

NEW APPROACHES IN ACOUSTIC EMISSION SIGNAL PROCESSING

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One of the main objectives of Acoustic Emission (AE) inspection of the units operating in static and dynamic loading conditions is the identification of acoustic emission sources taking into account either their location or physical nature.

Identification of the source location requires the pre-inspection of a unit under test (calibration) either of acoustic channel having its own wave distribution velocity or attenuation factor.

The techniques of measurement of acoustic impulse distribution velocity are based on measurement of difference between impulse arrival time per the spaced to a known distance conversion AE sensors. The most frequently met AE signal imitators are: Su-Nielsen source (pencil lead or glass capillary having its own specific properties) and an emitting conversion sensor.

Condition analysis of an acoustic signal distribution and of recording device parameters shows that during the calibration on items being most frequently AE inspected with element thicknesses 10 – 15 mm using 50 KHz – 0,5MHz devices the one of the normal polarized waves in the plates shall be registered – the Lamb waves.

It's incorrect to talk about velocity identification in this respect because every registered impulse represents a wavelet having frequency components; each of them has its own velocity.

Figure 1 shows the results of velocity measurement during the calibration made at different basic distances between AE conversion sensors. The analysis shows that under lower values of distances (~2 meters) the scatter of obtained values will be the greatest. This relates with the fact that at these distances all the frequency components are kept, either “quick” or “slow”. With increase of wavelet distribution distance the only greatest component reaches the farthest AE converter and therefore the scatter of obtained velocity values considerably decreases.

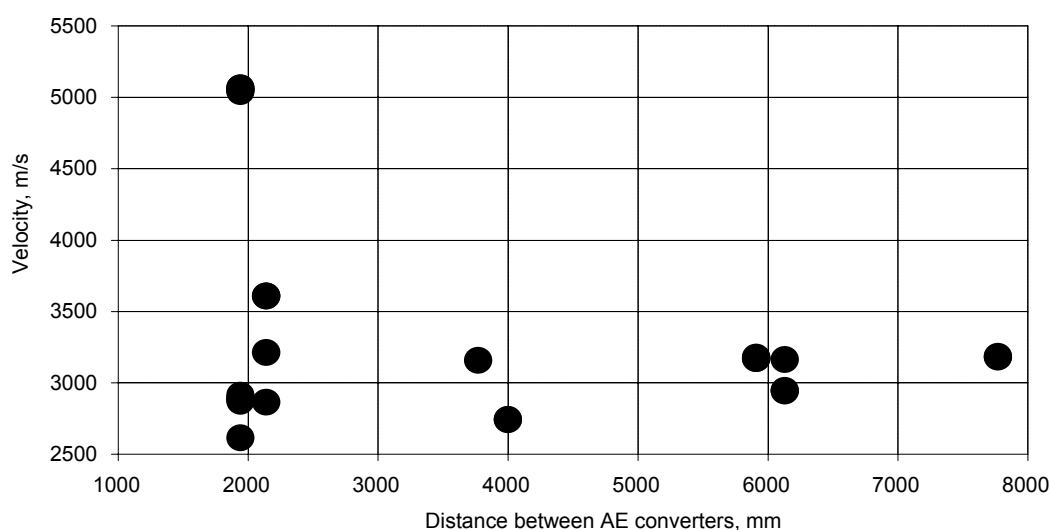


Fig. 1 Velocity measurement results under different basic distances between AE converters

What is meant here is not about errors in velocity value identification because we know the velocity of Lamb waves has frequency dependence (dispersion) while calibrating requires dispersion curves corresponding with the specific subjects and conditions of AE registration.

Evolution of electronics and computer sciences enables nowadays not only to measure the core AE signal parameters (including difference in arrival times at AE converter which is the characteristics defining velocity) but also to record them in a digital way with sufficient resolution virtually without limits on amount of information.

Obtaining of oscillation diagrams of AE signals enables to approach to this task of source location defining from the perspective of the most precise AE emission analysis based on the up to date signal processing techniques.

