ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1165388

THE POSSIBILITY OF APPLICATION ACOUSTIC EMISSION METHOD TO OPTIMIZE DETERMINATION OF FINISH LATHING PARAMETERS

Krzysztof Dudzik

Gdynia Maritime University, Faculty of Marine Engineering
Morska Street 81-87, 81-225 Gdynia, Poland
tel.:+48 58 690 15 49, fax: +4858 6901399
e-mail: kdudzik@am.gdynia.pl

Abstract

Nowadays acoustic emission (AE) method is used in many fields of science, including in the diagnosis of machining processes such as turning, grinding, milling, etc.

Determining of turning parameters has a great impact on the quality of the surface. This is especially important during finishing treatment. In the study of acoustic emission, method was used to optimize the cutting depth. Optimization was to determine the depth of cut, at which the vibration level exceeds the set level. The research was carried out on a universal CDS 6250 BX-1000 lathe centre using dynamometer DKM 2010 where assembled removable insert *CCMT 09 T304 PF. Lathing process was performed on the shaft of 40 mm in diameter made of S235JR steel.*

The research was carried out at constant cutting speed v = 145 m/min and at constant feed f = 0.114 mm/rev.

In the research was used a set of acoustic emission Vallen System. The kit includes: 4 channel signal recorder AMSY 6, two measurement modules ASIP-2/S, preamplifier with a frequency range 20 kHz – 1 MHz and the strengthening of 34 dB and AE signal measurement sensor type VS 150M, with a frequency range 100 – 450 kHz. During the study, the acoustic emission (AE) generated during the lathing process was recorded parameters: amplitude, number of events – hits, the effective value of the signal (RMS).

Analysis of the research results allowed to determine the maximum depth of cut, at which the vibration does not reach the set limit value.

The study can be the basis for the use of acoustic emission method to determine the parameters of the finishing lathing for obtaining a high quality surface.

Keywords: *Acoustic Emission (AE), diagnostic, finishing treatment, lathing, cutting parameters*

1. Introduction

The finishing treatments used for the formation of shape and surface of a workpiece are e.g.: turning, grinding, lapping, polishing, burnishing, etc. During finish treatment the final dimensions as well as functional properties are imparted to a given element by application of proper treatment type. Such an effect can be obtained elements of high accuracy (3-5 accuracy class) and low value of roughness parameter R_a (0.16-0.01 μm) [3].

The most common method of the surface layer forming is lathing. Conventional machining accuracy is usually considered as a function of the characteristics of all the components of machine tool, fixture, object, tool. There are: accuracy performance, and the accuracy of static and dynamic determining and cutting parameters, which are associated with strength, temperature and wear of the cutting edge [4].

To obtain a high surface quality should be optimized determination of cutting parameters. Manufacturers of tools give ranges of recommended parameters, but in order to achieve the best possible surface area is necessary to define the exact parameters. One of the criteria for the selection of turning performance is to reduce the tool vibration which results in surface quality. This is particularly important for finishing treatment. On the other hand, there is requirement of high machining efficiency as possible in order to reduce production costs.

One of the methods for monitoring and optimization of the machining process for selection of cutting parameters is the acoustic emission (AE) method. Acoustic emission is considered as a non-destructive methods included in Standard PN-EN 473: 2008, described and defined in PN-EN 1330-9: 2009 and PN-EN 13554: 2011. According to the definition acoustic emission (AE) is an evanescent elastic wave, which is the result of rapid release of the energy stored in the material by propagating a micro-damage (increase in micro-cracks, the movement of groups of dislocations) in the material or by a process (friction, leakage, etc.) [5, 8]. The typical frequency range of the acoustic emission is normally determined in 20 kHz – 2 MHz [9].

Acoustic Emission (AE) is a passive non-destructive method. Its main advantages are:

- high sensitivity of AE,
- the possibility of conducting continuous research,
- the possibility to locate the source of the AE signals generated by the damage, leaks, etc.
- the possibility of carrying out research without having to shut down equipment out of service [2].

The stimulus causing the release of energy and the formation of elastic waves can be: load operation, environment, temperature change, and the processes which are accompanied by acoustic emission changes both at the micro and the macro scale, such as: cracks, friction, plastic deformation, corrosion, leaks, structural and phase changes, chemical reactions, delamination, cracking of the fibres and matrix in composites, etc. [1, 6].

