

# The correlation analysis of informative AE signal parameters

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**Abstract.** Article contains results of signal parameter research depend on increase crack length. Analysis methods of signal parameter resistance to external influences and signals clustering from crack propagation and mechanical influences are described in this paper.

## 1. Introduction

Acoustic emission method of nondestructive testing is based on registration and analysis elastic waves, which arise in process of defects propagation. This method makes it possible to selective detect most dangerous defects for construction – fatigue cracks. Low noise immunity significantly limits area of using.

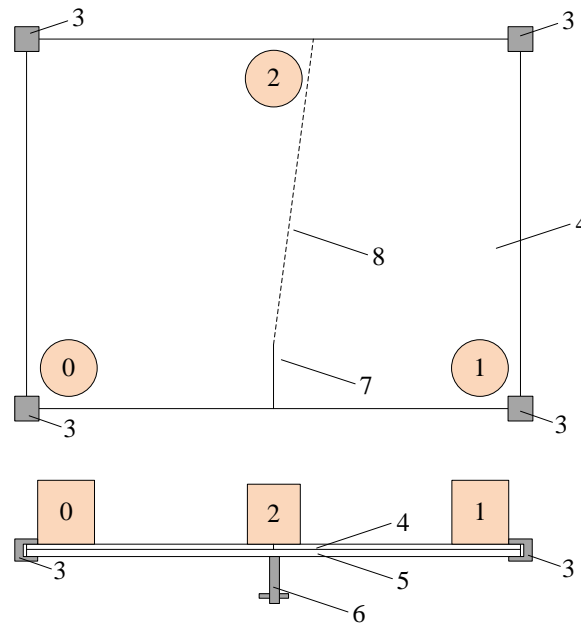
Clustering algorithms based on analyses forms and parameters signals are used to detect informative signals among all. Signals distortions during propagation in object and transformation in electroacoustic channel increase difficulty of these develop [1]. Construction materials viscosity significantly reduce during long operating, consequently part of fragile destruction raises and velocity of crack propagation increases [2]. Therefore fragile-type defects opportune detection is very important for nondestructive testing [3].

The purpose of research is developing methods of estimation informative parameters of acoustic emission signals, which arise in process of increase fatigue cracks.

## 2. Description of the experiment

Experimental research was carried out on glass square sheet (thickness 3mm, measurement 150x200 mm). Crack from 5 till 50 mm length was created by dynamic force. Glass sheet was placed on metal base plate, was fixed by clamps and was bended by screw rotation. Signals generated in process of bending were registered by acoustic emission system SCAD 16.03 (Siberian Aeronautical Research Institute, Siberian State transport university, Novosibirsk, Russia) with 2 MHz clock rate. Acoustic emission transducers were planted on sheet by scheme in figure 1.



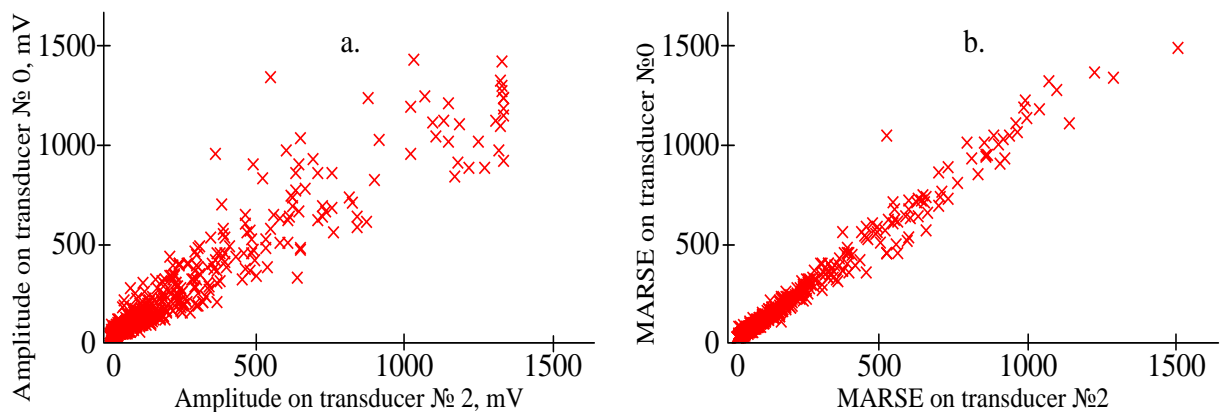


**Figure 1.** Experiment scheme: 0, 1, 2 – acoustic emission transducers; 3 – clamps; 4 – glass sheet; 5 – metal base plate; 6 – screw; 7 – crack; 8 – crack propagation trajectory.

