Ultrasonic application in turning process of different types of metals

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Abstract

Metal cutting by using ultrasonic frequencies vibrations is more rational in comparison with traditional cutting method. Research was applied in turning process. For this purpose the special cutting knife with ultrasonic vibration actuator of piezoceramics was created. The results proved theoretical investigation, which says that by using ultrasonic frequencies the surface of machined detail is improved. Also by turning various types of metal efficiency of applying vibrations in a cutting process was visible.

Keywords: vibrocutting, ultrasonic frequency, acoustic emission.

1. Introduction

Vibrocutting is realised by applying ultrasonic frequencies vibrations to the edge of cutting tool. This idea is mentioned in book "Vibrocutting" by J. Kumabe [1].

The average cutting force is 3-10 times smaller during vibrocutting period, comparing it with the force during traditional cutting. The cutting temperature is decreased by decreasing the cutting force; it becomes similar to room temperature. Also the chip has no white spots, which are appearing in a traditional cutting. The temperature formed during vibrocutting period does not influence accuracy of cutting process.

The monitoring of mechanical processes is not only important in production, but also in measurement fields too [2, 3]. Researchers seek to develop technologies for getting higher productivity processes, because there is need in industry for shorter production times and better surface quality of products. The biggest influence to these factors has temperature, tool wear and cutting forces. These parameters during machining period can be estimated from acoustic emission (AE) signals, which are generated in cutting zone.

2. Experimental setup

The investigation of the ultrasonic frequency influence in turning process was performed. Experiments were carried out with the CNC turning machine EO4621; the cutting materials were aluminium, brass and steel blanks and turning performed by only changing speed of cutting. For that purpose a special cutting knife with a piezoactuator was developed and it consists of two piezorings. The purpose of the piezoactuator is to get ultrasonic vibration on the edge of the cutting tool [4, 5]. For that purpose the high voltage generator is connected to the piezoactuator. The sensor, which is fixed near the insert, sends data to a computer through a data converter (Fig.1).

The turning process is observed in the form of acoustic emission (AE) signals in a computer. The task of this investigation is to find the regularity of AE signals and their response to changes in a machining process, for example, as a tool wear.

The second task is to describe difference of workpiece surface structure after turning with and without vibrations.

The third task will be to compare the wear of cutting inserts. Accordingly to theoretical data the cutting tool wears less, because of smaller cutting forces and temperature during vibrocutting.

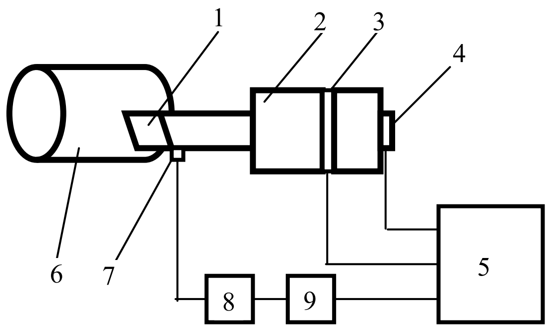

Fig. 1. **Scheme of control system: 1 – cutting tool, 2 – concentrator, 3 – piezorings, 4 – sensor of vibrations, 5 – control block, 6 – workpiece, 7 – sensor of acoustic emission, 8 – amplifier, 9 – frequencies' filter.**

3. Experiments

The first part of experiments was carried out to find out the frequency range, where AE signal level describes in the best way the nature of a dry friction in turning process.

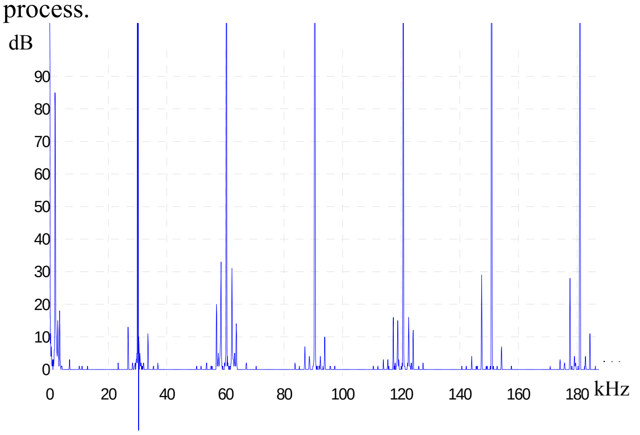

Fig. 2. **AE signals, generated by ultrasonic vibration generator, obtained at non-turning process**

Spindle rotation was set at 1900 rot/min; feed 0.05 m/min; cutting depth 0.25 mm. The frequency for getting ultrasonic vibrations at the cutting edge was set about 30.15 kHz. AE signals, shown in Fig. 2, are received at the time of non-turning process. Material of blank is aluminium.

