THE EFFECT OF GRINDING-SPECIFIC PARAMETERS ON THE SURFACE FINISH DEGREE AT CERAMICS GRINDING

Daniel POPESCU
University of Craiova, Faculty of Mechanics, daniel.popescu@oltenia.ro

1. INTRODUCTION

In case of ceramic material grinding there are specific phenomena different completely from the case of metal grinding.

The workability of ceramic materials depends on obtaining flawless products.

The instability of geometric and technologic parameters is the main cause that leads to occurrence of flaws such as cracks, fractures and material breaking.

Among the phenomena that occur during fine grain grinding of ceramic materials are:

- chip formation by appearance of scale-like material particles because of the cracks generated by the cutting force
- state modification of the material in the contact zone due to structure sagging which appears as a net of cracks after elastic recovery
- elimination of irregularly shaped particles due to shocks generated by entry or exit of the tool
- damage to the tool cutting edges which increases proportionally with the granularity of the workpiece material

In order to minimize the negative influence of these phenomena it is necessary to research the connections among the grinding parameters and the roughness of the ground surfaces.

2. THEORETICAL CONSIDERATIONS

Previous research indicates that the maximum undistorted cutting depth depends on a series of cinematic parameters of both the grinding machine and the tool.

The work schematic is presented in fig. 1:

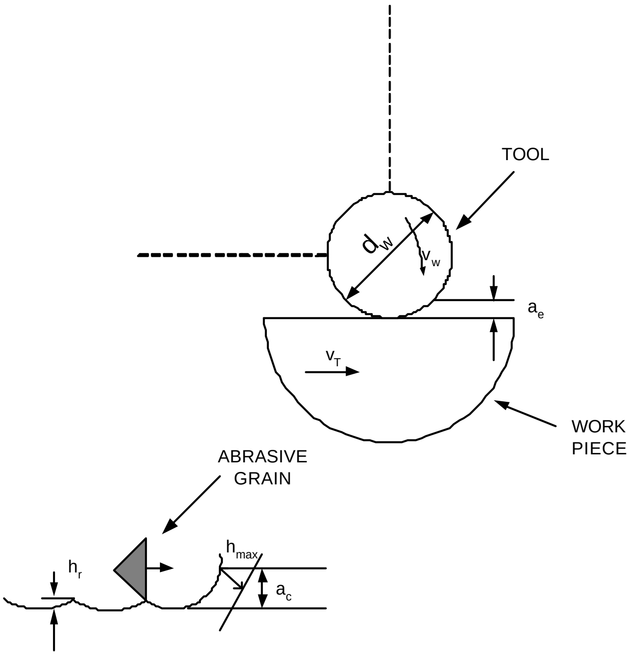

Fig. 1 Ceramic material grinding schematic

Thus:

$$h_{max} = \left(\frac{4v_T}{v_w Cr} \sqrt{\frac{a_e}{d_w}} \right)^{\frac{1}{2}} \quad (1)$$

where:

h_{max} - maximum undistorted cutting depth (μm)
v_T - table translation speed (mm/sec)
v_w - peripheral speed of abrasive tool (mm/sec)
a_e - cutting depth (μm)
d_w - diameter of the abrasive tool (mm)
C - density of abrasive grains (g/mm^2)
r - chip width over medium undistorted thickness ratio

We are interested in the residual depth of the grinded surface as function of the grinding parameters as well as the area of the transversal section of the ground surface.

We have:

$$a_m = c^{-\frac{1}{2}} \left(\frac{v_T}{v_w} \right) \left(\frac{a_e}{d_w} \right)^{-\frac{1}{2}} \quad (2)$$

where:

a_m - area of chip transversal section (μm^2)
v_T - table translation speed (mm/sec)
v_w - peripheral speed of abrasive tool (mm/sec)
d_w - diameter of the abrasive tool (mm)
a_e - cutting depth (μm)
C - density of abrasive grains (g/mm^2)

and:

$$h_s = \frac{1}{64} C \left(\frac{r}{d_w} \right)^2 a_e h_{max}^4 \quad (3)$$

where h_s - residual depth of ground surface (μm)

3. EXPERIMENTAL RESEARCH

The tested material is hot pressed silicon nitride (HPSN). The parameters employed in the experiments are identified in table 1:

	Size of abrasive grain (μm)	Table advance speed v_T (mm/s)	Cutting depth a_e (mm)
1	5.1	7.6	$13 \cdot 10^{-4}$
2	50.8	7.6	$25 \cdot 10^{-4}$
3	152	4.5	$13 \cdot 10^{-4}$
4	87.5	7.6	$25 \cdot 10^{-4}$
5	249	7.6	$25 \cdot 10^{-4}$
6	337	7.6	$25 \cdot 10^{-4}$

Table 1

By specific means and calculations were determined the other parameters corresponding to the testing conditions in accordance with table 2:

	Maximum undistorted chip width h_{max} (μm)	Residual thickness of ground surface h_s (μm)	Chip section area a_m (μm^2)
1	$745 \cdot 10^{-4}$	$7.22 \cdot 10^{-9}$	0.0179
2	$1351 \cdot 10^{-4}$	$0.47 \cdot 10^{-9}$	0.0457
3	$1600 \cdot 10^{-4}$	$0.9 \cdot 10^{-9}$	0.0638
4	$2079 \cdot 10^{-4}$	$0.2 \cdot 10^{-9}$	0.1081
5	$2805 \cdot 10^{-4}$	$0.8 \cdot 10^{-9}$	0.7968
6	$3380 \cdot 10^{-4}$	$0.001 \cdot 10^{-9}$	0.2861

Table 2

The density of the abrasive grains was C = 49.91 g/mm^2, cutting tool diameter d_w = 40 mm, and chip width to medium undistorted thickness ratio r = 15.

