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RESEARCH ON THE PROCESS OF SUPERFINISHING CERAMIC SURFACES OF CUTTING PLATES

This paper presents initial research on the surfaces of cutting ceramic plates ground using diamond grinding wheels. Ceramic materials were ground using a piezoelectric feed-in system whose aim was to minimize the effect of brittle cracking of the ceramic material in the machining zone. Due to precise machining it is possible to smooth out the machined surface by ductile-regime grinding the material removal mechanism and, in consequence, reducing the defects on its surface and in the surface layer of the ground material.

1. INTRODUCTION

Research of the grinding process in the conditions of plastic creep of the machined material, can be applied in shaping ceramic cutting blades that facilitate machining hard materials. Properly modified conditions in the process of cutting blade edges and surface grinding, enhance their durability [3],[5]. It is estimated that this could be obtained through reduction of defects in the surface layer of the plate and on its surface [4]. As a result, it will be possible to minimize blade surface defragmentation in service and to reduce its wear [8],[9],[10].

A customized piezoelectric feed-in system is proposed to facilitate conducting research of solutions related to machining brittle materials in conditions of ductile machined material removal and hard-to-cut materials. Such system makes it possible to obtain conditions in which the process of effective reduction of defects on the surface and on the surface layer of the machined material takes place [2],[6],[7].

2. CONDUCTING THE TESTS

Appraisal tests were carried out using the research post which made it possible to perform the grinding process with a precision of 2 to 3μm, using a high-output electrospindle with hybrid bearing (Fig. 1).

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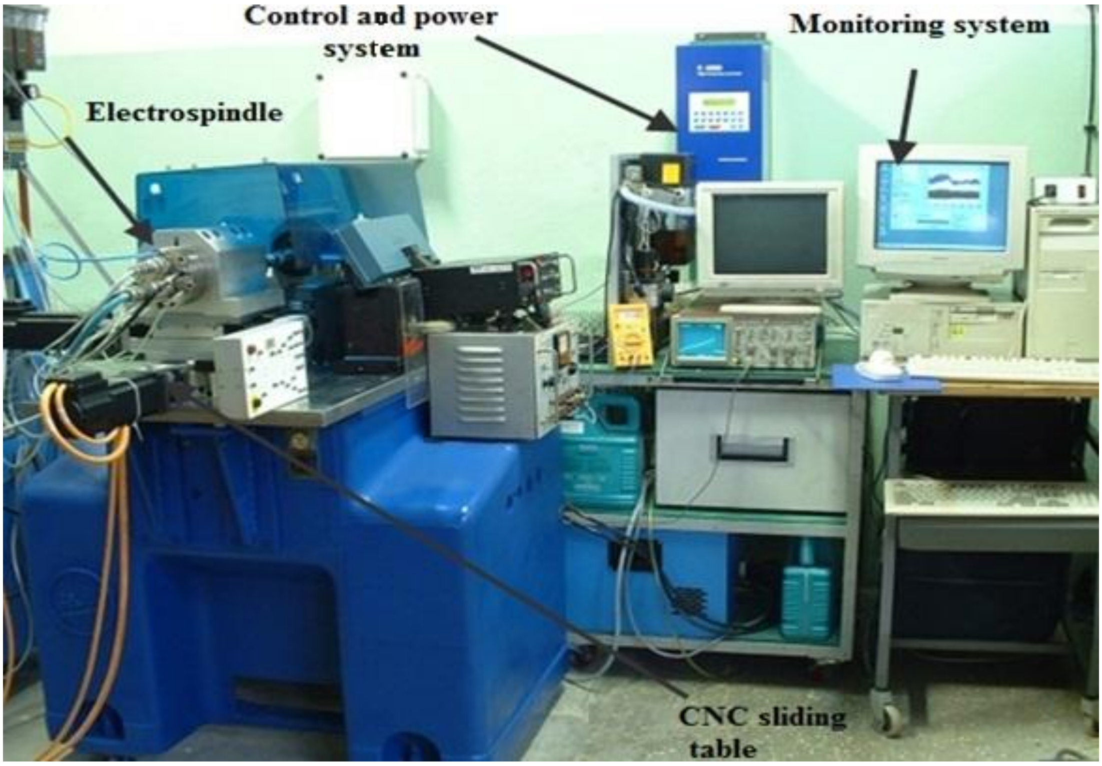

Fig. 1. General view of the research post [1]

Oxide ceramic plates and plates were selected for grinding, after which they underwent analysis checking the condition of the surface in their production stage (Fig. 2).

