Intelligent Acoustic Emission System

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Abstract. Acoustic emission (AE) - testing method has a set of standing out special features, distinguishing it from other testing methods. It's a passive control method with high defects-detecting sensitivity, that does not need scanning of object surface and provides remote object testing with defects location on distances from meters to hundreds of meters.

AE - method drawbacks are: high acoustic noise level induced by work of testing equipment, complexity of defects parameters estimation, high labor intensity and requirements to qualification of personnel, performing AE - testing.

Nowadays different schools of sciences perform investigations for further development of AE - testing method, its possibilities enhancing, accuracy improving and practical field enlargement.

Current article presents intellectual AE - system principles, such a system has upgraded AE - testing process by means of automation and intellectualization of functions, commonly performed by operator.

Intellectual AE - system has automation of next functions: sampling rate assignment for correct time and frequency resolution, adaptive filtering of AE - signals for their efficient detecting against technological equipment noise background, and automated data registration without setting of threshold, sceto and other parameters by operator.

Data registration procedure uses non-threshold statistical method of AE - impulses extraction on the basis of acoustic stationary noise properties changing. By means of digital signal processing pulse and continuous signal products are extracted, continuous product allows to identify leaks, technological noise and pre-destruction continuous emission.

Intelligent AE system can improve the accuracy and reliability of the AE testing. Precise detection of acoustic emission impulses improves the AE sources location result, and precise location provides the precise AE source evaluation. Automatic determination of the setting parameters allows us to reduce the human factor influence on the results of the AE testing.

Introduction

Acoustic-emission (AE) testing method has a set of outstanding advantages. It is a passive method with high sensibility of cracks detection, free of testing object surface scanning, capable of remote work on the distances from several to hundred meters.

Besides the method has a set of drawbacks either – those are: sensitivity to acoustic noises generated by work of facilities being tested, complexity of defects parameters quantitative estimation, high requirements to personnel performing AE-testing induced by intellectual principles of method, expressing in equipment setting and testing results estimation complexity.

Nowadays scientific schools perform investigations to further develop AE-testing method, enhance its possibilities, validity and field of practical implementation.

Current work describes principles of intelligent AE-system design; mentioned system allows improving AE-testing procedure by automation of functions, conventionally maintained by operator.

1. Intelligent AE-system overview

Intelligent AE-system is composed to have automation implementation of next functions: sampling frequency setting, AE-signals processing, that allows to extract AE-signals from technological facilities noise background effectively, and data registration without AE-signals counting parameters (as threshold, dead time, sceto time) setting [1].

1.1 Automated setting of filtering frequency band and sampling rate

Intelligent AE-system SMART performs data registration with diverse sample rates and digital filters bands. Sample rate and filter band setting is convenient operator task during system setting. User faulty definition of these parameters is risky of diagnostic data loss and distortion. Frequently an operator erroneously sets sample rate disregarding Nyquist sampling theorem and filter band discordantly with instrument and acoustic channels properties.

SMART AE-system automatically defines digital measuring channel parameters. Algorithm of parameters definition is based on analysis of AE sensor calibration impulse response. Signals obtained from the sensor in spare position and mounted on the testing object surface are analyzed. According with calibration results filter band is set appropriate to frequency characteristic of the sensor and acoustic channel. Sampling rate is set with providing of essential time and frequency resolution for further data processing.

1.2 Advanced data filtering

In convenient threshold way of data acquisition noise filtering is performed by neglecting of signal component below threshold. In intelligent AE-system SMART threshold-free data acquisition method is implemented [2]. Advanced data filtering methods application is essential for noise-resistant data registration without threshold, which prevents dummy registration of AE-impulses. In AE-system SMART signal detection filter is used. Impulse characteristics of signal detection filters are similar to AE impulses waveforms. Due to AE impulses waveforms versatility device has a bank of signal detection filters proper to eventual AE-signals.