The goal of experimental research was to analyze the effect of the grinding-specific parameters (h_{max}, h_s, a_m) on the HPSN ground surface roughness. It was used a synthetic non-water interfering abrasive fluid.

The variations of the surface roughness R_a obtained are presented in figures 2 - 4:

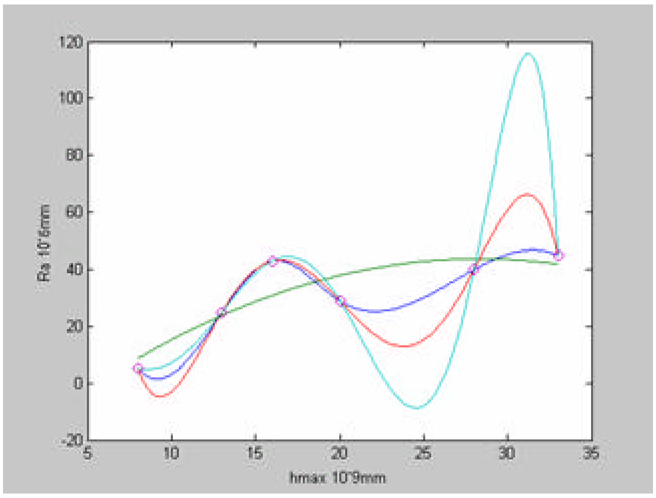

Fig. 2 $R_a = f(h_{max})$

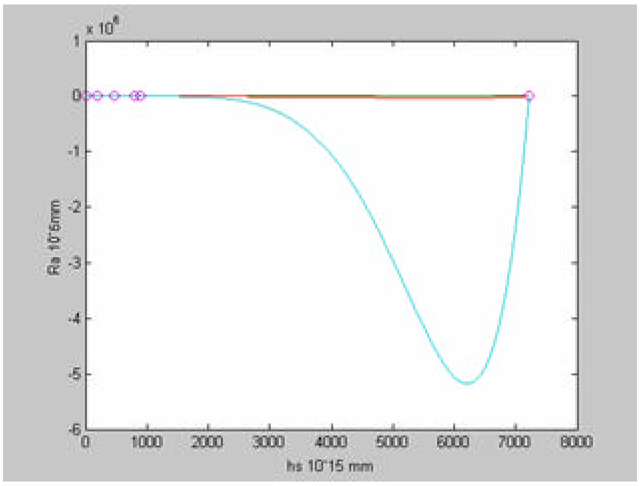

Fig. 3 $R_a = f(h_s)$

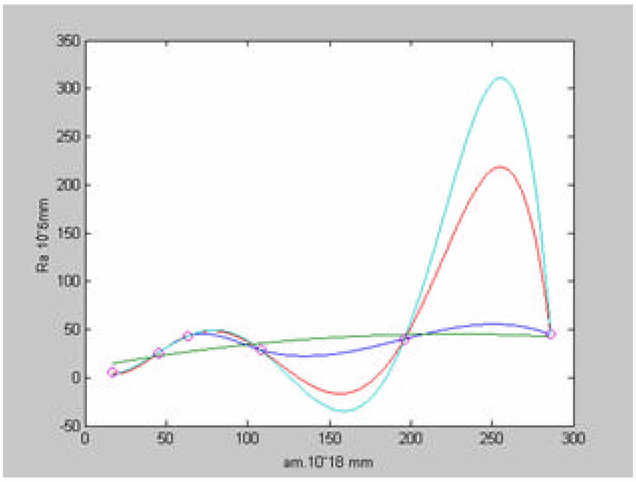

Fig. 4 $R_a = f(a_m)$

The roughness values in the six measurement points are given in table 3:

	1	2	3	4	5	6
R_a (mm)	$5 \cdot 10^{-2}$	$25 \cdot 10^{-2}$	$43 \cdot 10^{-2}$	$29 \cdot 10^{-2}$	$40 \cdot 10^{-2}$	$45 \cdot 10^{-2}$

Table 3

4. CONCLUSIONS

The previous graphs were obtained by means of 1st degree polynomials (linear regression) producing a linear dependency which minimizes the sum of squares between the approximation line and the given points.

Also using 2nd, 5th and 7th degree polynomials (polynomial regression) determined a better approximation of measured data. The best approximation was obtained when the polynomial degree is close to the number of measured values. The dependency $R_a = f(h_{max})$ indicates good approximation in the interval $h_{max} \in (5..20) \times 10^{-9}$ (mm), while $R_a = f(a_m)$ indicates good approximation in the interval $a_m \in (0..200) \times 10^{-18}$ (mm). The real profile of the finished surface is shown in fig. 4 where $R_a = f(h_s)$ presents the best approximation in the interval $h_s \in (0..3000) \times 10^{-15}$ (mm).

The finished surface profile also indicates the interval in which ceramic material grinding presents the best stability from dynamic point of view.

REFERENCES

1. Brinksmeier, H., Toushoff, H.K., Inasaki, I., Peddinghams, J., 1993, Technical reports – Basic Parameters in Grinding, Annals of the CIRP, Vol. 42/2, pp. 795-799.
2. Meier, J.E., Fang, G., 1994, Effect of Grit Depth of Cut on Strength of Ground Ceramics, Annals of the CIRP, Vol. 43/1, pp. 309-312.
3. Meier, J.E., Fang, G., 1993, Diamond Grinding of Silicon Nitride Ceramic, Proceedings of the International Conference on Machining of Advanced Materials, NIST special Publication 847, pp. 205-222.
4. Toushoff, H.K., Peters, J., Inasaki, I., Paul, T., 1992, Modeling and Simulation of Grinding Processes, Annals of the CIRP, Vol. 41/2, pp.677-688.