12th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

MONITORING TWIST DRILL WEAR BY AN ACOUSTIC EMISSION APPLICATION

Mr Vukasin Zogovic
University of Montenegro
Faculty of Mechanical Engineering
Cetinjski put bb, 81 000 Podgorica
Montenegro

ABSTRACT
Tool wear is one the highly negative phenomena in treatment process. The influence of tool wear process on state characteristics and output effects of treatment process is high and very bad. The wear of cutting tool wedge of working elements occurs continually, in all moments of the process, as well as in all technological conditions and treatment regimes. The complexity of the drill's geometrical shape, specific processes and conditions at which drilling is carried out, make twist drill wear process much more complex if compared to other tools. There are two methods of process monitoring of tool state (wear, fracture): direct and indirect methods. The research results of twist drill wear by an acoustic emission application are given in the paper.
Keywords: Tool Wear, Acoustic Emission, Drill

1. INTRODUCTION

Cutting process tribology, along with mechanics and thermodynamics, represents the third, both in theoretical and practical sense, important area of productive machinery treatment technology. One of the basic contents of cutting tribology are integral analyses of the tool element mechanism process (cutting edges and surfaces) of the cutting tool wedge and the study of regularities that connect tool wear process with other phenomena and output techno-economic effects of treatment process.

Tool wear is one of the extremely negative phenomenon in treatment process. Relatively high pressures, high temperatures as well as high relative speeds of harnessed pairs, within the cutting zone, are considered to represent basic conditions for tool wear process initiation and its intensive development. Cutting tool wedge working elements wear goes on continually and is present all the time during the process, also at all technological conditions and treatment regimes [3]. The complexity of geometrically shaped drill, specific features of the process and conditions at which drilling is performed make the process of spiral drill wear more complex if compared to other tools.

Researches done on of geometrical shape changes of winding drills cutting elements in the cutting process represent one of the most significant segment of integrated researches on treatment process of spiral drill aperture. Aiming at this, the Faculty of Mechanical Engineering in Podgorica has developed an intelligent system based on AE-sensor supported by Lab VIEW software. Experimental researches presented in this paper include tool wear process following by applying acoustic emission.

Acoustic Emission (AE) is the class of phenomena whereby transient elastic waves, in the range of ultrasound usually between 20 KHz and 1 MHz, are generated by the rapid release of energy from localized sources within a material, or the transient waves generated in this way. All materials produce AE during both the generation and propagation of cracks and during deformation. The elastic waves move through the solid to the surface, where they are detected by sensors. These sensors are transducers that convert the mechanical waves into electrical ones. In this way information about the existence and location of possible sources is obtained. This is similar to seismicity, where seismic waves reach the stations placed on the earth surface. After the signal processing, the location of the earthquake center is obtained.

2. TOOL WEAR

In the cutting process wear has its various forms, intensity and size per single cutting element. At initial cutting, tool blades are adjusted, i. e. micro-irregularities on cutting blades and treated objects collide, this leading to the fracture of the sawdust. Wear process continues along with the cutting process itself, thus spreading differently along tool contact surfaces depending on treatment conditions.

The influence of tool wear process on the state characteristics and output effects of treatment process is big and very bad. Many research have proved a very negative wear effect on: quality of surface treated, dimension accuracy and shape of the object treated, economy and productivity of treatment process, cutting forces (of resistance), dynamic stiffness of the treatment system, cutting temperature, tool geometry, wear stability and some other characteristics and effects of the treatment process.

Negative effects of tool wear process on single state characteristics and techno-economic process of the treatment are due to numerous groups of factors on the very process of tool wear. This group, primarily includes: types and characteristics of tool and working-piece material, cutting regime (cutting depth, speed, step), tool geometry, lubrication, and cooling means, cutting temperature, treatment system stiffness, and other treatment conditions.

This set of factors can influence on wear intensity of speed and character of a tool, thus on basic state features and key output techno-economic effects of the treatment process.

