MODEL FOR ESTABLISHING THE PROFILE OF THE CONTACT LINE BETWEEN TOOL AND WORKPIECE AT INTERNAL GRINDING OF CERAMIC MATERIALS

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1. INTRODUCTION

Because of their hardness and fragility as well as their dielectric properties, most ceramic materials are workable only by external or internal cylindrical grinding, plane grinding or by formation or profiling grinding.

The difference between external and internal cylindrical grinding is that in the latter case for the same cutting depth the contact between the active surface of the abrasive tool and the internal cylindrical surface is larger. This is because the contact is produced between the convex surface of the tool and the concave surface of the piece, while in case of external cylindrical grinding the contact is between two convex surfaces.

Also the static and dynamic rigidity are reduced at internal cylindrical grinding, which negatively influences the dimensional and geometric precision, the quality of the finished surface and the stability of the grinding process.

2. ESTABLISHMENT OF THE THEORETICAL ANALYSIS MODEL

Experimental research has shown tat internal grinding of ceramic materials is characterized by probabilistic mechanisms of cinematic parameters with significant influence on the obtained results.

The grinding technological system comprised of the abrasive tool, workpiece and the machine tool determines a dynamic behavior of the process, with rapid changes of the cutting conditions in the contact area.

The process behavior becomes non-stationary especially in case of grinding advanced ceramic materials, because the topography of the abrasive tool is subject to constant change produced by specific wear mechanisms. Since there are no auto-sharpening effects, the tool is constantly wearing.

Using the material scratch tests with triangular grains, it is considered the cutting schematic of a cutting edge presented in fig. 1:

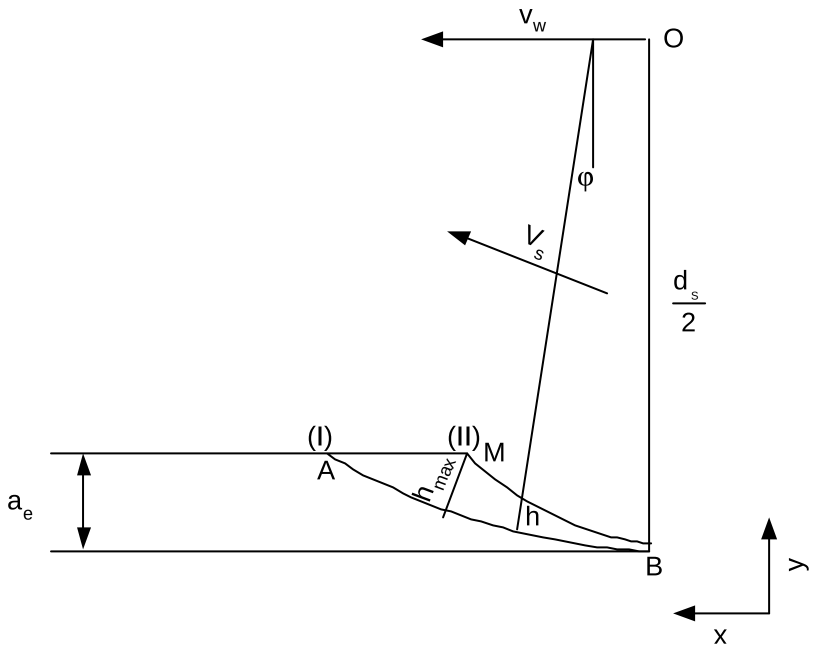

Fig. 1 Cinematic schematic with one cutting edge at internal grinding of ceramics

This cutting schematic with longitudinal workpiece advance is characterized by the comma-like shape of the abrasive grain path determined by superposition of two cycloids I, II. The thickness of uncut material h with respect to the rotation angle of the abrasive tool starts from zero in the point of contact B, increasing almost linearly until it reaches h_{max} in M, after which decreases towards A where the grain leaves the workpiece.

Under these circumstances, the parametric equations generating the abrasive grain trajectory are:

$$x(\varphi) = \frac{v_s}{v_w}\left(\varphi / \frac{v_s}{v_w} + \sin\varphi\right)$$

$$y(\varphi) = \frac{v_s}{v_w}(1 - \cos\varphi) \qquad (1)$$

$$q = \frac{v_s}{v_w}$$

where:

x, y (φ)	- parametric movement coordinates
φ	- rotation angle of abrasive tool
v_s	- linear speed of abrasive tool (mm/sec)
v_w	- linear speed of workpiece (mm/sec)
a_e	- cutting depth (mm)

3. ESTABLISHMENT OF THE THEORETICAL PROFILE FOR THE CONTACT LINE BETWEEN TOOL AND PIECE AT INTERNAL GRINDING OF CERAMIC MATERIALS

