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ULTRASOUND INFLUENCE IN HOLE GRINDING PROCESS TO AL203 MATERIAL

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Abstract: *Paper deals about analysis and solutions results of ultrasonic grinding process of hard machining materials. There are presented ultrasonic grinding modifications and achieved results for technical ceramics* Al_2O_3*.*
Key words: *ultrasound, grinding, ceramics, experiments*

1. INTRODUCTION

Up – to-date problem is machining of hard machining materials - represented by technical ceramics, characterized by high toughness, by wear and corrosion resistances. One of the intensification methods of ceramics machining process is ultrasound using in grinding processes.

2. CERAMICS GRINDING

High hardness of ceramics materials attends by characteristic brittleness and low plastics properties included low strengthening property result in separate mechanism of chip removing at grinding. It is a reason that the plastics deformation is not occurred at chip producing as at steel plastics materials. But material removing occurs at which grain slots by tool are sharper on machined surface.

Factors that make possible chip creations by plastics deformation these factors demand to use fine – grained diamond grinding wheels, accuracy and precision of wheel spindle setting – up, low feed and next requirements of process optimalization. Grinding wheel wearing is increased at high depth of cut or in straight contact between agglutinant tool material and workpiece. Requirement to agglutinant material is keeping and saving of sharpness and good resistance against abrasion and heating created by friction at straight contact of workpiece material. Material of agglutinant should have not only good adhesion and relation between particle named wheel toughness but good deformability at cutting force influence too. Cutting force at grinding is sum of cutting forces influenced to wheel grains. Radial component cutting force is higher than tangential in ceramics grinding that is a difference from metals. Force needed for successive plastics material deformation in area of chip creating is low. High accuracy demands high rigidity of grinding wheel because contact surface of wheel of workpiece material is large and radial force is substantial. Very important in grinding with little feed is using of cooling liquid with high cooling and lubrication properties because reduce tool grain wearing by heating created by friction of contact distance between tool and workpiece. For cutting force intensity substantial depend in addition to low feed, moving relation between tool and workpiece too. Next characteristic of ceramics grinding process is fact that grinding grains of wheel in parallel kind of grinding achieve maximum depth in consequence of this the cracks originate in working area. Danger of cracks origin is lower in opposed kind of grinding where in the start of grinding process is originated plastics deformed chip. Opposed grinding is more suitable for assuring of high dimension accuracy in lower machine tool spindle rigidity (Holešovský & Hrala, 2004), (Uhlmann at al., 1999).

3. ULTRASOUND AIDED GRINDING TECHNOLOGY

Grinding tool wobble by ultrasound energy increased intensity and quality grinding processes. Directed ultrasound field influences in process area. Cutting wedges of grinding wheel are positioned in resonance ultrasound wave systems antinodes of longitudinal stagnancy oscillation. Acoustic ultrasound energy directed to grinding place with cutting liquid influences to grinding process mainly by kinematics and dynamics effects of oscillation moving by active grinding grains. These effects showed as periodical direction change and momentary rate of cutting speed and cutting forces. In standard grinding is momentary speed vector constant and is in constant direction, showed in the Fig.1.

In ultrasound grinding is changed momentary rate and direction of final cutting speed of grinding grain periodical by vector sum that is in the Fig.2 (Maňková, 2000), (Ciutrila, 2001).

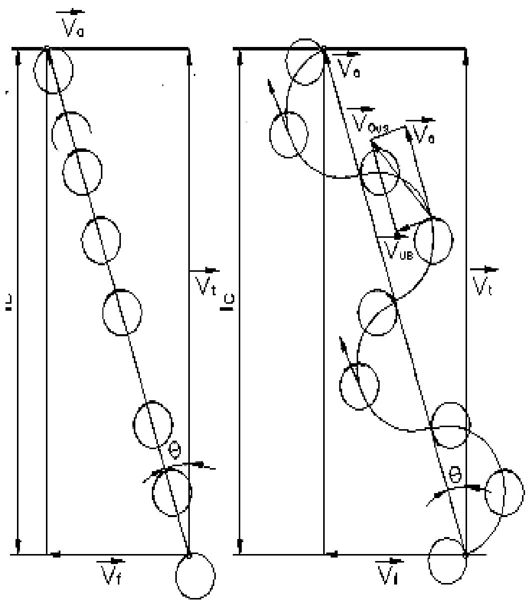

Fig.1. Kinematics of standard and ultrasound machining

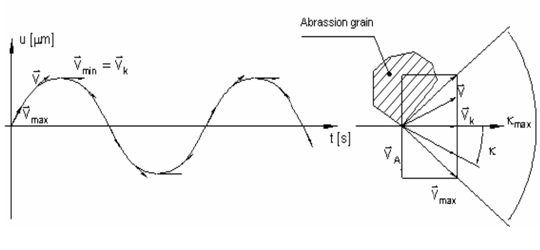

Fig.2. Kinematics model of ultrasound grinding process

4. EXPERIMENTS

For objective result acquirement of ultrasound influence in hole grinding process to $Al_2 0_3$ material were realised experiments and monitored properties of machined surface – intermediate arithmetic mean value Ra and maximum undulation of machined surface Rz at the same arithmetic requirements in one device - horizontal grinder by standard ultrasound and by ultrasound energy in opposed kind. All workpieces were centred and positioned in fixture that was fixtured in the jigs of horizontal grinder. Tool was shaped before experiment realisation (Lukovics & Sýkorová, 1999).

