JOURNAL OF ENGINEERING
ANNALS OF FACULTY OF ENGINEERING HUNEDOARA
Tome (year 2008), Fascicole 3, (ISSN 1584 - 2673)

MODIFICATIONS OF ULTRASONIC GRINDING

[1]František PECHÁČEK, [2]Marcela CHARBULOVÁ, [3]Katarína KURAJDOVÁ

[1,2] Slovak Univerzity of Technology in Bratislava, Faculty of Material science and Technology in Trnava, Institute of manufacturing systems and applied mechanics, Rázusova 2, 917 24 Trnava, SLOVAK REPUBLIC

[3]University of J. E. Purkyne, faculty of Manufacturing Technologies and Management, Department of technologies and material science, Na okraji 1001, 400 96 Usti nad Labem, CZECH REPUBLIC

ABSTRACT:
The contribution presents achieved results of solutions and analyses of the systems and processes of ultrasound aided grinding of hard-to-machine materials. Modifications of ultrasonic grinding with achieved results for different types of hard-to-machine materials are described. Among latest technologies allowing solving the problems of ceramic materials processing belong ultrasonic technologies, which significantly influence away, rationalization, efficiency as well as integration of many manufacturing processes.
KEYWORDS:
Ultrasonic grinding, Grinding modifications, Ultrasonic energy, Transducer, Concentrator

1. INTRODUCTION

Ongoing rising demands to product quality require a development of new design materials. Thanks to continuous progress new so-called advanced materials (technical ceramics, sintered carbides, optical fibres) are being developed, which have good mechanical, physical and chemical properties.

Considering its properties, which are characterized by high hardness, wear resistance and brittleness, it's processing carries lots of many substantive technical challenges in production.

Among latest technologies allowing solving the problems of ceramic materials processing belong ultrasonic technologies, which significantly influence anyway, rationalization, efficiency as well as integration of many manufacturing processes.

2. ULTRASONIC GRINDING

While grinding with ultrasound the kinematics of conventional grinding is placed into secondary longitudinal vibrations of active movement, which range of ultrasonic frequency is up to 22kH. Ultrasonic energy can be lead into contact zone by vibration movement of the tool or the workpiece. Oscillation actuating is being realized by external potential of the generator and by the ultrasonic transducer working in most cases on piezoelectric principle. Incoming vibration from transducer is being lead to the amplifier and based on the needs is being amplified. After fixing the tool whole vibration is being transferred to the tool. Intensity of achieved amplitude A = 4 µm can be increased up to 80 µm depending upon usage of further resonators.

3. MODIFICATIONS OF ULTRASONIC GRINDING

In consequence of different correlative location of the tool and the workpiece and of different directions of ultrasonic energy (vibrations) effect – axial, radial considering the axis of grinding tool; we can differentiate kinematics modifications of ultrasonic grinding: face ultrasonic grinding (drilling), cross outer ultrasonic grinding (knurl), plane ultrasonic grinding with radial workpiece vibration or with the axial workpiece vibration.

On fig. 1 are shown the schemes of face and cross grinding by tool vibration.

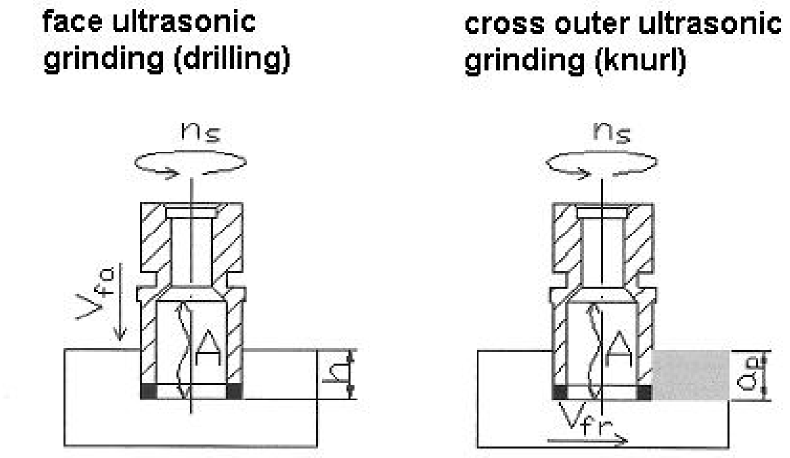

FIGURE 1 Ultrasonic grinding by the tool vibration

On fig. 2 are shown the schemes of ultrasonic grinding by the workpiece vibration.

