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WAYS TO ANALYSES OF BURST TYPE OF ACOUSTIC EMISSION SIGNALS DETECTED AT TESTED OF LOAD BEARING CAPACITY

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Abstract

The Acoustic Emission Method is able to locate active defects in material structure and construction. Places, of which accumulates stress, rise at loading construction. Consequent of these stresses, which they can reach up local high value, cracks in material construction rise and extend. The Acoustic Emission Method by means of sensors (mechanic to electric converter) records "acoustic waves", which explode from crack place in influence of vacation of tension (accumulated energy). In commonly these signals are in a pulse shape. Their registration and processing is possible to do several ways. It uses especially description single impulse (i) by selected parameters or (ii) by its whole time history. The subsequent analyses can use with advantages some modern mathematical procedures. This article presents using some mathematical analyses. It interests especially about less known method (Short Time Fourier transform and so on.).

Keywords

Acoustic Emission, "Burst" Type of Signal, Building Construction, Analysis, Active Defect, Fourier transform, Short Time Fourier Transform

Introduction

The Acoustic Emission Method is a tool from group of Non-Destructive Techniques, which is able to detect active flaws. Acoustic Emission (sometimes called Stress Wave Emission) can be defined as: "The elastic wave generated by the release of energy internally stored in a structure." Consequently, the Acoustic Emission Method can determine places where the locals stress reach up maximal value. Acoustic emission sensors select responses of structures generated by releasing of accumulated stress energy. It is not easy to find hidden information in signal about physical phenomena into tested structure. These information can make for classification and identification sources. This signal can be commonly analysed in time, frequency or time-frequency domains [2].

Burst Type of Acoustic Emission Signal

An acoustic emission signal can be described some parameters as Time Occurrence, Duration, Rise Time, Peak Acoustic Emission Amplitude, Acoustic Emission Counts, Energy,

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Average Frequency, Threshold Level, Root Mean Square, Average Signal Level, external parameters depended on loading or single test. Note, that some important parameters as Peak Definition Time (Rise Time Out), Hit Definition Time (Single Channel Event Time Out), Hit Lockout Time (Rear Time Out) and so on are necessary for correct determination events from hits. Some of parameters are shown in Fig. 1 [1].

The other way is recording actual amplitude of acoustic emission signal depending on time step. Here the electric signal is converted into (analogue) digital form and stores on files. Signal analysis can be used in "real time" or post-test. There it is often calculated the Fast Fourier transform algorithm to transform from time to frequency domain.

There are some basically ideas of recorded or description acoustic emission hits. Note that a hit is an impulse part of burst type of acoustic emission signal. One idea is to include in the hit description all consequences (reflections, alternate paths, etc.) of the source event. The hit definition time (rise time out) is used relatively long. Next idea is that the system throughput can be improved by discarding irrelevant parts and measuring only the main part of the wave.