One of such techniques is the continuous wavelet conversions. Continuous wavelet conversions result from 3-dimension time-and-frequency signal representation which enlarges the amount of information about it, either about time or spectrum peculiarities of a signal. Each wavelet registered by the AE converter possesses information about the distance it's already passed.

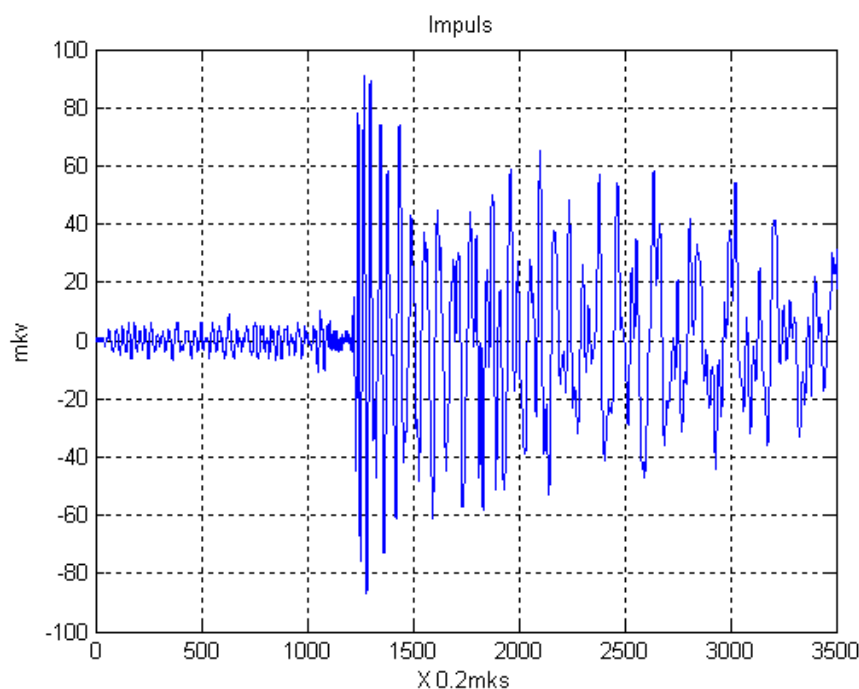


Fig. 2 Impulse from an imitator

To best illustrate the possibility of a wavelet analysis as well as to best understand the technique peculiarities in defining of the AE signal distribution velocity one shall use oscillating diagram obtained from Su-Nielsen source on a steel item having thickness 8 mm; the diagram is presented in Fig. 2 (distance between the source and AE converter 1930 mm).

Wavelets could be the different functions including the modulated by impulses sinusoids as well as functions having range leaps etc; the complex Gauss wavelet of the 30-order is used in present work. The selection of wavelet has in most cases heuristic character and is defined by the necessity of bigger resolution in frequency or time fields.

The analysis of obtained spectral recoding (Fig. 3) shows that actually registered wavelet forms two energetic arrays. Judging by the character of time dependencies (energy on frequency) it could be said for sure that there are two impulses in a wavelet presented by anti symmetric modes.