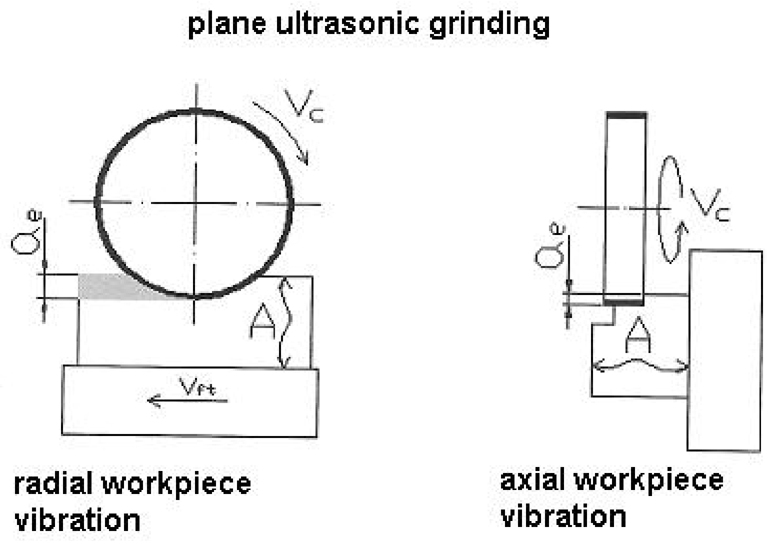

FIGURE 2 Ultrasonic grinding by the workpiece vibration

Kinematics of ultrasonic grinding significantly differs to conventional grinding methods. Every grinding grain of the tool follows the spiral curve on the workpiece face in the shape of sinusoid. Spiral consists of gradual segments sloping in certain angle. By movement of the grinding grain following the sinusoid trajectory the cutting edges of the grinding tool are used in different directions of the cutting.

At conventional grinding method of technical ceramics in the grinding process itself the cutting forces are being expressively increased (normal and tangential element), which cohere with increasing material removal. By increasing the volume of removed material the wear of grinding grains is being significantly expressed (diamond tools are being used to grind the ceramics) as a result of increased friction. At the same time, the forces, which affects to the grain are increasing to the critical level, which ends up with fission or cracking of the grains. Permanent contact of the workpiece and the tool at conventional grinding is a root cause of fast wear out of the grinding tool grains, which leads to decreasing cutting ability and increasing axial force (especially at constant feed). Out of this reason conventional method of ceramics grinding is not efficient.

Ultrasonic grinding is characterized by process stability no matter how much material was removed (process firm at high cutting depth as well). Shown contradiction is clear mainly in normal direction, i.e. in direction to the longitudinal workpiece vibrations. At the same time the work of ultrasonic system significantly decreases wearing of grinding grain as well as number of split of cracked grains.

Removing volume of the material and depth of cut at same technological conditions by ultrasonic face grinding depends on type of machined material and can be considered as relatively big.

By comparing of conventional and ultrasonic grinding method can be stated that at ultrasonic grinding process lower heat is being generated, which results into higher quality of machined surface (number of micro-cracks drops down), higher shape accuracy of the machined part and both cooling process and chips off-take are not so demanding for type of used fluid (water).

5. CONCLUSION

In respect of aforesaid can be stated that power ultrasonic grinding can be potential solution for efficient finishing machining of ceramic part. By trials and verifications of ultrasonic grinding support of the hard-to-machine materials at using innovated machine technique were proved that by applying the ultrasound are fulfilled requested demands on machining abovementioned materials.

Acknowledgements
This paper was created thanks to the national grants: VEGA 1/009/08 - ***Optimalized systems and processes of performance ultrasound***

REFERENCES
[1] ŠVEHLA, Š., ABRAMOV, O., CHORBENKO, I.: *Využitie ultrazvuku v strojárstve.* Alfa Bratislava, 1986, 314s.
[2] ŠVEHLA, Š., ŠVEHLA, B.: *Ultrazvukové metódy a technológie. Strojárstvo 4.* 2000, s. 30 – 31
[3] BELANČÍK, F.: *Ultrazvukové technológie. Technológie zajtrajška a dnes ...!, Strojárstvo.* 2002, s.50
[4] VOGT, B.: *Ultrasonic – Technologie revolutioniert die Bearbeitung hardsproder Werkstoffe.* Verfahren 36, 2002, s. 6 – 10

[5] TOLNAY, M., GREGUŠ - KOLLÁR, J., MIHALČÁK, P.: *Konštrukcia nástrojov pre ultrazvukové obrábanie.* Zb. Náradie 2005, SOPK Trenčín, pp. 185 - 188
[6] UHLMANN, E.; DAUS, N.A.: *Ultrasonic Assisted Face Grinding and Cross-Peripheral Grinding of Ceramics.* Proceedings of the 7th Int. Symposium Ceramic Materials and Components for Engines, June 19 – 21, 2000, Goslar, Germany
[7] SPUR G., UHLMANN E., HOLL S.-E.: *Ultrasonic Assisted Grinding of Ceramics.* Proceedings of the 9th CIMTEC World Ceramic Congress, Florenz, Italien, 14. - 19.06.1998
[8] ISHIKAVA, K.; SUWABE, H.; NISHIDE, T.; UNEDA, M.: *A Study on Combined Vibration Drilling by Ultrasonics and Low-Frequency Vibrations for Hard and Brittle Materials.* Precision Engineering 22: 1998. pp. 198 - 205
[9] SUZUKI, K.; MAKIZAKI, T.; UEMATSU, T.: *Ultrasonic Grinding Utilizing Traveling Wave Vibration.* EUSPEN Conference Proceedings, Bremen, 31.5.- 4.6.1999, pp. 286 - 289