The acoustic waves propagate in all directions from the source, can thus be recorded by one or more sensors mounted on an object or component. During the propagation waves are suppressing the AE, which limits the distance over which they may be detectable. This distance is dependent on many factors, including mainly on properties of the material, the geometry of the object and the level of interference from background noise [7]. An example of AE signal is shown in Fig. 1.

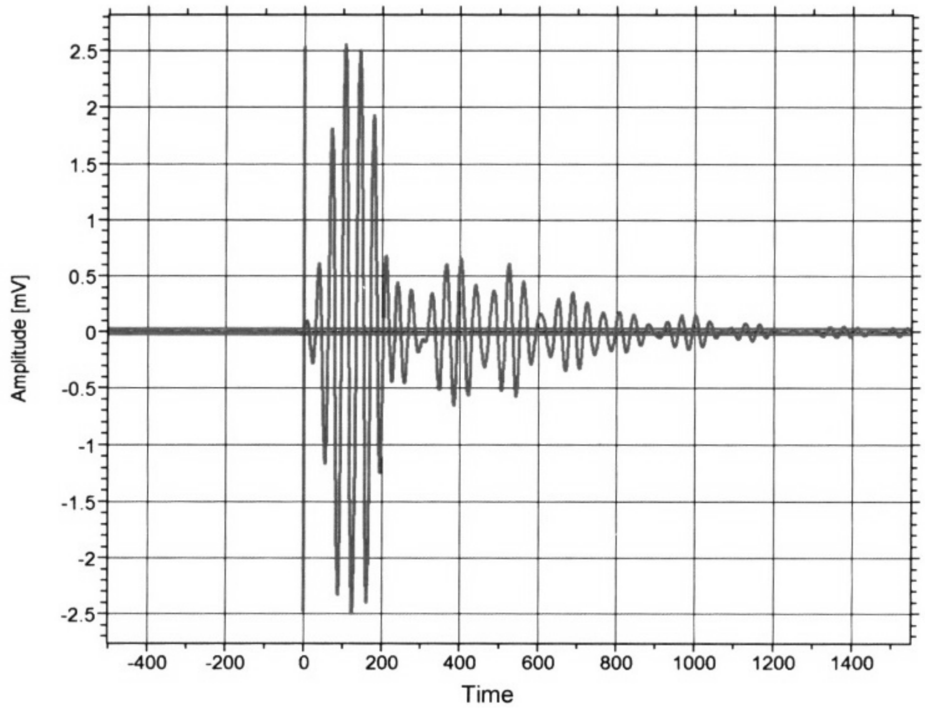

Fig. 1. An example of typical Acoustic Emission burst signal [7]

According to PN-EN 1330-9: 2009, AE signal can be characterized by parameters such as: amplitude, energy, rise time, duration, number of exceedances of the threshold of discrimination – hits, RMS of the signal, etc.

The article presents the possibility of using acoustic emission method for optimizing the selection of cutting parameters.

2. Research methodology

The process of turning of shaft ϕ 40 mm in diameter, made of S235JR steel was carried out on a universal CDS 6250 BX-1000 lathe centre. The lathing process was conducted by a cutting tool with CCMT 09T304 – PF removable insert. As a tool was used DKM 2010 Dynamometer. There was possibility of controlling lathing process by that dynamometer but in the research it was used only as a grip for removal insert. The view of equipment used in research is presented in Fig. 2.