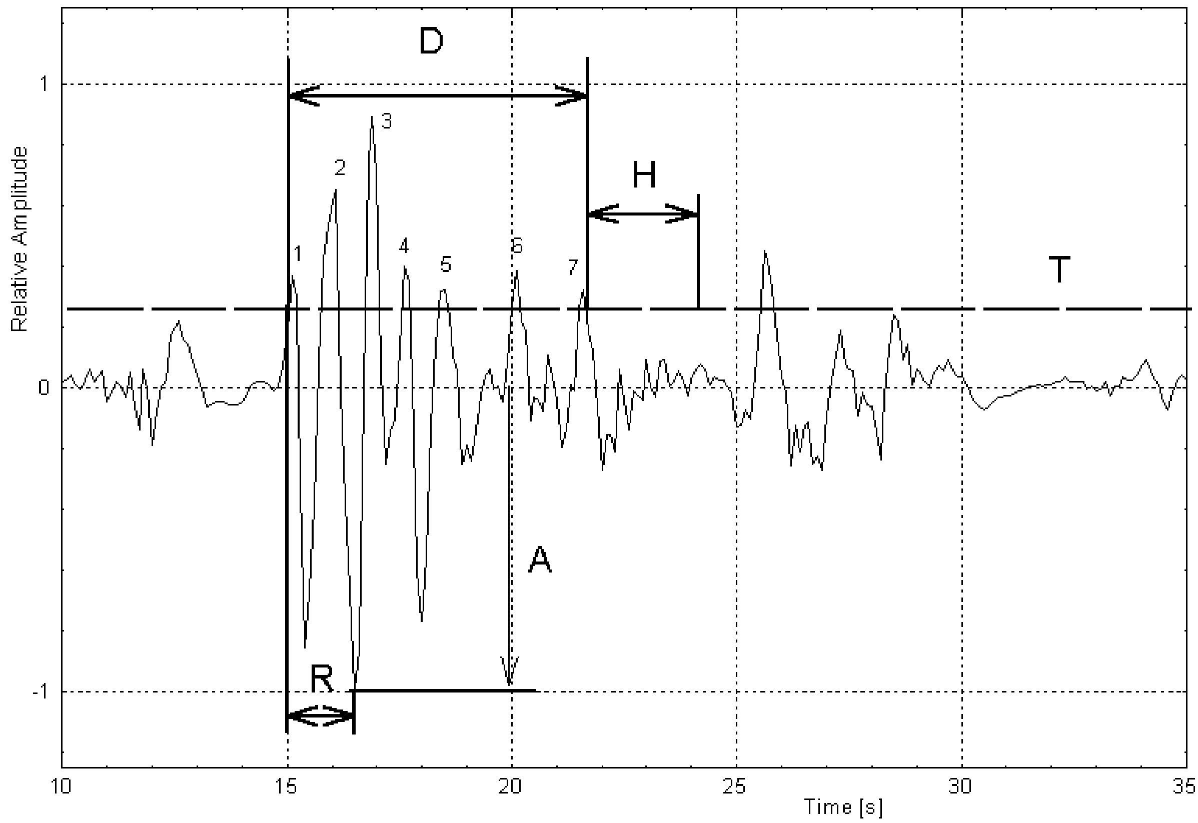

***Fig. 1** The chosen part of acoustic emission hit (from Fig. 2).*
D – duration, R – rise-time, A – amplitude, H – rear time out, T - threshold

Signal Analysis

Many analyses transform time representation of amplitude into frequency domain or spectral representations. Most of these methods are based on the Fourier Transform, which for discrete time signals is given by the following formula, known as the Discrete Time Fourier Transform. Their discrete definition is followed

$$X(k)=\sum_{n=0}^{N-1} x(n)\cdot \exp(-i\cdot 2\cdot \pi \cdot k\cdot \frac{n}{N}),$$

where $x(n)$ is sampled signal by sampling frequency f_s (in Hz), N is length of the signal, f_k is discrete frequency ($f_k = \frac{k}{N} f_s$), note that i means imaginary unite [3].

Short Time Fourier Transform, as the time-dependent Fourier Transform, is the windowed, discrete-time Fourier transform for a sequence, computed using a sliding window. This transform represents a sort between the time and frequency view of a signal. The information about time and frequency is limited precision. The size of the shifting window determines this precision. The Short Time Fourier Transform is defined as the Fourier transform of a Gaussian windowed time signal for various positions of the window. Their discrete definition is followed

$$S(m,k)=\sum_{n=0}^{N-1} x(n)\cdot g^*(n-m)\cdot \exp\{-i\cdot 2\cdot \pi \cdot k\cdot (n-m)\},$$

where $n\cdot \Delta t$ is time step ($f_s = \frac{1}{\Delta t}$), $m\cdot \Delta t$ is delay (shifted time), g is shifted window [2].

Note that the neurone network analysis is interesting for analysis acoustic emission signals [5].