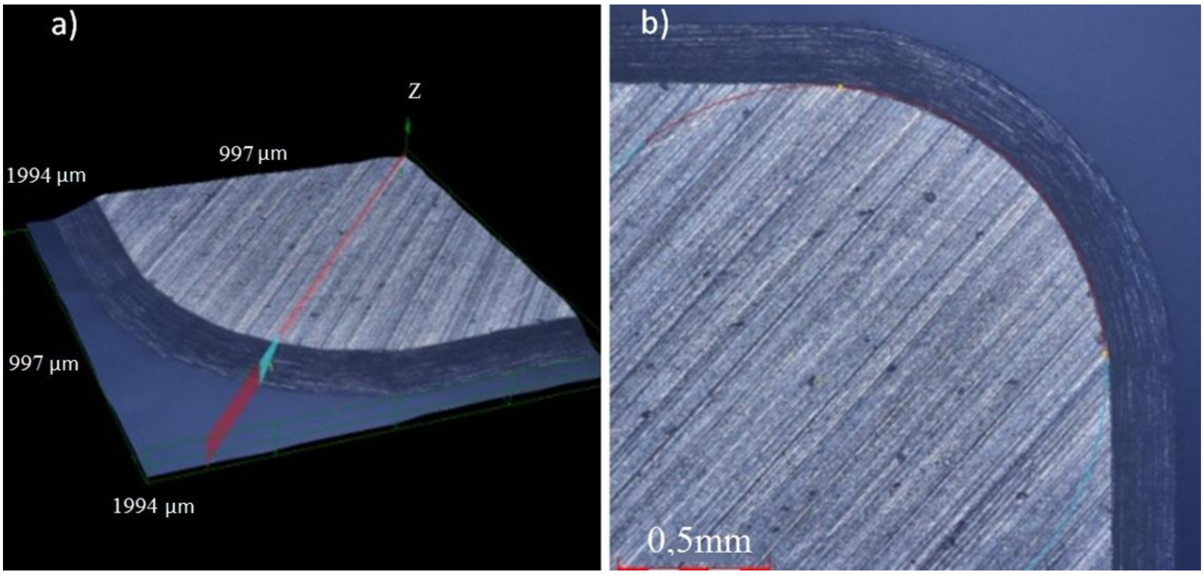

Fig. 2. Plates' surface condition before their grinding: a) phase view b) nose radius view

An Olympus DSX 500 (zoom 139X) microscope was used to examine the surfaces of cutting plates produced by Kennametal company. What can be observed in the images are post-machining marks, as well as elements of chips and entrapments in the material structure. Figure 2 presents the cutting blade geometry with a visible nose radius and phase reinforcing its edge. Figure 3 depicts a view of the ceramic plate with clearly visible macro chips on the edges.