### 3. Signal parameters resistance

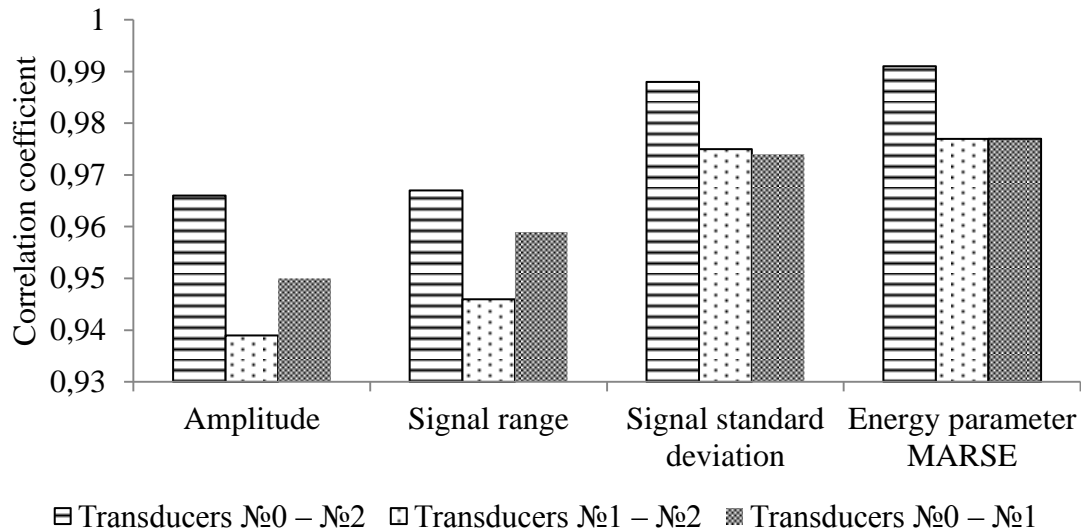
Concept of signal parameter resistance to small source perturbations was introduced in this paper. The signal parameter  $P_1$  is more stable than the signal parameter  $P_2$  if the source parameter perturbation  $P_0$  causes the signal parameter perturbations such that  $|\Delta P_1| \leq \varepsilon_1$  and  $|\Delta P_2| \leq \varepsilon_2$ , wherein the inequality  $\varepsilon_1 < \varepsilon_2$  is true [4]. Signal parameters, such as the signal amplitude  $U_m$ , the signal range  $R_{AE}$ , signal standard deviation  $U_{CK}$  and signal energy parameter MARSE were researched during the experiment.

Correlation analysis was used for resistance research. Signal parameters from two acoustic emission transducers relate by linear dependence, correlation coefficient is 1 (figure 2). External influences can reduce correlation and introduce fuzziness, which value is considered parameter characteristic [5].



**Figure 2.** Amplitude and MARSE correlation between transducer №0 and transducer №2 with coefficients are 0.94 and 0.99.