1.3 Threshold-free data acquisition

Threshold-free data acquisition module is a main one in intelligent AE-system. Convenient way of data acquisition in AE-testing method is threshold registration. Threshold registration is reliable and simply implementable, but has a set of substantial drawbacks. First of all, threshold setting is a function of operator, so threshold value is feasible faulty due to human factor. Secondly, arrival time of AE-impulse is counted inaccurately as a time of threshold crossing. Arrival time inaccuracy leads to inaccuracy in AE sources coordinates location. As an alternative to threshold registration intelligent threshold-free method based on signal detection theory could be introduced. In the introduced method AE-impulses are considered and extracted as fragments of continuous data flow, which have stated temporal and spectral properties. Method implementation induces application of on-line functioning change point detection algorithms. Intelligent threshold-free method of data acquisition allows detecting precisely arrival time of AE-impulses in on-line mode. [3]

2. System implementation

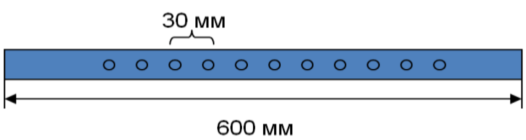
During current stage of the project intelligent system SMART has been implemented in the portable 2-channel device UNISCOPE. Device outline is presented on Fig.1.

Fig.1 UNISCOPE device outline

UNISCOPE is a portable battery-powered device that could perform on hand AE-testing of compact scale and long length objects with linear location of defects. SMART system integration to UNISCOPE significantly enhances device field of use due to effective noise reduction. In SMART mode device is capable of AE-testing of gas compressor stations facility: pipework, valves, air-cooling units. At oil refinery plants industrial pipelines and compact pressure vessels could be tested. Lots of lab experiments have proven effectiveness of SMART system.

2.1 SMART location results

As is well known, precision of AE-sources location depends on accuracy of AE-impulses arrival time detection. As SMART AE-system allows to precisely detect signals start time, its location accuracy is expected to exceed convenient AE-systems one with threshold data acquisition.



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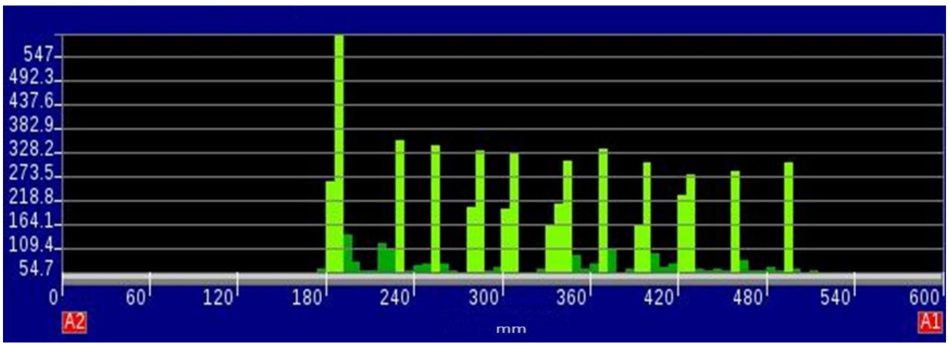

b

Fig.2 Pencil breaks location results

The experiment was performed to test SMART system location accuracy. 11 points with distances of 30 mm between them were selected on the plate with dimensions 600x30x8 mm (Fig.2a). In each point AE-impulses were emitted by electronic imitator. Location results are presented on Fig.2b. Each point of emission is represented by distinctly located group. Location inaccuracy was about 15mm, what is comparable with sensor diameter size.

2.2 Location against noise background

Noise-resistivity of system was tested by experiment with location against acoustic noise background. Experiment scheme is presented on Fig.3. Two sensors were mounted on tight metallic plate with length of 400 mm. Mounted on center of plate with 125 mm distance to each sensor imitator was used as AE-impulses source.

