11th International Research/Expert Conference
”Trends in Development of Machinery and Associated technology”
TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.

APPLICATION OF ACOUSTIC EMISSION TO INVESTIGATING POSITIONAL ACCURACY OF DRILLED APERTURES

Mr Vukasin Zogovic, Prof. dr Milan Vukcevic, Prof. dr Zdravko Krivokapic
University of Montenegro
Faculty of Mechanical Engineering
Cetinjski put bb, 81 000 Podgorica
Montenegro

ABSTRACT
Drilled aperture position accuracy depends on a great number of parameters that may be classified into four groups. Those are the parameters that are characteristic for: engine operation, working-piece condition, tool and cutting regime elements. The results of the current investigations of the influences of parameters characterizing the state of a working piece on positional accuracy of drilled apertures by applying acoustic emission have been presented in this paper. To use acoustic emission at quality control within real period of time, it is necessary to investigate all the relevant parameters within limits of real working conditions. Aiming at this, the Faculty of Mechanical Engineering in Podgorica has been developing a measurement system based on AE-sensor supported by LabVIEW software.
Keywords: Acoustic Emission, Drilling, Positional Accuracy

1. INTRODUCTION
Out of all machining procedures, drilling represents one of the most frequently used ones. This process, as it is known, occurs in very complex and difficult conditions accompanied by specific demands for a treatment quality. Having in mind the fact that more than 50% of drilling operations are final ones, there is a need for building an intelligent system for monitoring the drilling treatment process by means of acoustic emission [1]. Majority of the authors consider the problem of appliance of acoustics emissions from theoretical points of view. That is a general and non adequate approach [3], [5], [6] and [8]. In order to use acoustics emission in real-time control it is necessary to investigate all relevant parameters in real work conditions at that from experimental point of view. Such experimental approach is a topic of this paper.
As it is known the machining process causes elastic deformations transmitted to a machine structure. This produces waves called acoustic emission and they are generated by different sources. Main sources, in machining process, of acoustic emission are: friction, plastic deformation in the cutting zone, creation and ship fracture, etc.
Aiming at comprehensive researches of the hole treatment processes with twist drills, the Faculty of Mechanical Engineering in Podgorica has been developing an intelligent system whose base is made up of AE-sensor supported by software Lab VIEW.

2. ACOUSTIC EMISSION
In many manufacturing processes machining forces in tools and materials generate high-frequency acoustic emission (AE). The use of acoustic emission techniques for process monitoring has the potential of ensuring high product quality while minimizing the total cost of a product. Processes such as cutting, grinding, forming and joining all generate acoustic emission for reasons unique to each process. In many cases, the emission can be monitored to characterize the process, to detect defects or process abnormalities in situ, and to detect finishing quality.

Recent attempts have concentrated on the development of the methods which monitor the cutting processes indirectly. Among these indirect methods, AE is one of the most effective.
"Acoustic emission (AE) is the class of phenomena whereby transient elastic waves are generated by the rapid release of energy from a localized source or sources within a material, or the transient elastic wave(s) so generated" (ANSI/ASTM E 610-77). Clearly, an AE is a sound wave or, more properly, a stress wave that travels through a material as the result of some sudden release of strain energy. In recent years, AE instruments and systems have been developed for the monitoring and nondestructive testing of the structural integrity and general quality of a variety of materials, manufacturing processes, and some important devices.

2.1. Acoustic Emission Signal

Based on the analysis of AE signal sources, AE derived from metal turning consists of continuous and transient signals, which have distinctly different characteristics. Continuous signals are associated with shearing in the primary zone and wear on the tool face and flank, while brust or transient signals result from either tool fracture or chip breakage.