2.1. Tool wear parameter measuring methods

Some liquid wear state of a cutting tool is expressed (is quantified, and described) by either wear parameters or wear characteristics. Within the cutting tribology there are three wear parameters. They are: linear Bi wear parameters, volume Vi wear parameters, and mass Mi wear parameters. Nowadays, two measuring technique groups to measure tool wear parameters are used. One relates to out-of-process systems, the other to process measuring system.

The essence of out of process systems lies in the fact that they are used only after cutting process stoppage, i. e. to measure the volume of a given wear parameter in any treatment moment, it is necessary first to stop the cutting process, then measure the value of a given parameter.

In modern productive lines, such a tool wear measuring method has become a highly limiting factor. Thus the development of another group of measuring techniques, i. e. process measuring systems, primarily industrial process tool wear suppliers that generate signals on wear parameter values during the process, is of a great importance.

2.2. Division of Process Tool Wear Suppliers

There are several criteria for dividing sensor wear, namely more methods of tool wear measuring by process sensors. The most important ones are: direct and indirect, contact and non-contact, continual and periodical measuring methods. Different measuring principles are used: mechanical, optical, pneumatic, electrical, acoustic, radioactive, electronic, and similar.

The direct measuring method includes a direct measuring of wear parameters on the cutting tool wedge, during the very treatment process. In most cases, direct tool wear measurement, as it is known, is made difficult, thus wear sensors are relatively complex ones.

The indirect measurement method is used widely and progressively. They have been developed as an alternative to more complex direct methods, as the principles and measurement technique used in indirect methods are relatively more simple. They are also suitable for the wear process even in short intervals of existence as well as for registering sudden wear tool changes, for example - the moment of cutting blade destruction.

2.3. Suppliers for Indirect Tool Wear Measurement

The base for sensor technique development in indirect tool wear measurement methods is a set of those treatment process characteristics, namely a set of different signals originating from single unit of treatment systems (machine, tool, working-piece), these being functionally connected with the wear parameters determined by correlations. These characteristics of signals represent, as regard the existence of the correlations, bearers of information on the size and speed of the working elements of cutting tool wedge wear. Measuring single characteristics correlated with tool wear, that are relatively easily or more easily measured if compared to direct methods, wear parameter value are measured indirectly in this way.

The most frequently used bearers of information (signals) on tool wear during cutting process are the following: cutting forces (resistance, torques, cutting temperature, vibrations and noise (acoustic emission), cutting strength, quality characteristics, and others. These measurements, directed to tool wear as their final goal, determine the names of possible indirect methods of tool wear measurements at the same time.

3. EXPERIMENTAL RESEARCHES

An intelligent system based on AE-sensor aided by Lab VIEW software has been developed at the Faculty of Mechanical Engineering in Podgorica, aiming at integral researches of aperture (hole) treatment process by spiral drills. Experimental research works are carried out, according to a given experiment plan, on the universal milling machine, the main goal being to follow spiral drill wear process by applying acoustic emission.

Acoustic emission is accompanied by Multifunction Data Acquisition (DAQ) Device M Series NI PCI-6251 (16-Bit, 1MS/s (Multichannel), 1,25MS/s (1-Channel), 16 Analog Inputs, 24 Digital I/O, 2 Analog Output and Professional Accessory Set.

Acoustic emission measurement is performed by AE sensor, 8152 B2 type, made by KISTLER, within an interval range of 100 up to 900 KHz.

AE Signal acquisition is done by a virtual instrument specifically developed for this purpose, by using Lab VIEW software 8.5. The data are later processed by using proper softwares, and analysis of wear process is made (Fig. 1).

Conical and sharpened spiral drills with cylindrical hand of 12 [mm] in diameter are used in experimental researches. Samples are made from C. 1530, its hardness being 210HV10.

The measurement of relevant spiral drill wear parameters, in it all operating phases is carried out on the universal tool microscope, made by "Carl Zeiss".

