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# FEATURES OF DIAGRAMS OF PHASES AND ANOMALY OF STRUCTURES OF DYNAMIC SYSTEMS DURING DEGRADATION OF THEIR PROPERTIES

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**Summary.** With the use of statistical analysis methods aspects of emission signals stream and kinetics of plural origin cracks and resonance excitation of the proper modes of generation automodels of generation of intercommunication emission signals of physical and mechanical properties of materials are explore by the change of their mechanical and physical properties. It is expedient to use this mechanism of intercommunication for determination of the actual state of material in the process of exploitation.

Keywords: degradation, emission, model, stability, phase portrait.

### INTRODUCTION

It is known that inevitable investigation at deformation of solids is an accumulation of damages not only at the level of elementary defects of crystalline grate but also at a higher scale level.

It is accepted to consider that at exhausting of resource of longevity, i.e. destruction, there is investigation of these processes. Physics of transformation of accumulation of elementary defects of crystalline structure of distribution type in a crack is studied in satisfactory detail. It is shown with the use of methods of registration and peak-temporal analysis of signals of acoustic emission, that at deformation of material the future area of break is tightly coupled with the cracks accumulated on the previous stages and there is a hierarchy of growth of correlated nascent cracks in it. It has formed a casual enough appearance as a result of variable active formation of cracks in different local areas because of making progress under the action of loading reduction of accommodation ability of surrounding volume.

The use of modern physical methods of research allows to state that the process of accumulation of defects of materials and destruction is accompanied by the processes of emissions.

It allows to examine emission as a method of research of the states of structure of material and kinetics of process of degradation of its properties.

## **OBJECTS AND PROBLEMS**

Deformation and destruction of all solids excites in them the row of processes — emission of electrons and ions, shedding light, radiation of sound, electromagnetic radiation in a radio frequency

range; there are publications reporting about a x-ray photography radiation [1]. These processes are the least studied in metals, experimental facts are however accumulated and their explanation is offered. The offered mechanism of emission process in metals consists in the following [2]. At destruction nearby the top of crack plastic areas appear with the high concentration of distributions. After the removal of loading there is a distribution return of the deformed layer, steam of distributions of opposite sign related to annihilation and with wedging of mobile distributions out. The real distributions in metals have a difficult structure and their complete annihilation is improbable. Annihilation only of separate parallel segments is possible in every distribution reaction. Annihilation of such segments is accompanied by a selection of considerable energy, to showing up in different family effects of emissions.

A study of statistical aspects of stream of sources of signals of emissions and kinetics of plural origin of cracks and resonance excitation of the proper modes of automodels of generation of signals of emissions is on principle important for finding out of mechanism of forming of main crack. The effect of periodic change of physical and mechanical properties of the deformed crystalline materials can be presented as a display of organization of band of distributions during plastic deformation [3]. Recently, there was experimentally found out the similar phenomenon of periodic change of parameters (number and sizes of particles of wear, intensity of signals of acoustic emission, generated cracks) of wear of crystalline materials at a dry friction [4]. This effect, having the undoubtedly applied meaningfulness, is by nature related to the processes of destruction of superficial layer and with anticipating destruction plastic deformation of superficial layer.

Coming from these physical conformities to the law, the purpose of these researches consists of construction of model of monitoring of destruction of solids, coming from the pictures of transformations of bands of interactive distributions (generators of signals of emissions) and cracks (transmitters of destruction). Within the framework of the offered model the imperfect structure of material evolves as follows. In the beginning under the action of the mechanical loading, service of material (for example, by a contact with the moving body of friction) conditioned by birth, distributions are intensively generated in a superficial layer. The flat accumulations of distributions, put on the brakes the scopes of corns and other internal obstacles, serve as the embryos of cracks whose growth takes place due to absorption of distributions. Development of the system of cracks, attended with absorption of distributions, results in a rapid confluence of cracks and in the total to the avalanche removing a layer by the layer of particles of superficial layer. The particles of destruction, removed a layer by a layer of material, take away with itself cracks and bare a new superficial layer for a contact with the body of friction. In a new superficial layer again, there is an accumulation of distributions and cracks. The process of removing a layer by the layer of particles is thus hampered. Then, as a result of development of the system of cracks again, there is an avalanche removing a layer by the layer of particles, bare a new superficial layer et cetera.

If a metal is examined as a system, generally nonlinear, it is possible to apply to it the known methods of control of the state, such as an analysis of transmission function on entrance influence and response of the system. Such approach allows not to sink in consideration and analysis of processes of flows in a metal during exploitation in time, but allows to describe current status of the system, which is characterized as steady or unsteady. Under the stable state the capable working state of the system is understood, i.e. it is described by the legitimate values of the explored parameters in a certain moment of time. Every system must be foremost capable of working, i.e. must normally function and be insensitive to extraneous indignations of different family. For the performance of any practical objectives the system must be steady. Stability is property of the system to go back into the initial or near to it set mode after an exit from it as a result of some influence.