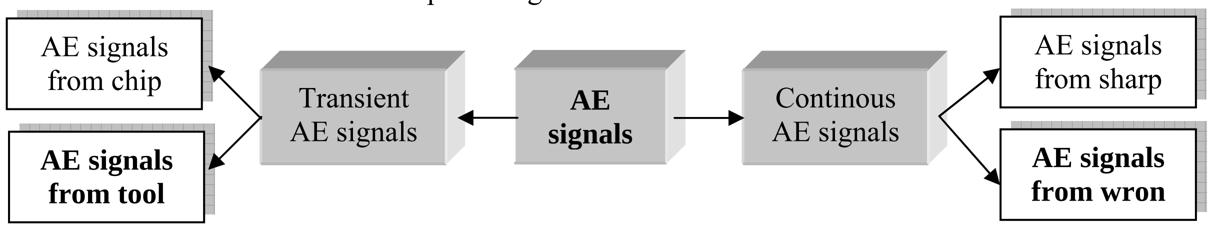

Figure 1. AE signal type in cutting process

2.2. Position accuracy of drilled holes

Taking into account the desired hole parameters such as diameter, diameter tolerance, positioning tolerance, hole surface roughness, available tools and machines, it is possible to determine an optimal sequence of operations. Although the hole parameters influence the selection of machining operations for a sequence, the required hole positioning accuracy influences, above all, selection of the first drilling operation.
The positional accuracy of holes when drilling in solid material depends on the following parameters:

- Machine: Stability, positioning accuracy, repeatability, play and others.
- Work piece: Stability, roughness, perpendicularity between the tool and the drilled surface, machinability of the material and others.
- Tool: Length, diameter, stability, tool point geometry and others.
- Cutting data: Cutting speed, feed rate.

3. EXPERIMENTAL RESEARCHES

Experimental researches were carried out in the laboratory of the Faculty of Mechanical Engineering in Podgorica in accordance with the established experiment plan. Experiments were done on the universal milling machine, with a basic aim to determine the effect of parameters characterizing the state of a working piece on positional accuracy of drill apertures by applying acoustic emission. Conically sharpened spiral drills with a cylindrical handle of 12 [mm] in diameter are used. Cutting regime: revolution number 355; 500; 710 [rpm]; step 53.33; 74.67 and 105 [mm/min]; drilling depth 1 = 15 [mm].
The acquisition of AE signals has been performed by using a virtual instrument especially developed for these purposes. The instrument is based on LabVIEW 8 software. The all signals are recorded simultaneously. The obtained results are stored in adequate databases and lately processed and analyzed by appropriate software.

3.1. Measurement Equipment

The position accuracy of drilled holes has been measured by specially designed transducers, which have simple construction high senility, high speed response as well as linear transfer function with average error of 0.5%.

Acoustic emission measurement has been done with AE-sensor of 8152B2 type, made by KISTLER, with the measurement range in the interval from 100 to 900 KHz, which, as recommended in the paper [3], meets the needs of conditions of the researches. Application examples are monitoring of processes, tools and machines in metal cutting as well as forming operations. Thanks to its rugged construction and the tightly welded housing this sensor can operate under severe environmental conditions in industry, too.

3.2. Hardware and Software

PC Pentium 4 is used for experimental researches and data processing. Positional accuracy is followed by the system for data acquisition: AD/DA convertor of DT 2801-A type and software for data processing – GLOBAL-LAB.
Acoustic emission followed by Multifunction Data Acquisition (DAQ) Device M Series NI PCI-6251 (16-Bit, 1MS/s (Multichannel), 1.25 MS/s (1-Channel), 16 Analog Inputs, 24 Digital I/O, 2 Analog Output and Professional Accessory Set. LabVIEW 8 is a graphical development environment for signal acquisition, measurement analysis, and data presentation. It gives the flexibility of a programming language without the complexity of traditional development tools. All LabView programs, or virtual instruments (VIs), have a front panel and a block diagram.

3.3. Work piece

Testing samples of dimensions ∅30x40[mm] made from Č.1530 (steel 1530), of hardness 210HV10 and thermally worked Č.1530 at 350÷400HV10. Two different kinds of work piece surfaces were used: milled (rough surface, Rz=15) and ground (fine surface, Rz=6). The work pieces were mounted on base plates with three different slopes: 0°, 2.5° and 5°.