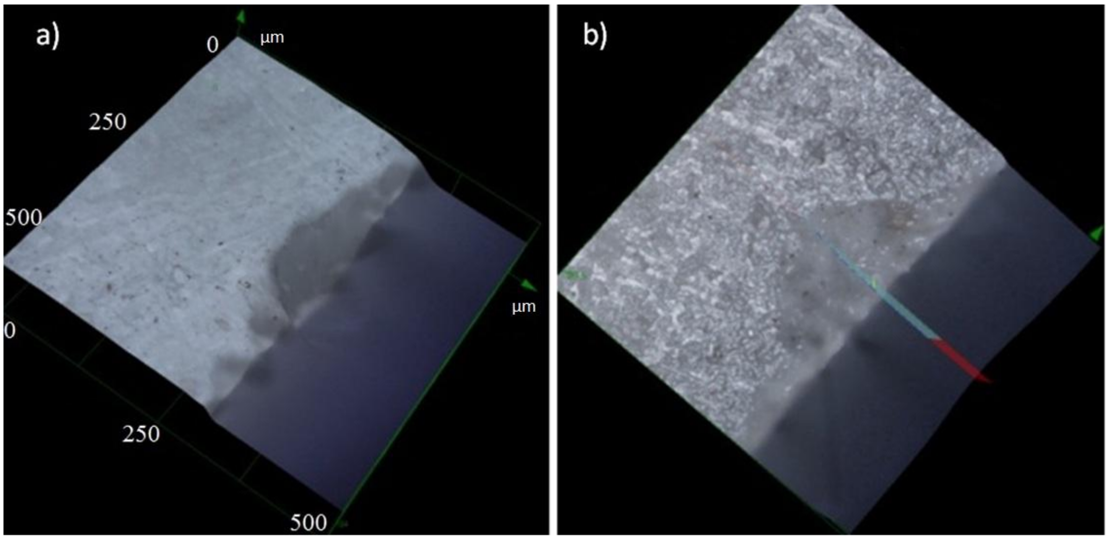

Fig. 3. Condition of the plates surface SNG 120700: a) b) chipping of the cutting edge

What can be observed in the presented images are chip marks created during the applied (machining) load on the edge of ceramic plate SNG 1207 (square plate with clearance angle 0^o, 7mm thick and whose cutting edge was 12mm long). The next image presents blade of the ceramic plate with nose radius and phase (Fig. 4).

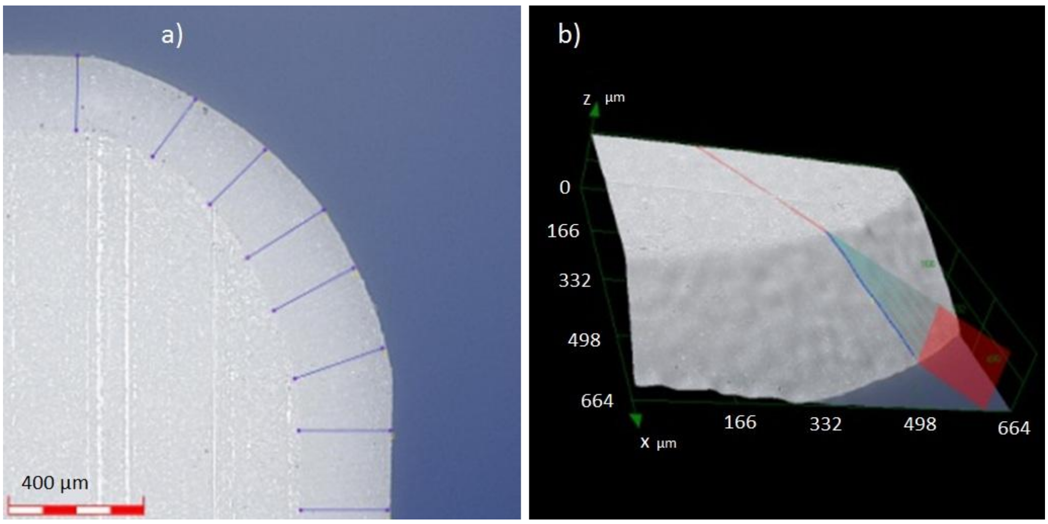

Fig. 4. Condition of the SNGN 120712 plates after the production stage: a) nose radius view, b) phase view

The surface was also analysed before the machining with an examination on the stylus profilometer Hommell Tester T8000. The image presents surface of KY3500 SNGN 120712 type plate and selected plate surface roughness profile with registered values of its parameters (Fig. 5).