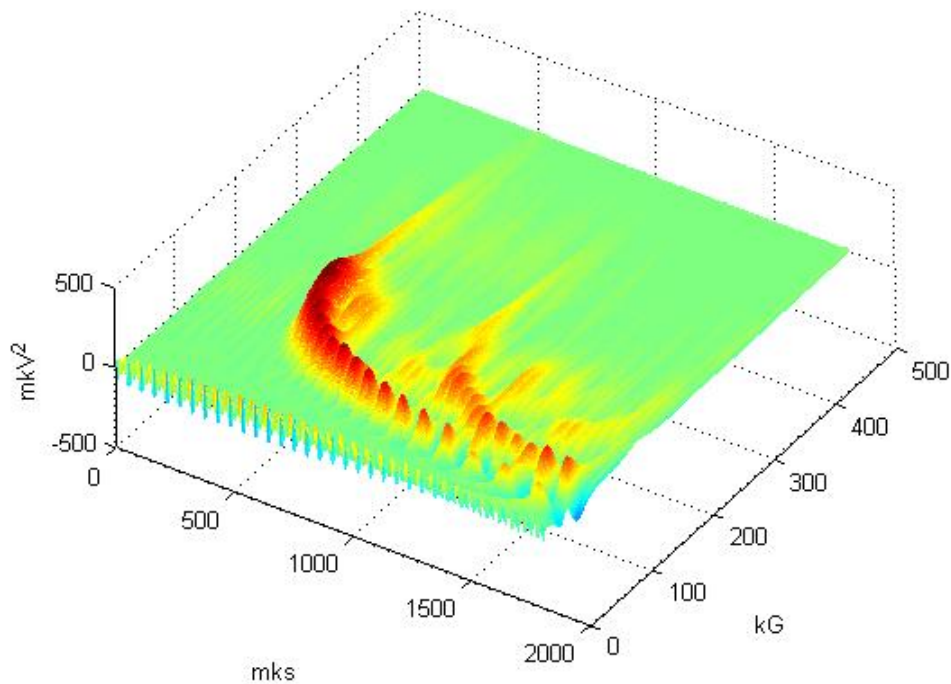


Fig. .3 Spectral recording resulted from the impulse conversion wavelet (amplitude-frequency-time)

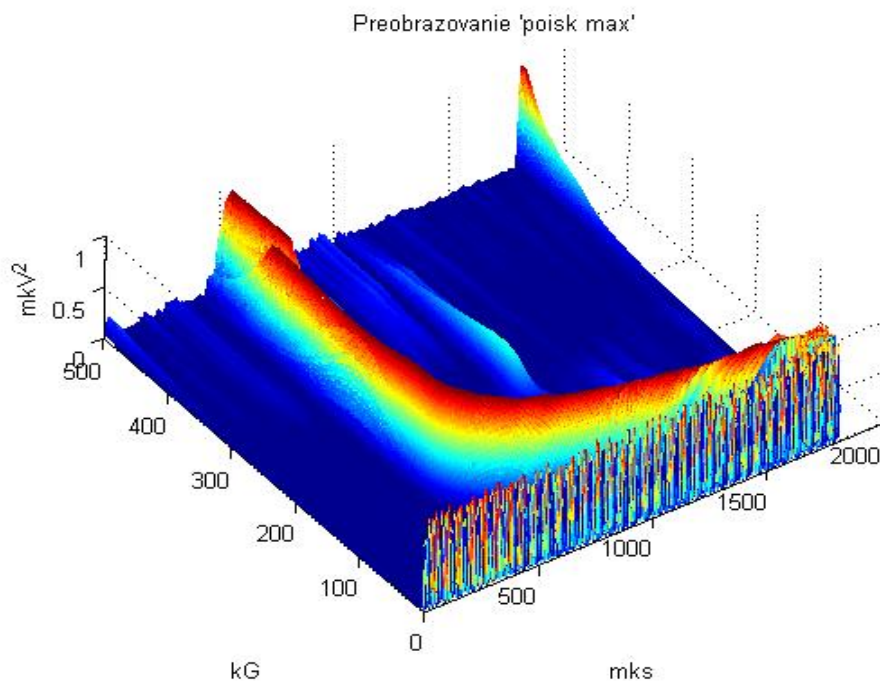


Fig. 4 The result of spectral recording conversion according to “maximum search” technique.

The reason for given superposition may be the reflection from the closer edge of an item or binary actuating of an imitator. Then it's necessary to process the spectral recording to outline the main energetic components. This procedure is called maximum search; the results are presented in Fig.4.

The objective of further processing of an image is to obtain the unique relations between signal spectral maximums and their arrival time at AE converter. To complete the task it may be necessary to obtain values through a specific technique of image processing that received the name “binarization”. This technique results from frequency-time dependencies of the spectrum energetic maximums.