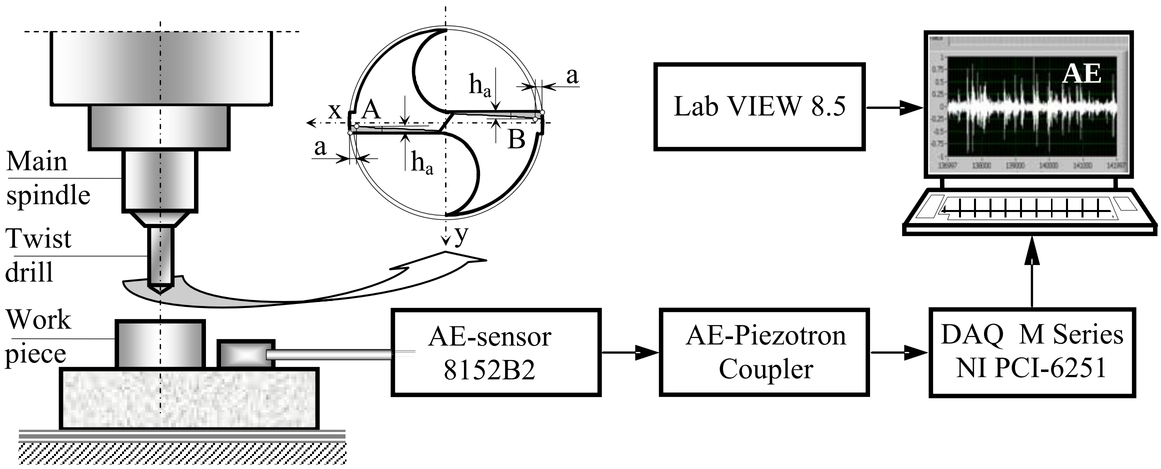

Figure 1. Scheme of carrying out experiments.

4. RESULT ANALYSIS

Only some research results are presented in this paper. Experimental results of AE signal intensity and RMS AE signal, for the case of sharp tool drilling are shown in Fig. 2, whereas experimental results of AE signal intensity and RMS AE signal, for the case of blunt tool drilling are shown in Fig. 3. These two extreme cases, from the experiment plan, clearly show the influence of tool wear degree on the intensity of AE and RMSAE signals. Experimental results of AE signal intensity and RMS AE signal for the case of sudden tool wear changes and the interval of cutting blade destruction are given in Fig. 4.

5. CONCLUSION

Based on the results presented, it may be concluded that there is a dependence between parameters characterizing the spiral drill wear and AE and RMS AE signals intensity. Analyzing the experimental results shown in Figures 2, 3, it may be concluded that AE signal and RMS AE signals intensity is considerably greater for the case of blunt tool if compared to sharp one. This means, the higher the wear parameter values, the higher AE and RMS AE signal values. Wear along the back spiral drill surface is taken as a bluntness criterium.

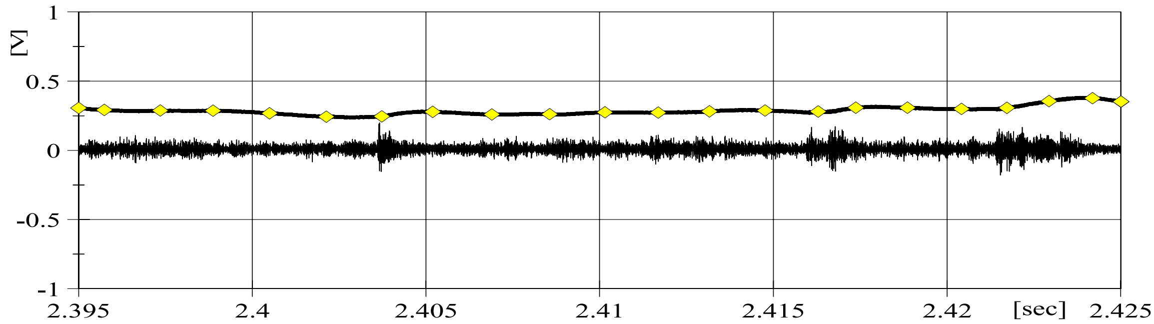

Figure 2. AE and RMS AE signals the case of sharp tool drilling.