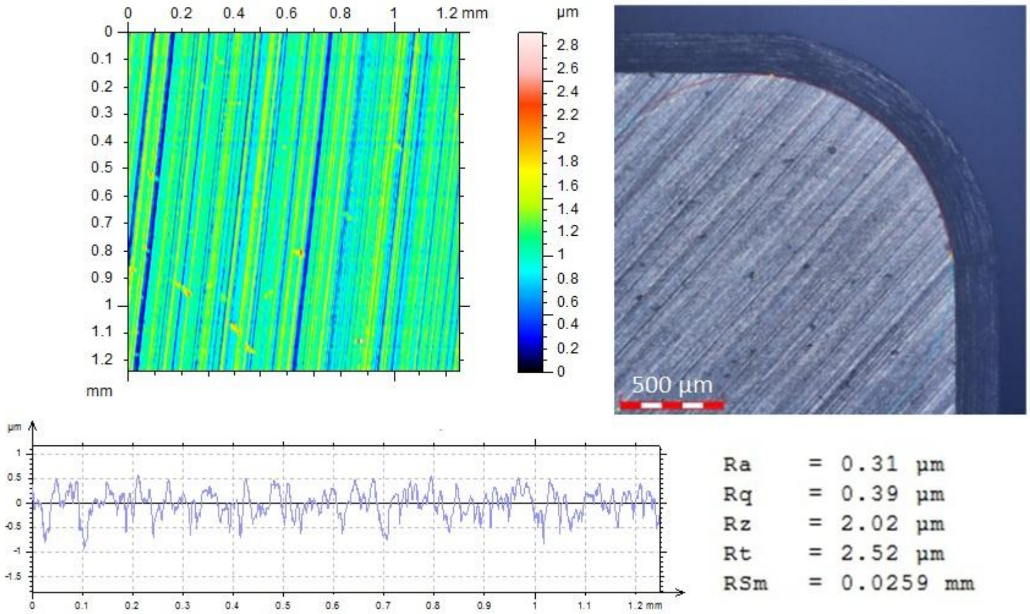

Fig. 5. Features of KY3500 SNGN 120712 plate surfaces

Figure 6 presents results of analysis of SNG 120700 type plates.

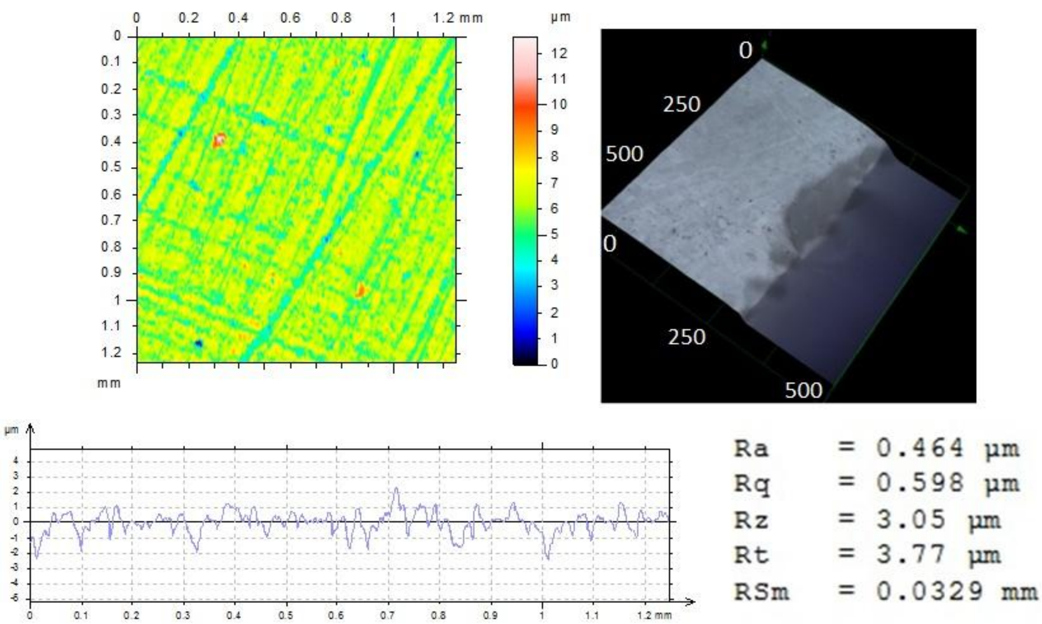

Fig. 6. Features of SNG 120700 ceramic plate surfaces

The surface roughness of the measured profile is in this case Ra>0,4μm and is considerably higher when compared to oxide ceramics. The criss-cross post-machining marks are evidence of the surface grinding process. The next image presents a roughness trace of the SNG 120712 ceramic plates (Fig. 7). The roughness measurement was conducted on the plate side surface after grinding. In this case the roughness value was Ra>0,3μm.

