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Abrasive grains micro geometry: a comparison between two acquisition methods

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Abstract

One of the aspects that makes difficult grinding processes modelling is the non-deterministic nature of the cutting tool, in particular the abrasive grains of the grinding wheel have a random distribution and an undefined geometry that influences the grinding forces.

In order to develop a reliable 3D model of the grinding process the actual microgeometry of abrasive grains must be acquired. This paper compares the results of two different acquisition methods: the geometry acquired via a laser non-contact instrument is confronted with the one acquired using a computer tomography; the accuracy of the grain micro geometry provided by the two approaches is discussed.

Keywords: grinding; computer tomography; micro-geometry

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1. Introduction

The grinding models proposed in literature can be classified as: (i) physical process models (analytical and numerical models), (ii) empirical process models (regression analysis, artificial neutral net models) and (iii) heuristic process models (rule based models) [1, 2, 3].

In order to achieve an experimental validation of the proposed model, the actual microgeometry of the grinding wheel surface should be taken into account. Unfortunately, due to the scale of the cutting grains a complete acquisition of the grinding surface would be nowadays impossible for the huge computational requirements necessary to completely describe the wheel surface.

To face this technological limit a previous experimental study investigated the grinding process by considering a single abrasive grain whose geometry was acquired by a stylus instrument [4]. Although the experimental study provided interesting results about the relationship between the grain geometry, the measured forces and the 3D FEM model, the filtering effect due to the stylus instrument geometry, suggested to assess other acquisition methodologies.

Actually, the conical shape of the stylus prevents the acquisition of surfaces whose slope is greater than the cone semi-aperture angle. Consequently, the cone aperture angle limits the acquisition of the grain cutting face, resulting in an artefactual geometry characterized by negative rake angles.

In order to achieve better and more accurate geometrical description of the actual abrasive grain, two acquisition methods that can overcome the stylus instrument limit are presented and discussed, precisely: computer tomography, and non-contact laser triangulation.

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2. Experimental setup

2.1. Material

Among all the different types of abrasive grain materials currently available on the market this study focuses on pure aluminum oxides (Al_2O_3) grains that due to their wide range of applications in grinding processes. A grit size equal to 16 FEPA has been chosen in order to allows a better comparison within the two measuring methods.

A total of 25 grains was acquired using the Computed Tomography; 4 of these grains were randomly chosen to be measured with the non-contact laser triangulation. The limited number of samples scanned with the laser was justified by the consistency and repeatability of the obtained results as well as for the considerable duration of the acquisition procedure.

Each grain used for this study, randomly chosen from the entire stock available, has then been mounted on top of M4 steel screws using a bi-components epoxy resin (Fig 1) to be correctly hold in place during measurements.

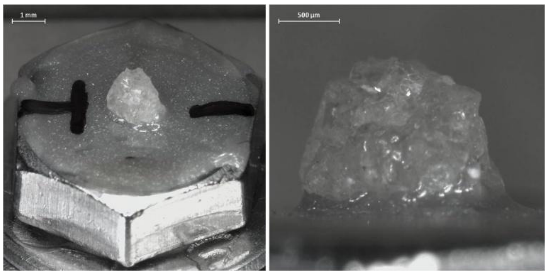

Figure 1: An aluminum oxide abrasive grain mounted on the screw.

2.2. Computer tomography

A Zeiss Metrotom 800 Computer Tomography has been use to obtain the 3D geometry of each abrasive grain. The characteristics of the machine are listed in Table 1 while Table 2 shows the scanning parameters optimized for the grain acquisitions.

Table 1: CT machine performance features

Zeiss Metrotom 800	
Tube	130kV/39W
Detector	1900 x 1512 pixels
Measuring range	Φ 125 x 150 mm
Lifting table adjustment range	290 mm
Source detector distance	800 mm

Table 2: CT scan parameters optimized for grains geometry acquisition

Scanning parameters	
Current	65 kV
Voltage	61 µA
Integration time	1000 s
Gain	8.0 x
Image averaging	2 images
Binning	1 x 1

2.3. Non-contact laser triangulation

The same grain samples have been acquired by a non-contact laser instrument, specifically a Taylor Hobson Talyscan 150 configured with the laser probe; Fig. 2 shows the positions of the laser source and linear CCD array used by the triangulation method.

The samples geometry was acquired by using a square grid with sampling step $\Delta x = \Delta y = 5$ µm.

The acquisition procedure consists of the following phases: (i) sample spraying with a white welding developer (DN R2.82: ROTRIVEL U) in order to reduce optical laser ray-grain material artefacts, (ii) six lateral view acquisitions with spacing $\Delta\alpha = 60°$, (iii) one top acquisition to integrate lateral views data.

Fig. 3 shows the dividing device for the rotation of the sample during the lateral acquisition phase.

Figures 4 and 5 display the lateral and top acquisition phases respectively. Fig. 6 shows the pseudo-colour six lateral acquisitions obtained by using the described experimental setup.

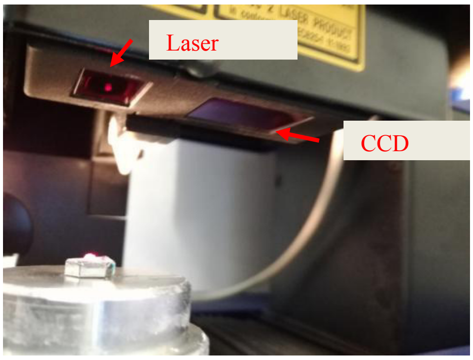

Fig. 2: Non-contact laser triangulation system

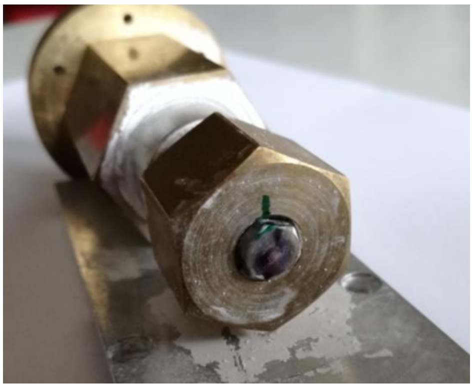

Fig. 3: Dividing device