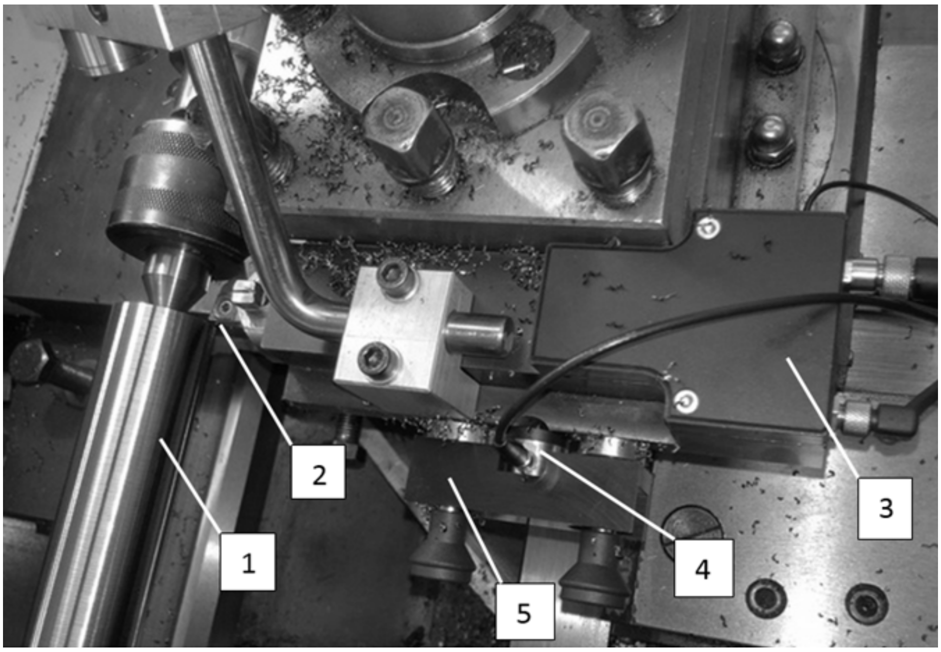

Fig. 2. The view of equipment used in research: 1 – shaft, 2 – removable insert, 3 – grip for insert (dynamometer), 4 – acoustic emission sensor, 5 – magnetic holder for sensor

Cutting parameters were selected on the basis on the data of cutting tool manufacturers. The research was carried out at constant cutting speed Vc = 145 m/min and at constant feed f = 0.114 mm/rev. Depth of cut was reduced by 0.3 mm starting at a_p = 1.5 mm until reduction of the vibration levels below the required level. For monitoring this process acoustic emission method was used.

Research of acoustic emission (AE) accompanying the lathing process was performed using a kit consisting of 4-channel signal recorder type AMSY 6 and two measuring modules ASIP-2/S from Vallen System. The kit includes pre-amplifier with a frequency range of 20 kHz – 1 MHz and the strengthening of 34 dB and a sensor signal measurement AE, VS 150M, with a frequency range of 100 – 450 kHz. The system includes a data recording module – 8MB per channel and software for recording and analyzing AE data. The sensor is mounted on the surface of the tool (dynamometer) by means of a magnetic holder MAG4M – dedicated to the sensor used. Between the sensor and the surface the coupling fluid was used. View of the laboratory stand is shown in Fig. 3.

3. Research results

During the study, the acoustic emission (AE) generated in the lathing process carried out on a test, recorded a number of parameters which were analysed. These parameters were e.g.: amplitude, number of events – hits, energy, RMS of the signal. The analysis of that parameters was made using Visual Vallen AE software. The test was repeated three times for each value of parameter a_p.

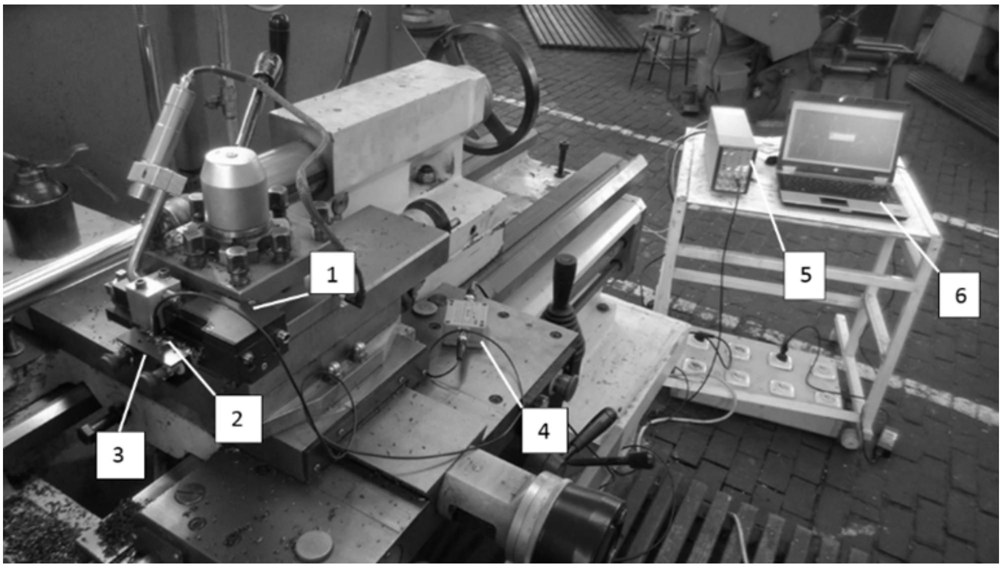

Fig. 3. General view of laboratory stand: 1 – tool (DKM 2010 dynamometer with removable inserts), 2 – AE sensor 3 – holder of AE sensor, 4 – preamplifier, 5 – AE recorder, 6 – computer

Examples of graphs recorded in the tests for each of the cutting depth a_p are shown in Fig. 4-8. Fig. 9 shows the number of events (hits) and the amplitude of the signal generated by the system while there was no contact of the tool with the workpiece.