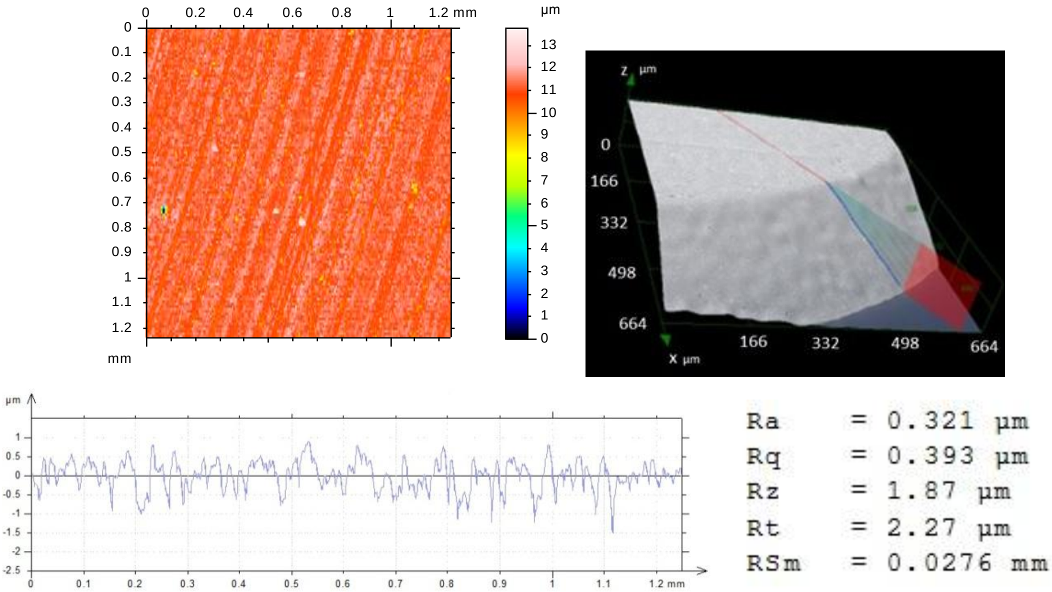

Fig. 7. Features of SNG 120712 ceramic plates' surfaces

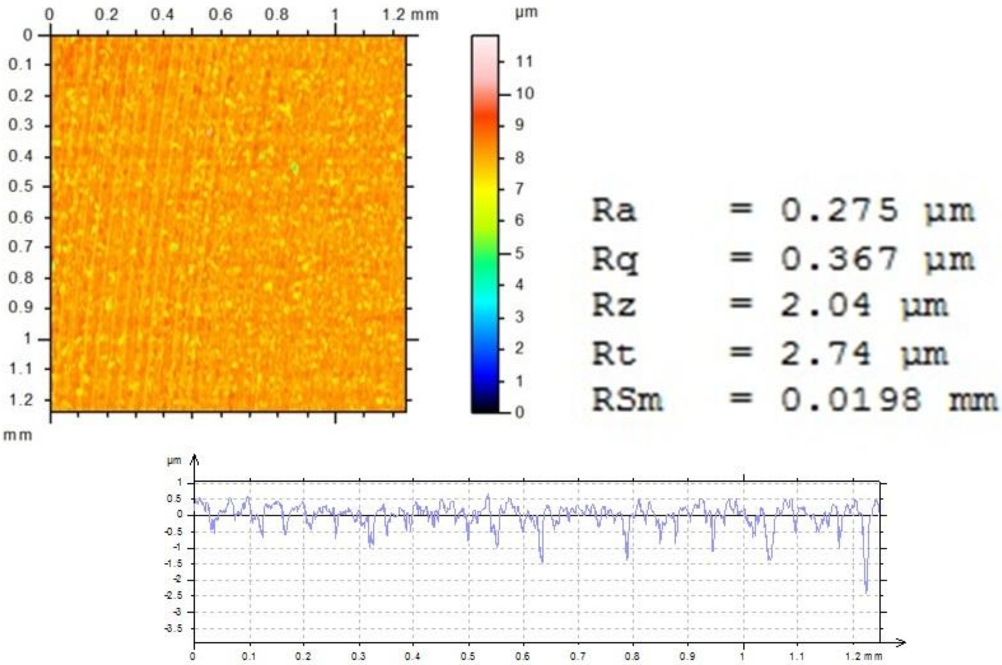

Fig. 8. Features of SNG ceramic plates surfaces after grinding

The next step was conducting a test in which the side surfaces of SNG plates made from corundum ceramics were ground by making a pass along its side edge at 27m/s (15 000rev/min for a 35mm grinding wheel) and in-feed of 2μm. The results presented in figure 8 were obtained as a result of the above process.