Experiment

The acoustic emission signal was chosen from group of hits collected at testing of contact properties of surface layers of materials for ball bearing [4]. This test was carrying out in the Axman station. It simulated real function of ball bearing with possibilities of easier measurement of acoustic emission then at real ball bearing and of change of the tested structure material. Here it is shown a signal generated at pitting occurrence. The hit was sampled by 10 MHz frequency.

The time history of signal at pitting is shown on Fig. 2. There are about three hits in different time steps. The first is created in the origin of monitored signal, next one about 15 μs from origin and next about 35 μs.

The frequency spectrum computed by Fourier Transform from Fig. 2 is displayed on Fig. 3. Because selected frequency was got in 10 MHz, the maximal showed frequency is 5 MHz. The maximal spectral component is on frequency about 700 kHz, the next two local extremes are on frequencies 500 kHz and 1.2 MHz. Note, that these frequencies are computed from whole signal, does not reflect special frequencies of individual hits. Thus the frequency spectrum shows frequency component of whole computed part of signal, i.e. their values are average of individual time parts of signal.

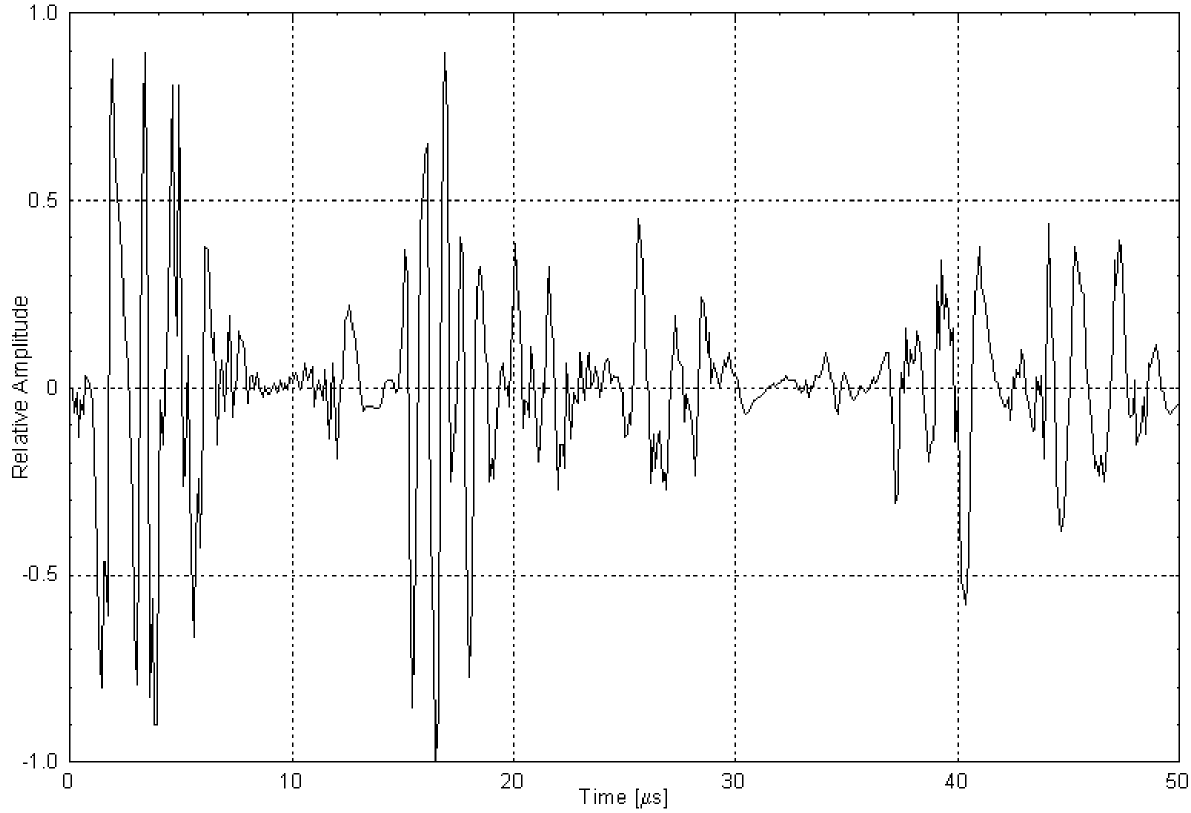

Fig. 2 *The acoustic emission signal collected at rising pitting.*

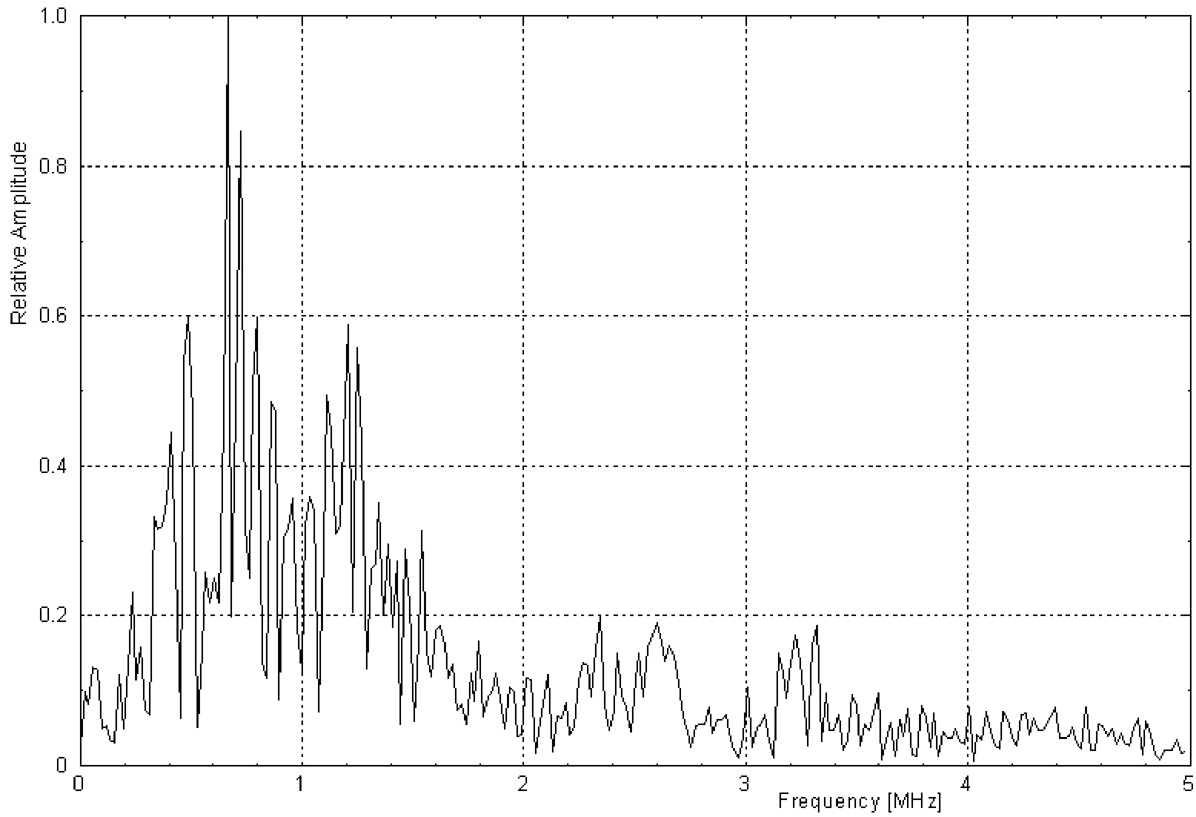

Fig. 3 *The frequency spectrum of acoustic emission signal (from Fig. 2).*

Time-frequency transformation (Fig. 4) of the acoustic emission signal (from Fig. 2.) shows values of spectra (in dB) in time and frequency positions. Thus, frequency component under 1 MHz is preferred in the first and last hits and frequency components over 1 MHz (to 1.7 MHz) are dominated in the second hits with centre about 15 μs.