4. RESULT ANALYSIS

Due to large amount of researches, this paper only shows some results of research. On Fig. 2 are shown experimental results of position accuracy of drilled holes for the case of working piece slope of 5°, rough surface Rz=15 and hardness of 400HV10. On Fig. 4 are shown experimental results of AE and RMS AE signal intensity for the same case. On Fig. 3 are shown experimental results of position accuracy of drilled holes for the case of working piece slope of 0°, fine surface Rz=6 and hardness 210HV10 and on Fig. 5 are shown experimental results of intensity of AE and RMS AE signals.
These two extreme cases from experiment plan clearly show influences of parameters characterizing the state of a working piece on positional accuracy of drilled apertures and intensity of AE an RMS AE signal.

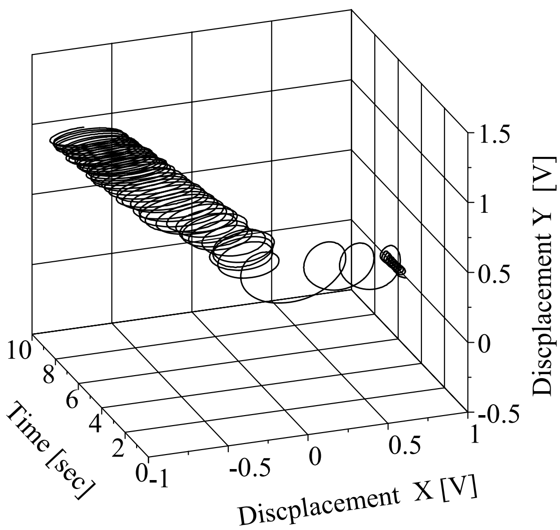

Figure 2. Radial displacement of signals of the drill's head for case of 5° working piece slope, rough surface Rz=15 and material hardness of 400HV10.

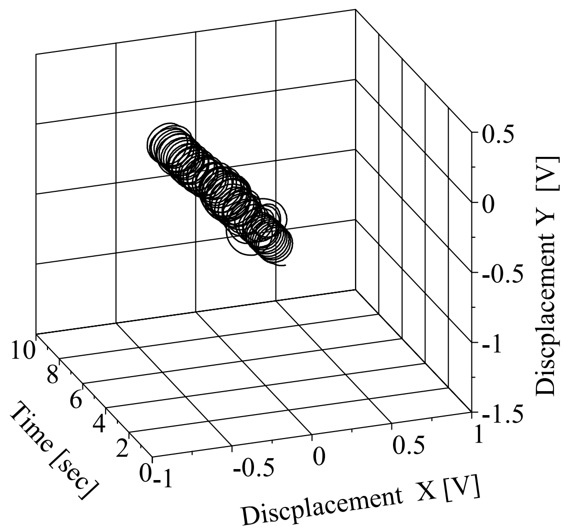

Figure 3. Radial displacement of signals of the drill's head for case of 0° working piece slope, fine surface Rz=6 and material hardness of 210HV10.

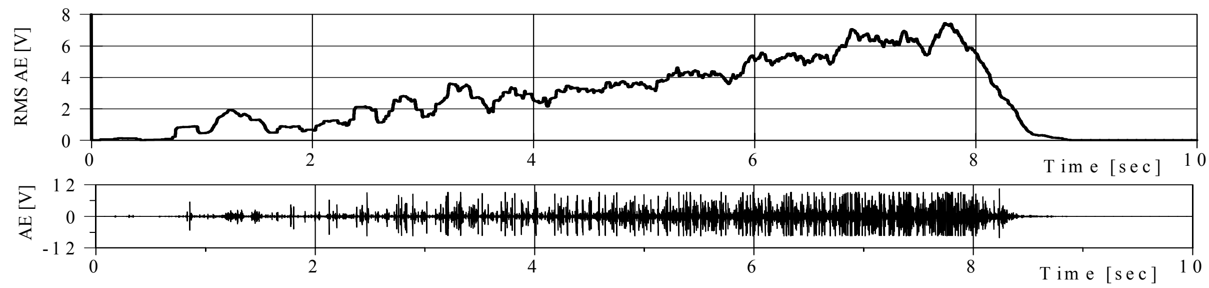

Figure 4. AE and RMS AE signals for the case of 5° working piece slope, rough surface Rz=15 and material hardness of 400HV10.