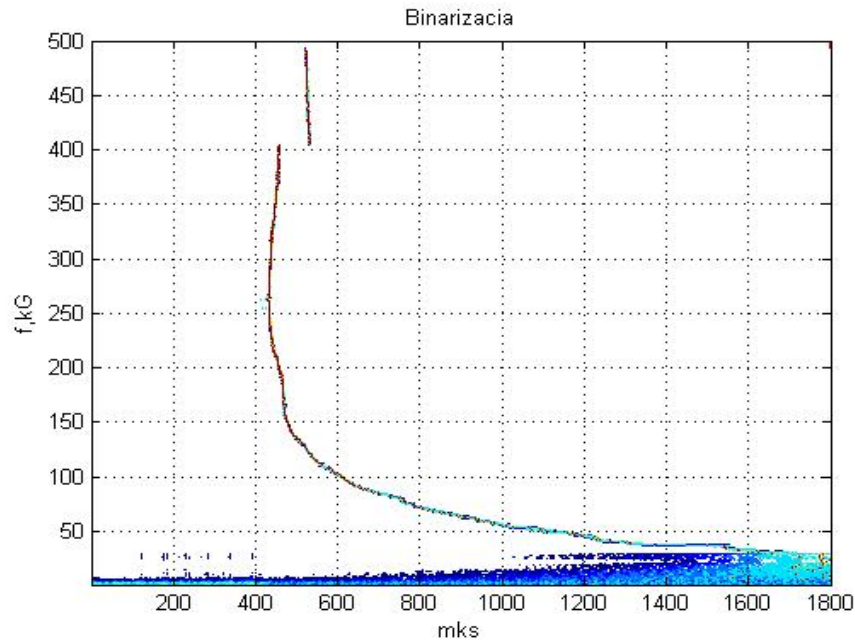


Fig. 5 Frequency-time dependency of spectrum energetic maximums

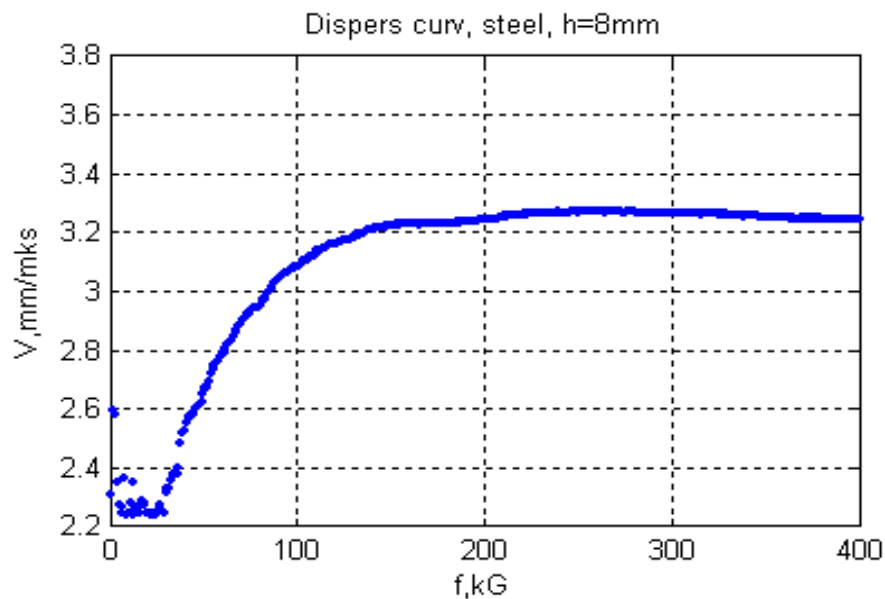


Fig. 6 Dispersion curve for anti symmetric zero mode

Knowing the arrival time of frequency components of an impulse it's easy to build up the dispersion curve for anti symmetric zero mode of Lamb's wave (fig.6) distributing inside of the inspection subject. Similar curve could be obtained for the symmetric mode.

Withdrawals:

1. The technique that enables to build up the dispersion curves for zero mode velocity of Lamb waves using a single registered impulse.
2. This technique may be comprised into pre calibration procedure prior to AE inspection.
3. This technique proposes to refuse the threshold detection of differences of arrival time of an impulse at scattered converters to detect the distance from a source to a receiver because each impulse carries information about the distance it had already passed.