An increase in roughness of particular sections of the ground surface was observed with the applied grinding speed (decreasing the rotational speed to 10 000rev/min, which amounts to 18m/s) with the same in-feed (Fig. 9).

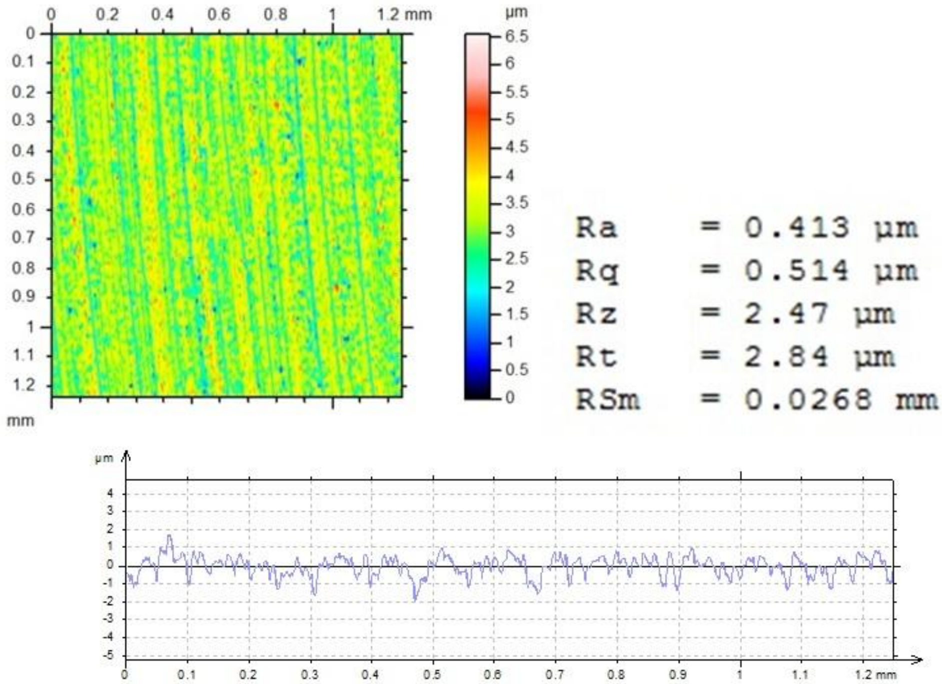

Fig. 9. Features of the SNG ceramic plates' surfaces after grinding

The measurements clearly show that limiting the cutting layer per single abrasive grains in the grinding zone results in decreasing surface roughness. This effect was obtained through modifying the grinding speed with constant programmed micrometric in-feed.

3. SUGGESTED WAYS OF SMOOTHING OUT THE GRINDED SURFACES OF CERAMIC MATERIALS

The initial results obtained clearly point to the conclusion that in the case of machining ceramic materials it is possible to finish the ceramic plate surfaces in a far more efficient way- by using a precise steering system based on piezoelectric actuators. Application of a system performing the CNC micrometric in-feed in the conducted tests did not deteriorate the features of the ceramic material ground surface . On the contrary, slightly lower values were obtained, in comparison to the initial machining carried out at the plate manufacturer's.

In the next research stage, piezoelectric piles are planned that would minimize the in-feed to nanometric values. As a result, it would be possible to limit the undesired phenomena that occur in the grinding zone, including the progressive penetration of the abrasive grains into the machined material, which may in turn contribute to power increase in the grinding zone (the cutting layer per single abrasive grain is augmented), which causes considerable increase of the abrasive grain load and therefore a temperature rise in the machined material surface layer, as well as on the surface and in the deeper layers of the grinding wheel active surface. Cracks on the surface and in the surface layer of the machined material, as well as grinding wheel cracks which finally led to its disruption were observed for such machining conditions in the previously realized research stage [7].

One of the possibilities of controlling the temperature in the grinding zone (as suggested as a result of the obtained research results analysis) is application of piezoelectric piles that facilitate controlling the in-feed and contact frequency over a given time unit (Fig. 10).