Main parameters:

- frequency of workpiece rotation: 120 – 280 min^{-1}
- frequency of spindle operating speed /of tool/: 16000 – 20 000min^{-1}
- depth of cut: 0,02 – 0,04 mm
- longitudinal feed: 0,2 – 1,5 $m.min^{-1}$
- tool - diamond: Φ 30 x 15 mm
- workpiece: Φ 55,7 x 41 x 6 $Al_2 0_3$
- power of ultrasound generator: 1 kW
- amplitude of ultrasound vibrations: 6 - 12μm
- resonance frequency: 22,8 kHz

Particular achieved values Ra and Rz in standard and ultrasound grinding at same technological requirements were monitored and noted into table and graphs from where we choose next that is showed in the Tab.1 and Tab.2:

Frequency of workpiece	Frequency of tool	Ra	Rz	Ra ultrasound	Rz ultrasound
120	16 000	0,71	5,6	0,31	2,0
120	20 000	0,6	4,9	0,16	1,5
180	16 000	0,81	5,8	0,4	1,5
180	20 000	0,72	5,1	0,2	1,35

Tab.1. Table of measured value in depth of cut 0,04mm and with longitudinal feed f = 0,6 $m.min^{-1}$

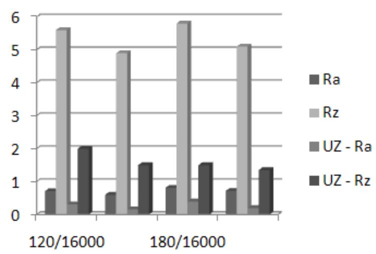

Fig. 3. Diagram of the Tab. 1. values

Frequency of the workpiece	Frequency of tool	Ra	Rz	Ra ultrasound	Rz ultrasound
120	16 000	0,5	4,8	0,2	2,2
120	20 000	0,4	3,9	0,07	0,8
180	16 000	0,6	3,2	0,25	2,5
180	20 000	0,4	3,0	0,1	0,8

Tab.2. Table of measured values in cut depth 0,02mm a longitudinal feed f = 0,3 $m.min^{-1}$

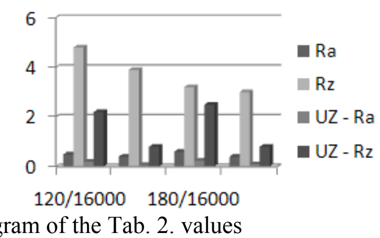

Fig. 4. Diagram of the Tab. 2. values

5. REVIEWING

By obtained data comparing is possible to say that increasing of machined surface roughness aided by ultrasound at $Al_2 0_3$ material is:

- Most distinct modification of parameter Ra was obtained at requirements: longitudinal feed - 0,3 $m.min^{-1}$, depth of cut – 0,02 mm, workpiece rotation frequency - 120 min^{-1}, tool rotation frequency - 20 000 min^{-1} and Ra was 82,5% modification.
- Least distinct modification of parameter Ra was obtained at requirements: longitudinal feeding - 0,6 $m.min^{-1}$, depth of cut - 0,04 mm, workpiece rotation frequency - 180 min^{-1}, tool rotation frequency - 16 000 min^{-1} and Ra 50,6% modification.
- Most distinct modification of Rz was obtained at requirements: longitudinal feeding - 0,3 $m.min^{-1}$, depth of cut - 0,02 mm, workpiece rotation frequency - 120 min^{-1}, tool rotation frequency - 20 000 min^{-1} and Rz 79,5% modification.
- Least distinct modification of parameter Rz was obtained at requirements: longitudinal feeding - 0,6 $m.min^{-1}$, depth of cut - 0,04 mm, workpiece rotation frequency - 180 min^{-1}, tool rotation frequency - 16 000 min^{-1} and Rz 46,5% modification.

6. CONCLUSION

Positive effect of power ultrasound to grinding process of hard and brittle materials by grinding diamond tools is in using their suitable kinds and at correct design of technological contributions proves in generally:

- Multiple increase of cutting property and speed of feed into cutting place,
- By ceramics machining with diamond tool with high depth of cut,
- By quality increasing of machined surfaces of ceramics material by decreasing of surface roughness,
- Grinding tool operated in self – sharpening process.

Possitive effect is in higher productivity and intensification of machining process in comparing with ultrasound machining with free abrasion too.

7. ACKNOWLEDGEMENTS

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