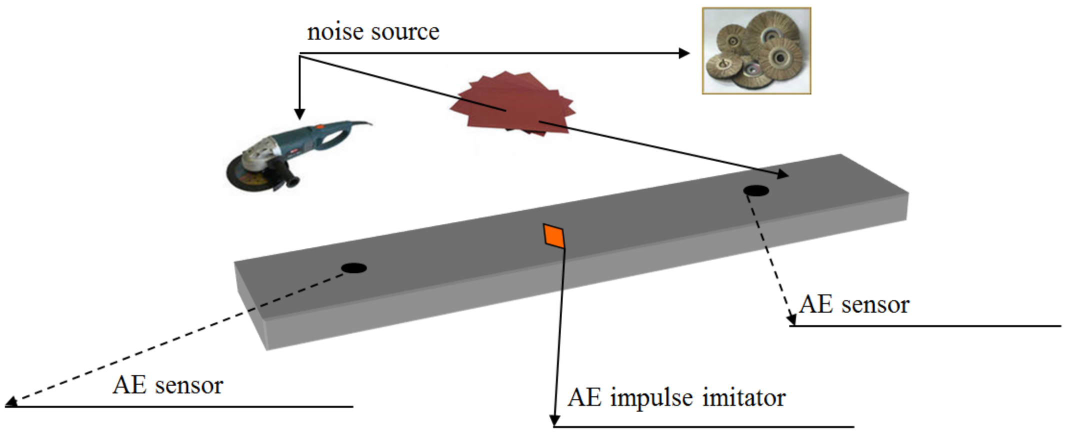

Fig.3 Location against noise experiment scheme

Noise sources were emulated by tools producing friction or vibration – abrasive paper, grinder, drill. AE-impulses were emitted 10 times per second during 10 minutes. AE-impulses amplitude was about 50dB, as noise level was about 45-50dB.

AE-source location results are presented on Fig.4. For comparison both location results for convenient AE-system (Fig. 4a) and for SMART system (Fig. 4b) are shown.

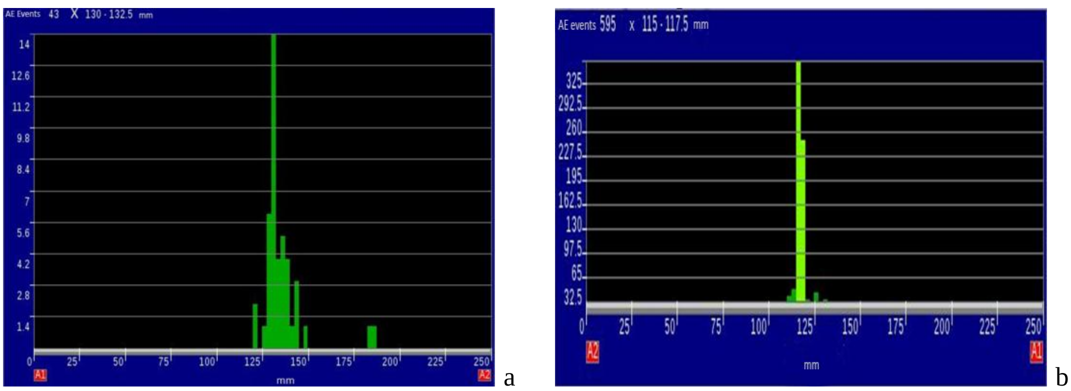

Fig. 4 Results of location against vibration noise background a. Convenient AE-system b. SMART AE-system.

Fig. 4a location map contains only 43 from 600 events, as SMART system location obtained 595 AE-events. Poor location result of convenient AE-system is induced by vibration noise registration, that leads to erroneous forming of AE-events and further violation in signals arrival times difference defining. SMART AE-system does not register vibration noise as AE-events due to intelligent registration method, which provides location of 99% AE-impulses.

3. Conclusion

Presented AE-system has a set of substantial advantages. Intelligent AE-system allows improving accuracy and validity of AE-testing results, as precise AE-impulses detection provides AE-sources location alignment and correcting of its criterion scoring results. Automated digital measuring channel parameters setting shortens period of AE-testing procedure and play down the impact of human factor on testing results.

References

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