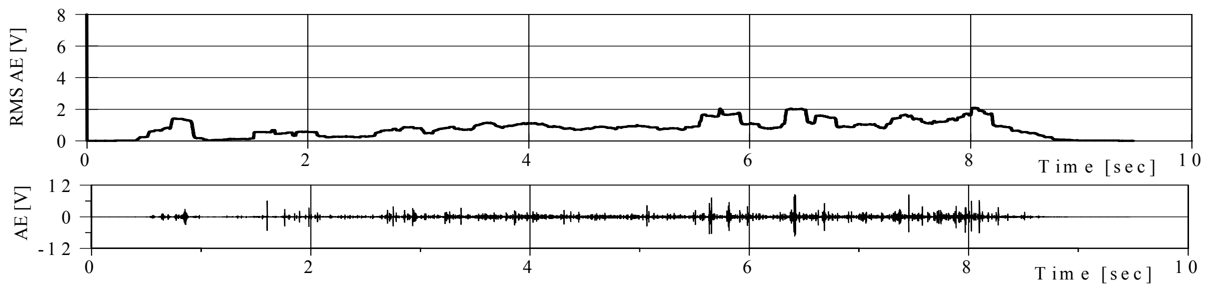

Figure 5. AE and RMS AE signals for the case of 0° working piece slope, fine surface Rz=6 and material hardness of 210HV10.

5. CONCLUSION

Based on the results obtained, it may be concluded that there is dependence between the parameter characterizing the state of a working piece, positional accuracy and AE and RMS AE signal intensity.

Analyzing experimental results shown in Figures 2, 3, 4 and 5, we have come to a conclusion that positional accuracy error values, AE and RMS AE signal intensity are considerably higher for the case of working piece slope of 5°, rough surface Rz=15 and hardness of 400HV10.

From the diagrams shown, it may be noted that a higher value of AE and RMS AE signals corresponds to a higher positional accuracy error values.

To accept such results safely and establish a mathematical dependence between the parameters observed, more complex experimental researches are needed.

6. REFERENCES

[1] Byrne, G., ..., Tool condition monitoring - The status of research and industrial application, Annals of CIRP, Vol.44/2, 1995, pp. 541-576

[2] Zogovic, V., Vukasojevic, R.,: Influence of cutting data an the positioning accuracy of drilling, 26TH International Conference of Production Engineering, Podgorica-Budva 17-20. September 1996.

[3] Moriwaki, T., ...,A new approach to automatic detection of life of coated tool based on acoustic emission measurment, Transactions of the ASME, Vol.112 Aug. 1990, pp. 212-218

[4] Krivokapic, Z., Zogovic, V.: An acoustic emission using in following state of the tool, 25. JUPITER Conference with foreign participants, Beograd, 1999.

[5] Chen X Q, Zeng H., Dietmar W.: In-Process Tool Monitoring trough Acoustic Emission Sensing, AT/01/014/AMP, 2001.

[6] Armarego, E.J.A., Smith, A.J.R., Gong, Z.J.: Four Plane Facet Point Drills - Basic Design and Cutting Model Predictions, Annals of CIRP, Vol.39/1, 1990.

[7] Zogovic, V., Vukasojevic, R.,: Influence of cutting data an the positioning accuracy of drilling, 26TH International Conference of Production Engineering, Podgorica-Budva 17-20. September 1996.

[8] Xiaoli Li, : A brief review: acoustic emission method for tool wear monitoring during turning, International Journal of Machine & Manufacture 42 (2002) 157-165

[9] Kaminski, J., Crafoord, R.,: Position Accuracy of Drilled Holes, Annals of the CIRP, Vol.40/1/1991.