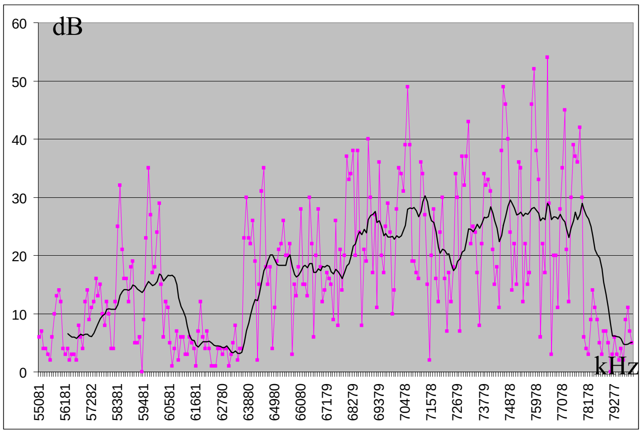

Fig. 3. **AE signals received during turning process, then ultrasonic vibration generator is not working (aluminium blank)**

AE signals in the frequency range can be distinguished from spindle rotation frequency and other noises during turning without ultrasonic frequency.

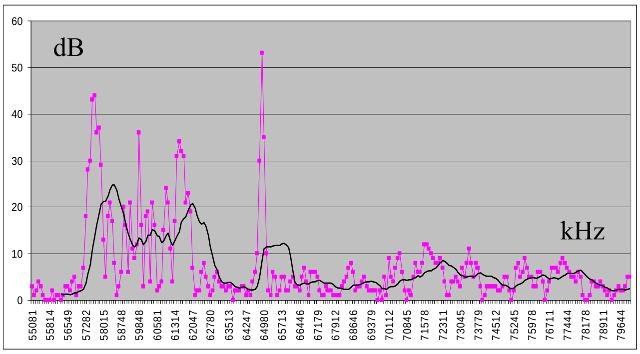

Fig. 4. **AE signals received at turning process, then ultrasonic vibration generator is working (aluminium blank)**

The intensive AE signals, which do not coincide with the ultrasonic vibration, are excited in the frequency range of 60-80 kHz. These signals were identified as dry frictions signals.

AE signals, received during turning when ultrasonic frequency vibration generator is turned on, are shown in Fig. 4. The level of AE signals decreased by 6-7 dB after applying vibrations in the frequency range of 60-80 kHz for aluminium. For brass and steel AE signals decreased by 10-15 dB.

The second part of experiments was carried out to find the tool's durability and the better surface roughness of the workpiece by applying vibrocutting. Two turning processes with and without vibrations were performed under the same conditions as: feed – 0.1 m/min and spindle rotation speed – 1800 rot/min; in the same time was carried 12 pass at the length - ≈ 15 mm. Turning process was monitored by using acoustic emission method.

4. Results

Surfaces of the workpiece after turning were analyzed by using atom force microscope (ATM) and results are shown in Fig. 5 and 6. The surface by using vibrations in cutting process is smoother comparing with non-vibration cutting, and also it is without micro cracks.

Roughness of the surface was measured and found to be: a) aluminium blank – without vibrations – Ra = 2.17 μm, and with vibration – 2.11 μm, b) brass blank – without vibrations – Ra = 4.57 μm, and with vibration – 3.86 μm,c) steel blank – without vibrations – Ra = 3.51 μm, and with vibration – 2.92 μm,.

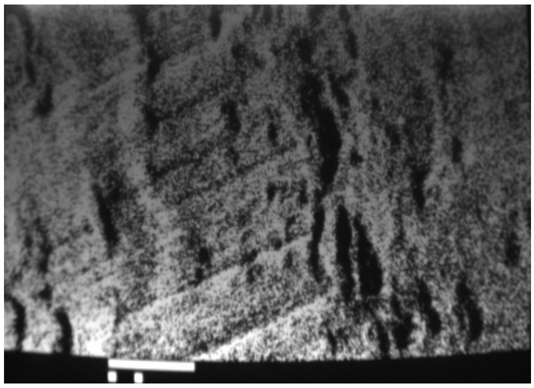

Fig. 5. **Workpiece of aluminium after non-vibrocutting (multiplied by x2000 times and the length of the band is 10 μm)**