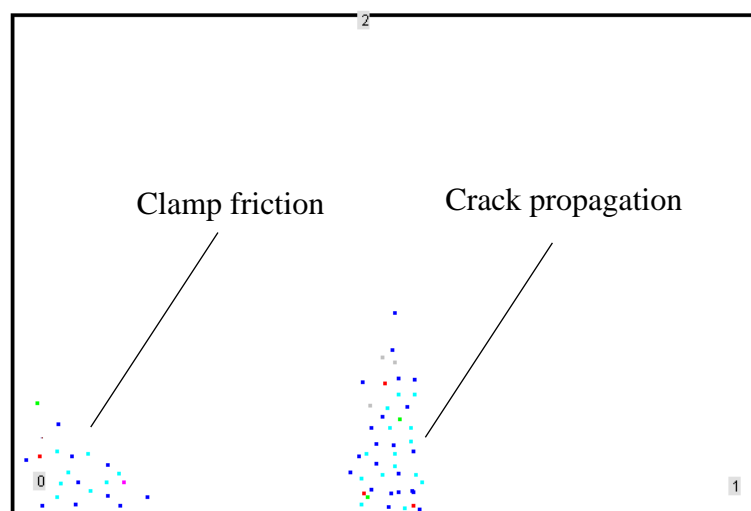
Correlation coefficients registered during the crack propagation were possessed the values from 0.94 till 0.99. Maximal resistance to perturbations was observed for the signal standard deviation and MARSE, minimal – for the amplitude and the signal range (figure 3).



**Figure 3.** Correlation coefficients for the signal parameters.

#### 4. Clustering

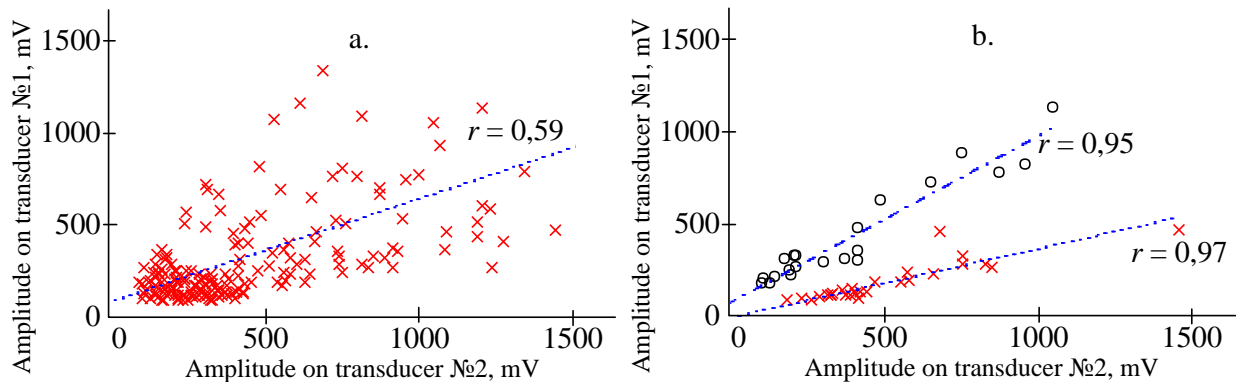
The main purposes of clustering are AE signal union and division in over data stream. Clustering accuracy significantly depends on informative parameter set. Parameter set selection reason depends on construction element type, signal source characteristics and used equipment. Signals registered during the experiment were generated from various sources: crack propagation in central area of glass sheet and clamp friction in transducer №0 area (figure 4). Different type of influence on glass sheet and various signal source areas were lead to infringement of signal parameter correlation, coefficient is 0.59.



0, 1, 2 – Acoustic emission transducers

**Figure 4.** Location panel of acoustic emission signal sources in software SCAD 16.03 AES51.

With using recursion algorithms signal parameters were divided into two clusters (figure 5, b), correlation coefficients each of which were more 0.95. Cluster with correlation coefficient  $r = 0.97$  consisted of signals from crack propagation area, cluster with  $r = 0.95$  consisted of signals from clamp friction area.



**Figure 5.** Correlation between amplitude on transducer №1 and №2, lines are linear approximation with correlation coefficient  $r$ : a. all signals, b. two clusters.

Clustering accuracy was inspected using signal shape analysis by manual mode and using location panel in software AES 51 by automatic mode (figure 4).

## 5. Conclusions

Correlation coefficients registered during the crack propagation were possessed the values from 0.94 till 0.99. Used the method of correlation analysis was proven effective to make clustering possible. Stream of acoustic emission signals with low correlation  $r = 0.59$  was divided into two sub streams with high correlations  $r = 0.95$  and  $r = 0.97$ . It allowed identifying two signal source areas are due to crack propagation and clamps friction.

## References

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