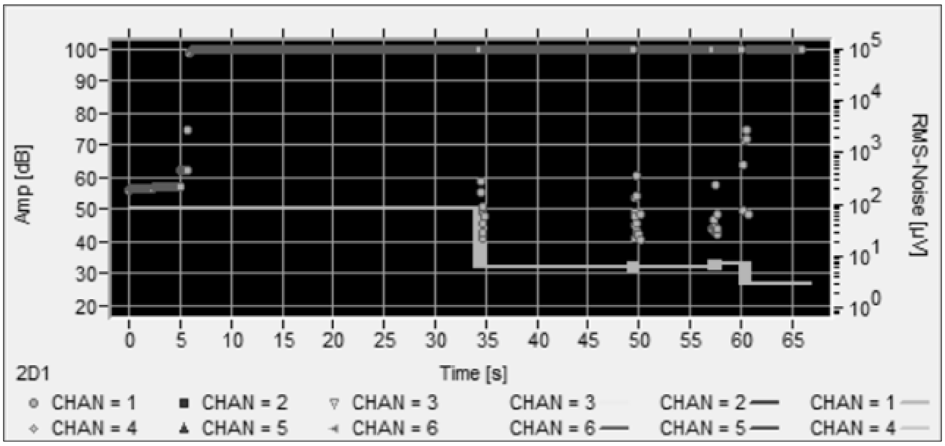

Fig. 4. Chart of number of hits and their amplitude changing as a function of time, a_p = 1.5 mm

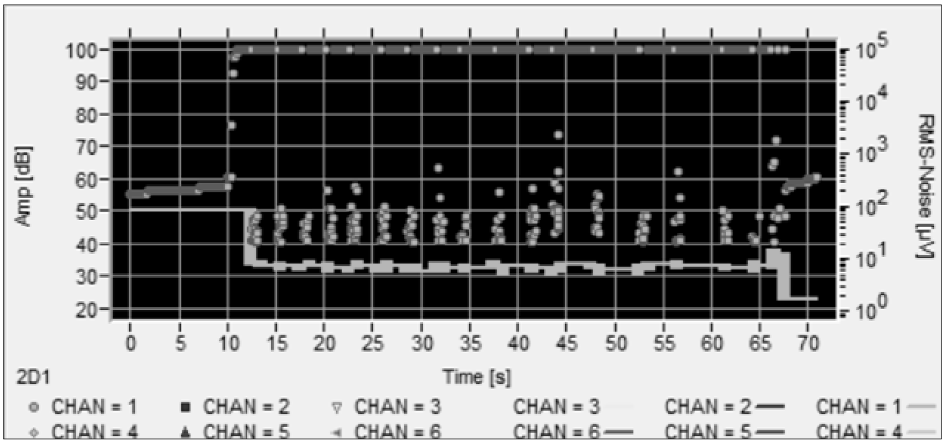

Fig. 5. Chart of number of hits and their amplitude changing as a function of time, a_p = 1.2 mm

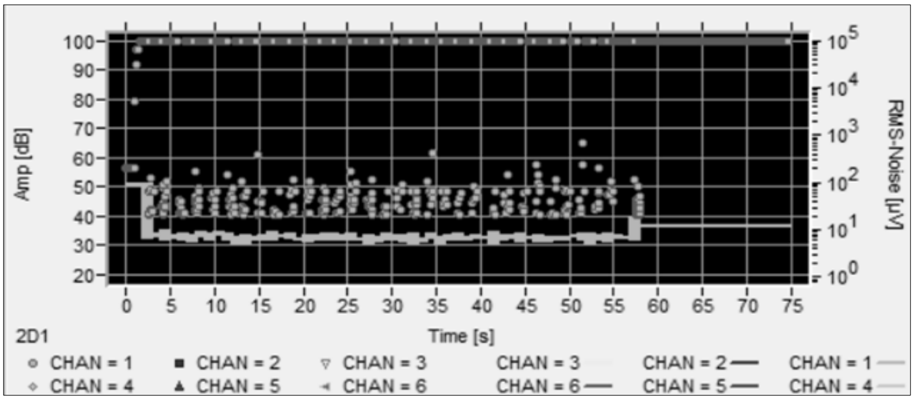

Fig. 6. Chart of number of hits and their amplitude changing as a function of time, a_p = 0.9 mm