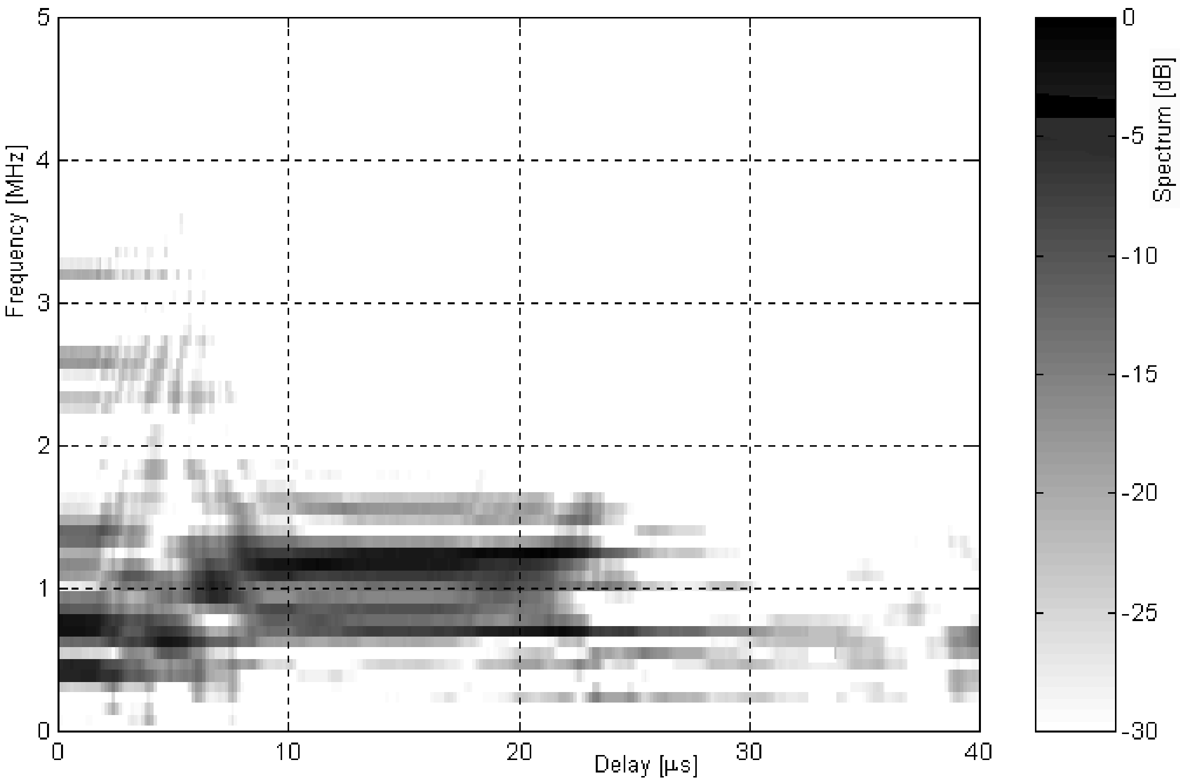

Fig. 4 *Time-frequency spectrum computed by Short Time Fourier Transform of acoustic emission signal from Fig. 2.*

Result

At analysis of the acoustic emission signal, acquainted from a surface contact loaded specimen, it have been succeeded to find out a characteristic representation of individual hits and damage of part surfaces, exposed to a point contact load. There were find differences in description of the acoustic emission signals at separate parts of test.

There are some mainly differences between parametric description of the hit and recording some hits or some parts of signal. Because this test was done relatively long time (some days)

- the parametric description worked whole time of test,
- some hits were recorded only in chosen time intervals.

Therefore, the more information is in the recorded hit, but the hits cannot be collected in all time, because system that would be made to save each value at sampled frequency 10 MHz over tens days does not exist.

Time-frequency analysis is one of the powerful tools to find hidden information from acoustic emission signal (from separate hits).

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