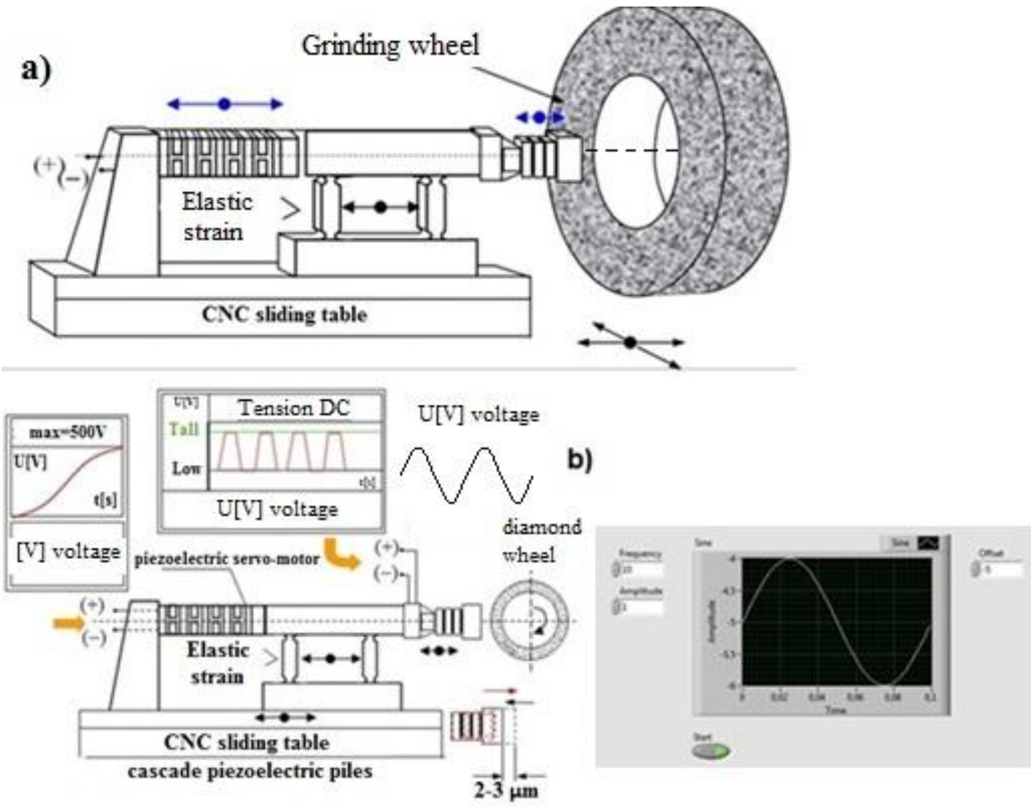

Fig. 10. The functioning of the machining head: a) the system of generating controlled vibrations in the machining zone b) application for generating reciprocating movement in the grinding zone

Another function that may be added to the presented idea of using piezoelectric piles in machining ceramic material is the function of precise penetration of abrasive grains' apexes into the machined material, which may result in greater machining precision and thus in reduction of defects in the surface layer of the machined material, as well as in easier transition into the state of plastic creep of the machined material (controlled vibrations in the grinding zone). As a result, the above method may allow for controlling the plasticizing of the subsurface layer of the machined material by maintaining proper temperature in the grinding zone on minor micro- or even nano-surfaces of the ground material. Figure 10b presents a fragment of application used for generating reciprocating move in the grinding zone using piezoelectric piles.

4. SUMMARY

The research on ceramic plate surfaces presented in this paper was carried out without application of the piezoelectric actuator that works in accordance with the rule presented in point 3. On basis of the hitherto realized research it can be estimated that using the piezoelectric feed-in system allows for obtaining greater machining precision and better effects on the surface and in the surface layer of the machined material (limiting the in-feed- to nanometric values). Application of a few sparking-out passes perpendicular to the rotation axis of the grinding wheel with striking end, using AE signal, allows for smoothing the ceramic plate surface out and, in consequence, for increasing the quality of the plate surface and its surface layer. What is planned in the next research stages is smoothing out the ceramic cutting plate surfaces with controlled in-feed depth that does not exceed a few dozen nanometers and that results in an effect of plastic creep of the machined material in the grinding zone.

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