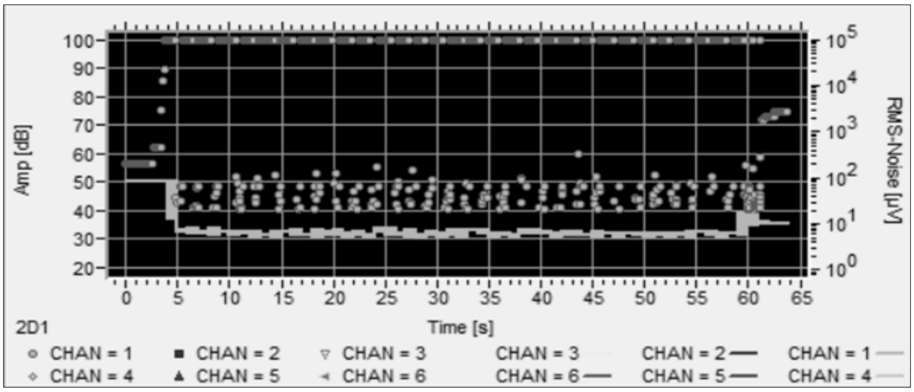

Fig. 7. Chart of number of hits and their amplitude changing as a function of time, a_p = 0.6 mm

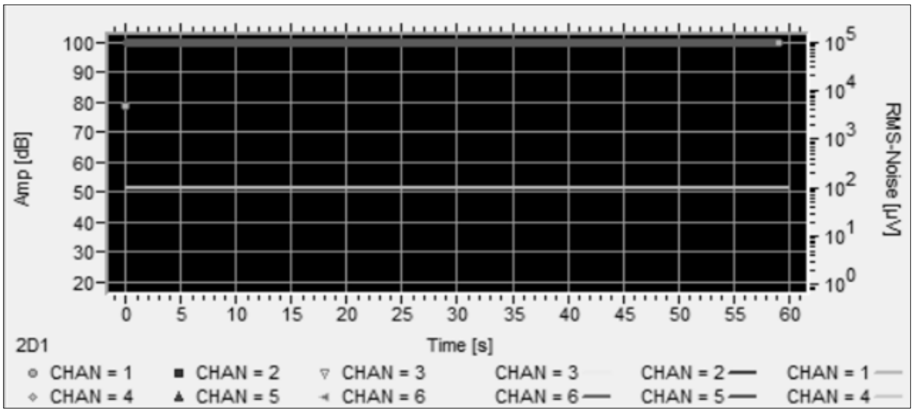

Fig. 8. Chart of number of hits and their amplitude changing as a function of time, a_p = 0.3 mm

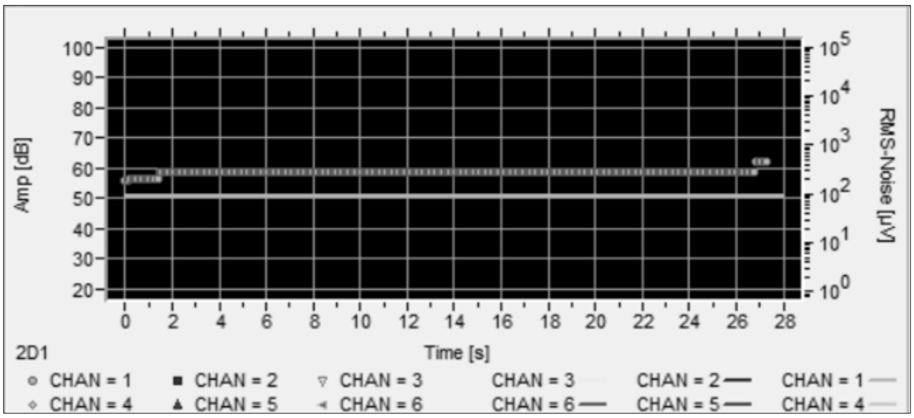

Fig. 9. Chart of number of hits and their amplitude changing as a function of time, a_p = 0.0 mm