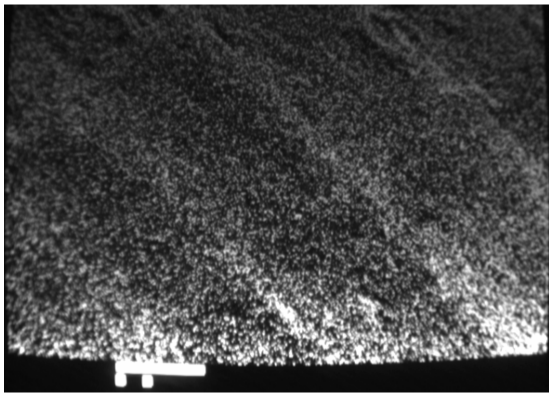

Fig. 6. **Workpiece of aluminium after vibrocutting (multiplied by x2000 times and the length of the band is 10 μm)**

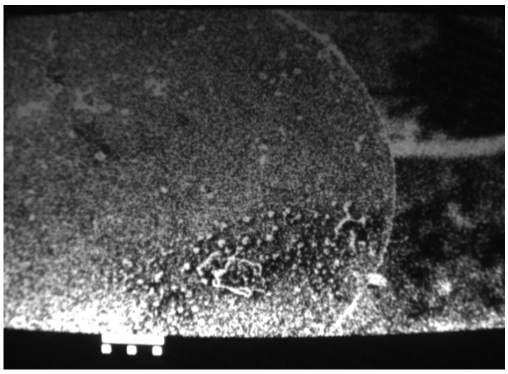

Fig. 7. **Cutting edge of new insert (multiplied by x100 times and the length of a band is 100 μm)**

The roughness measurement of surfaces proves that vibrocutting is better in comparison with a traditional cutting from the point of a wiev of surfaces quality [6].

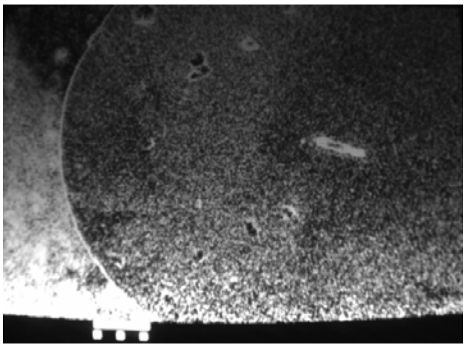

Fig. 8. **Cutting edge of the insert after applying vibrations to turning process**

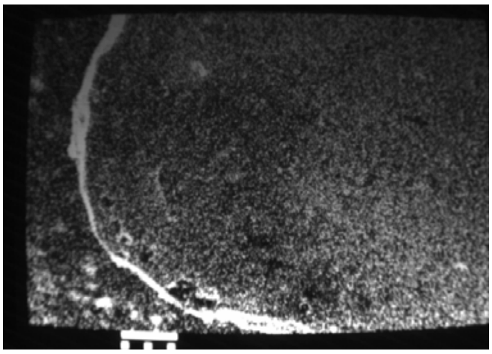

Fig. 9. **Cutting edge of the insert after traditional turning process**

Analysis was made not only of the workpiece surface, but also of the tool's insert by using ATM. New insert is shown in Fig. 8, and as you can see the cutting edge is not deformed and is without damages. After making the second part of experiments with vibrocutting, the insert is not differing very much from a new one and it almost without damage (Fig. 8). When insert used in a traditional turning process under the same conditions as vibrocutting process, it is damaged on the cutting edge and its shape is deformed (Fig. 9).

5. Conclusions

The results show that by using vibrations in a turning process, the surface roughness of a workpiece is better comparing with a traditional turning, while the same cutting conditions as cutting speed and feed are kept. The surface obtained after vibrocutting is smoother and without micro cracks.

The second important fact is that the insert wears less in vibrocutting process then traditional.

AE signals during application of ultrasonic frequencies vibrations are more stable and smaller by 6-7 dB then without vibrations.

Future steps in ultrasonic applications have to be done to direction to analyze tools wear during longer time of work using both ways of cutting - conventional and vibrational.

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Ultragarsinio tekinimo naudojimas įvairioms medžiagoms apdirbti

Reziumė

Aprašyta, kaip ultragarsinio dažnio virpesiai gali būti naudojami tekinimo procese. Ruošinio, tekinamo naudojant ultragarsą, paviršius gaunamas glotnesnis nei ruošinio, tekinamo be vibracijų. Eksperimentiškai nustatyta, kad tekinimo su vibracijomis metu įrankis dyla mažiau nei be vibracijų.

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