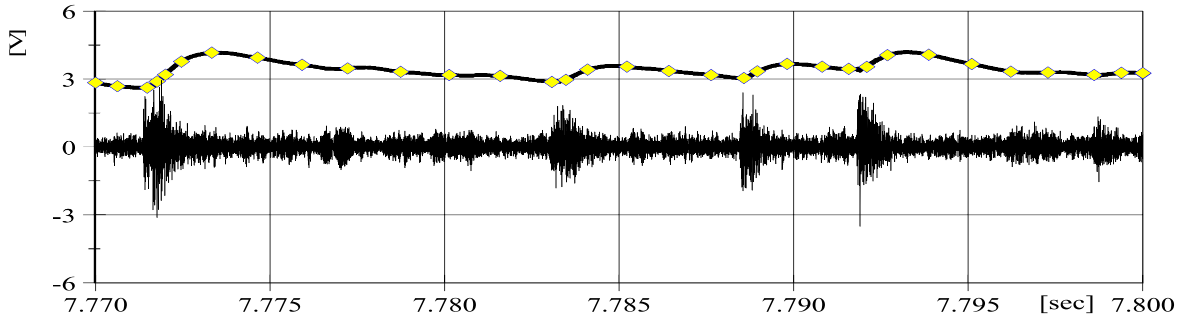

Figure 3. AE and RMS AE signals for the case of blunt tool drilling.

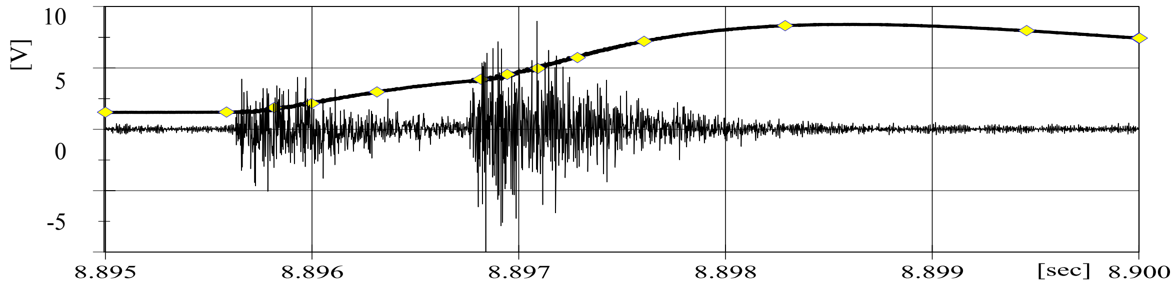

Figure 4. AE and RMS AE signals for the case of tool blade destruction.

Figure 4 illustrates the case when the tool is in progressive wear phase that is completed by a destruction of working elements of cutting tool wedge, and sometimes the very cutting blade is fractured. AE or RMS AE signals, along the time extended axis, point out the necessity of drilling process stoppage and a prompt tool replacement.

To use AE sensor successfully when spiral drill wear measurements are concerned, it is necessary to experimentally determine a sufficiently functional connection between a given characteristic of the treatment process (AE signal) and tool wear parameters to identify wear tool in the treatment process, by virtue of this dependence and proper process sensor.

More complex experiments are needed to make some mathematical dependence and define limit values of the observed parameters.

6. REFERENCES

[1] Chen X Q, Zeng H., Dietmar W.: In-Process Tool Monitoringtrough Acoustic Emision Sensing, AT/01/014/AMP, 2001.

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

[3] Stanić, J.:Teorija obrade metala I, Mašinski fakultet Beograd, 1986

[4] Zogović, V, Vukasojević R., Stojanović R.,: Preliminary Research of Drilled Holes Parameters by an Acoustic Emission Application, WSEAS Transactions on Information Science and Applications, Issue 9, Volume 2, September 2005, ISSN 1790-0832

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