction

To meet the demanding requirements of industries, material scientists are engineering new types of cermets and technical ceramics. These new materials are often characterized by a superior hardness and extreme durability but suffer from bad machinability. ELID-grinding has proven to be an efficient technique to process some of the hardest materials known and also allows for achieving mirror-like surfaces with Ra roughness values in the nanometre range. Due to an electrolytic passivation process the metallic wheels are kept sharp during the ELID-process. This dressing process has been investigated thoroughly at KU Leuven [1]. The passivation layer lowers the holding force of worn out abrasives so that fresh grits continuously protrude from the wheel surface. It is important to choose proper process parameters so that the grinding conditions remain favourable and constant. For instance, grinding with too aggressive parameters will break and tear off the passivation layer more

rapidly than its in-process electrolytic growth. In the end this results in bad surface qualities and process instabilities.

2 ELID-grinding setup

Figure 1: Retrofitted JUNG surface grinder

Experiments have been carried out on a retrofitted JUNG JF520 surface grinder, as shown in Figure 1. The ELID power supply is a Fuji ELIDer 910 from Nexsys and the coolant is a dilution of CIMIRON CG7. The workpiece material is a cermet from Ceratizit called L4752 and has a hardness of 1950 HV10. The final part requires a high shape accuracy and a superb surface quality.

3 Grinding experiments

The production cycle is divided into three subsequent steps. At first a ‘rough’ grinding wheel with diamonds of 46 µm is used to remove material in an efficient way. After this grinding step, the ‘finishing’ steps are applied. Two consecutive ELID-finishing steps are carried out using CIB wheels with average grit sizes of 10 µm and 2.5 µm. In contrary to conventional polishing methods the finishing is carried out on the same grinding machine to improve the final workpiece accuracy.

3.1 ‘Roughing’ step

During this step the material removal is mainly carried out in a brittle mode in order to maximise the MRR. In the following paragraphs the ELID-grinding is compared to the conventional grinding methods and the maximal MRR is investigated.

3.1.1 Comparison with conventional grinding techniques

A comparison is made between ELID-grinding with a CIB wheel and conventional grinding using both a CIB wheel and a resin-bonded wheel. All wheels are meshed with grits of 46 µm. Figure 2 depicts the grinding forces and the final roughness after grinding of 375 mm³ at a MRR of 0.08 mm³/s. From these figures it seems that resin-bonded grinding is the preferred technique because of the low forces and the good surface quality. However, the G-ratios of the resin wheels are very low, below 10, while the CIB wheels show very little wear with G-ratios higher than 50. The G-ratios for ELID-grinding lie in between these two around a measured value of 30. Furthermore, grinding with a resin-bonded wheel shows a clear chattering behaviour.

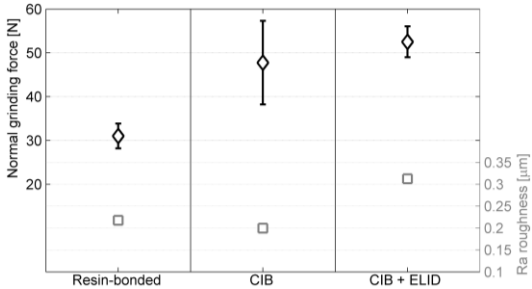

Figure 2: Comparison of different grinding techniques

3.1.2 Maximal material removal rate

A series of experiments have been conducted to find the maximal MRR. Figure 3 shows the grinding forces and roughness values for both conventional and ELID-grinding using CIB wheels. The normal forces are always a bit higher during ELID-grinding which can be explained through the bigger contact area due to the oxide layer. Therefore higher MRR's can be reached without the passivation process. The measured roughness however is lower in the case of ELID-grinding. Several other experiments have shown that after a certain amount of material removed the wheels have to be re-sharpened during conventional grinding, but not during ELID-grinding. Therefore ELID-grinding is favourable for achieving long and stable grinding cycles.

3.2 ELID-finishing

In 'ELID-finishing' the material is machined in a ductile way which leads to a superior surface quality. During this step it is important to find a balance between processing time and process stability. Using a CIB wheel with 10 µm grits an average roughness of 0.06 µm Ra or 0.42 µm Rz can be reached. The roughness is measured optically to a value of 0.011 µm Sa or 0.077 µm Sz after the final step using the 2.5

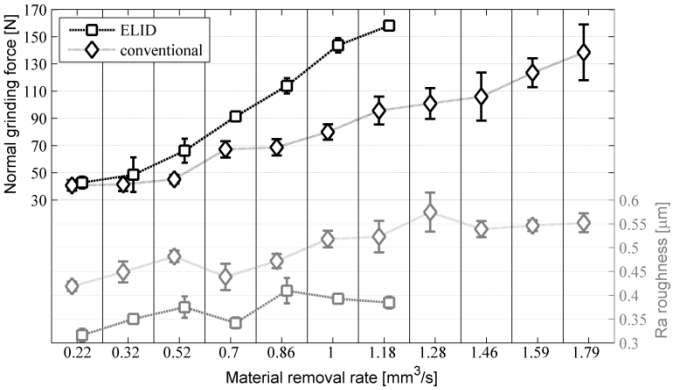

Figure 3: Maximal MRR of ELID-grinding and metal-bonded grinding

µm grits wheel. Figure 4 shows the results of a Design of Experiments with the following grinding parameters: the depth-of-cut a_e, the axial cross feed Δz and the duty ratio R_c of the power supply. To improve the surface roughness it is advised to decrease the axial feed and to maximize the duty ratio. The wheel can be lowered at both sides to increase the productivity without affecting the final roughness too much. Too high normal forces however lead to chattering and cause waviness on the workpiece surface. The axial feed has a very large influence on this maximal force.

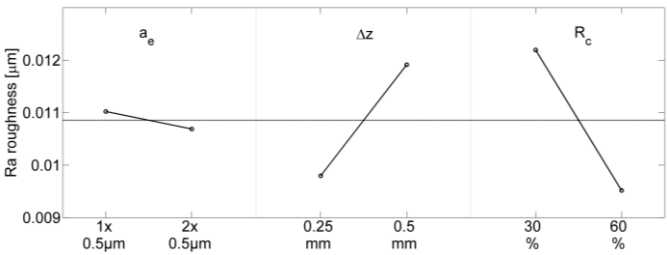

Figure 4: Primary effect during ELID-finishing with a CIB wheel of 2.5 µm grits

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[1] Kersschot, B., Qian, J., and Reynaerts, D. Growth and Properties of the Passivation Layer in ELID-grinding. Proceedings of the 3rd International Conference on Nanomanufacturing (nanoMan2012), pages 414–418.