Tab. 1. Average value of chosen parameters recorded during research

Cutting depth [mm]	Number of hits [-]	Energy [eu]	RMS [µV]
a_p = 0.0 (no contact)	23 273	696 657	91.10
a_p = 0.3	7 185	263 883 971	94.20
a_p = 0.6	5 416	114 403 557	12.36
a_p = 0.9	6 984	108 498 375	10.60
a_p = 1.2	7 483	213 274 630	18.10
a_p = 1.5	9 219	275 681 030	45.76

Analysis of the data obtained in the research allowed to determine the depth of cut, which allowed stable working conditions of the tool. In the Fig. 4-7 considerable spread of recorded events is seen. In the Fig. 8, 9 steady energy level of recorded events is noticeable. Besides noticeable scatter of the graphs, it is possible to establish a stable lathing conditions based on the RMS value of the signal – the higher instability and thus the vibration level, the lower the RMS value. The stability of the system recorded during lathing at a depth of cut a_p = 0.3 mm. In this case, the RMS value of the signal reached a similar level which was recorded in the absence of contact between the tool and the workpiece. In the case of larger depths of cut, RMS value reached up to 9-fold lower – maximum was observed for depth of cut a_p = 0.9 mm. The other recorded parameters, e.g.: number of hits, energy of the signal, rise time, duration, etc., do not allow unambiguous determination of the stable operation of the tool.

4. Summary

Correct selection of cutting parameters has a very large impact on the quality of the surface. The choice of these parameters based on data provided by the manufacturer of the tool may prove to be insufficient, especially in the finishing treatment process. It is possible to assess the correctness select the cutting parameters on the basis of e.g.: roughness of workpiece surface, temperature distribution – thermography methods, measurements of cutting forces that, vibration, acoustic emission, etc.

In the research acoustic emission method was used. It allows to define the parameters at which the lathing process proceeds more or less stable. There is a possibility of continuous controlling the process allowing inform the operator about additional circumstances affecting the quality of the rolling process, e.g.: damage of the cutting edge of the tool.

The application of acoustic emission to optimize the selection of cutting parameters allowed to determine the maximum depth of cut, at which the process was stable – a_p = 0.3 mm. With a range of parameters recorded during the test proved to be the most useful parameter was RMS of the signal. The higher the RMS value reached – the more stable lathing process was. As a result, it was possible to determine not only the recommended depth of cut but also those at which the process characterized by the worst stability – in that case there was a_p = 0.9 mm. This makes it possible to so select the machining process which allows to eliminate this value of this parameter not only in the case of finish but also the rough lathing. This can enable obtaining better quality of the surface and reducing wear of the tool.

References

[1] Baran, I., *Identyfikacja uszkodzeń korozyjnych zbiorników na paliwa płynne metodą emisji akustycznej*, Rozprawa doktorska, Kraków 2013.

[2] Baran, I., Nowak, M., Schmidt, J., Ono, K., *Potentials of AE application in testing industrial pipelines,* Advances in Acoustic Emission, USA 2007.

[3] Labuda, W., *The analysis of cutting tool geometric on cutting forces and surface roughness of steel applied to marine pumps shaft pins*, Journal of KONES Powertrain and Transport, Vol. 21, No. 1, Warsaw 2014.
[4] Labuda, W., *The influence of cutting parameters on cutting forces and surface roughness,* Journal of KONES Powertrain and Transport, Vol. 21, No. 3, Warsaw 2014.
[5] Malecki, I., Ranachowski, J., (reds.), *Emisja Akustyczna, źródła, metody, zastosowania,* Pascal Publications, Warszawa 1994.
[6] Ziegler, B., *Contribution of acoustic emission into optimal bearing lubrication,* Journal of KONES, Warszawa 2007.
[7] Ziegler, B., *Zastosowanie emisji akustycznej do identyfikacji warunków smarowania łożysk ślizgowych,* Rozprawa doktorska, Koszalin 2009.
[8] Ziegler, B., Miszczak, A., *Acoustic emission as a friction force indicator after test stands experiments*, Journal of KONES, Warsaw 2007.
[9] *Vallen Systeme, AMSY-6 Handbook, System description*, Germany 2010.