The following parameters were used in the experimental tests: abrasive tool diameter d_s = 40 (mm), linear cutting speed v_s = 27.5 (mm/sec) and piece advance speed v_w = 7.62 (mm/sec). The profile of the tool center displacement along X axis is depicted in fig. 2:

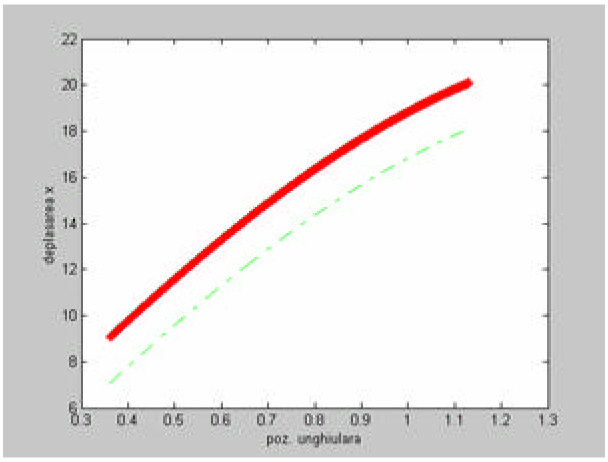

Fig. 2 Displacement profile for the x(j) coordinate of the tool center

By analyzing the curves from fig. 2 it can be noted that modifying parameter q by increasing v_w = 100 (mm/sec) the profile remains unchanged, the difference between the two curves being given by modification of the parameters g(curve 2) = f(curve 1) + 2 displacement units.

The equation that generates the profile of the contact line between tool and workpiece is given by:

$$Z = \left[400\left(x^2 - y^2 + 2\right) - x^2\right]^{\frac{1}{2}} \qquad (2)$$

In fig. 3a, 3b and 3c is presented the profile of the contact line between tool and workpiece at internal grinding of ceramic materials in the general case, with contour and level lines.

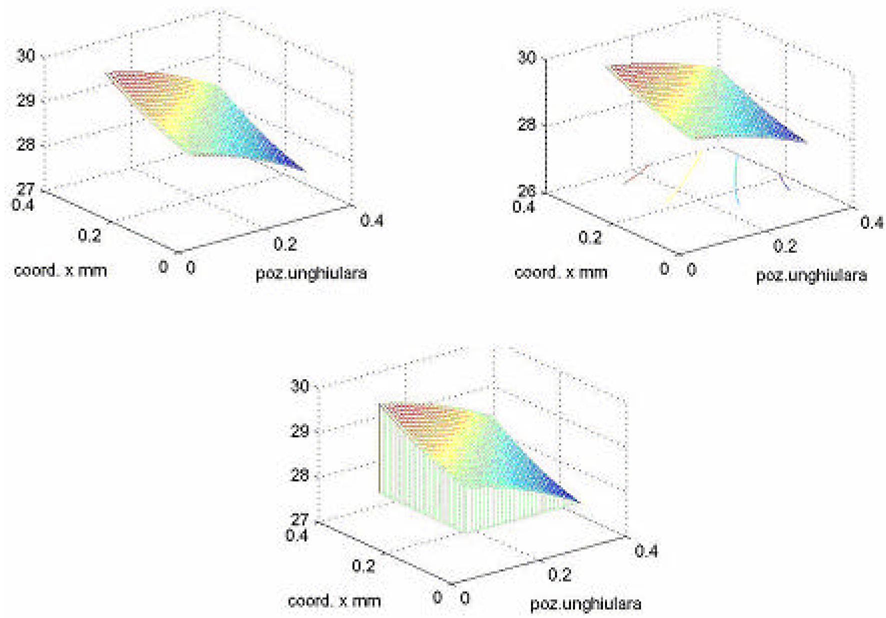

Fig. 3 Contact line profile

4. CONCLUSIONS

The analysis of the contact line profile indicates that in the case of the presented model the simulation results are close to the theoretical profile of grinding with a single cutting grain.

The analysis domain was the interval 0.1 ÷ 0.4 (mm) for the horizontal displacement coordinate of the cutting tool center.

The micro granular wear is smaller in case of internal grinding than in the case of external grinding, due to the fact that the ration between the equivalent thickness of the grain and the contact length is smaller in the case of internal grinding.

The size and shape of the contact line indicate the stability of the grinding process, obtained by optimal correlation between the geometric and material characteristics of the abrasive tool, tool formation or sharpening conditions, parametric conditions of the grinding process, nature of the ceramic material and the semi-finished product fabrication mode.

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