Within the framework of the offered model periodicity of evolution of band of interactive distributions and cracks in a superficial layer can be described the system of nonlinear differential

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equalizations which can be decided in separate rare cases. However, regenerate equalizations of large number of the systems can be linear. Thus processes in the systems are described as linear differential equalizations of the kind [5]:

$$a_n y^{(n)}(t) + a_{n-1} y^{(n-1)}(t + \dots + a_0 y(t)) = b_m x^m(t) + \dots + b_0 x(t).$$
(1)

The decision of differential equalization (1) is related to calculable difficulties, therefore research of the system is conducted by indirect methods, being based on the operating method of Laplas and transformation of Fur'e. For this purpose the following basic descriptions are used: transmission function, transitional and impulsive-transitional function, complex coefficient of transmission and frequency description.

The widest application was obtained by the use of transmission function which is determined from the following correlation: applying transformation of Laplas to equalization (1), we will get

$$D(p)Y(p) = N(p)X(p) + M_{H}(p),$$
(2)

where

$$D(p) = a_n p^n + a_{n-1} p^{n-1} + \dots + a_0,$$
(3)

$$N(p) = b_m p^m + b_{m-1} p^{m-1} + \dots + b_0.$$
<sup>(4)</sup>

Y(p) is transformation of Laplas for the output signal of the system; X(p) is transformation of Laplas for an output signal;  $M_{\mu}(p)$  is a polynomial, representing the initial conditions.

We will enter the followings denotations:

$$W(p) = N(p)/D(p); W_H(p) = M_H(p)/D(p).$$
 (5)

Then expression (2) will be adopted by a kind

$$Y(p) = W(p)X(p) + W_{H}(p).$$
 (6)

This equalization is linked by representing the output signal of the system with representing an entrance signal and initial state of the system. The function of W(p) characterizes dynamic properties of the system, she does not depend on managing influence and fully determined the parameters of the system of  $a_i$  and  $b_i$ , this function is named a transmission, and function  $W_H(p)$ – by a transmission function in relation to the initial state of the system.

At zero initial conditions the transmission function of the system is equal to attitude of image on Laplas of output signal toward transformation of Laplas entrance signal. A transmission function is shown a rational function in relation to the operator of transformation of Laplas:

$$W(p) = \frac{b_m p^m + b_{m-1} p^{m-1} + \dots + b}{a_n p^n + a_{n-1} p^{n-1} + \dots + a_x}.$$
(7)

For realization of such an approach the entrance affecting system must be a step or impulsive one.

Impulsive influence can be presented as an aggregate of influence of harmonic constituents. For the decision of tasks at impulsive excitation the transformer frequency methods can be applied, based on the mathematical vehicle of transformations of Fur'e and Laplas.

An important moment of analysis of the state of the system is drafting of his mathematical model.

The variety of models is determined by various approach to the decision and analysis. If a model is simple enough and described by an easy linear equalization it can be rationally applied to a temporary realm. But if equalization shows difficulty, it can appear that passing to the frequency area simplifies a decision on an order. For some models, frequency description can be obtained analytically, but it is impossible to find a decision in a temporary realm.

Direct transformation of temporary realm to the frequency area is generally possible only for linear models in a temporary realm. However, formulated satisfactory empiric models can be directly applied in a frequency area.

Frequency description can be simply obtained by a transmission function, replacing the parameter of p its imaginary part of wi. As W(p) is an analytical function, its conduct along an imaginary axis in the plane of p will determine its general character in all complex plane. The empiric functions of transmissions can be found directly from experimental data. On the basis of response to an impulsive entrance signal a transmission function, relation of amplitudes (amplification factor) and phase corner, can be appraised (lag on a phase, difference of phases).

Transmission function of the system on which depends the external influence on the law of change of this influence is determined only by properties of the system [6].

Using the mathematical vehicle of transformations of Laplas it is possible to analyse a transmission function as connection between the signals of entrances and outputs of electromagnetic transformer at any moment of time.

In the examined case a research object is a metal which is characterized as a nonlinear system. For simplification of analysis of such systems the linear approaching is used based on the followings positions:

1. If characteristic equalization of the linear system has all roots with negative material parts, the actual system will be steady. Members of the second can not change high degrees stability of the system cast aside at transformation of equalization.

2. If even one root has characteristic equalization with positive material part, the actual system will be unsteady. Cast aside members of the second can not give high degrees of the system stability.

3. If characteristic equalization has even one zero root or pair of the imaginary attended roots, the conduct of the actual system can not be determined by its linear equalization. Members of the second and high degrees can radically change the description of the process of the real system cast aside in this case.

For research of the nonlinear system it is suggested to use the method of trajectories of phases, the essence of which consists in the following [7]. If any system is described by differential equalization of n – oho order, its state is determined at every instant by the value of the managed size of x or any other size. Multidimensional space of co-ordinates of the explored size of x is named phase space. Point in phase space with the current values of co-ordinates, determining the state of the system (or phase), is named a depicting point. The co-ordinates of depicting point change at any change of the state of the system. The trajectory of its motion in phase space is named a phase trajectory. The initial conditions of the system determine initial position of depicting point in phase space. Aggregate of trajectories makes a phase picture (portrait), characterizing all possible states of the explored system.

The method of trajectories of phases is practically used for the systems of the second and third order. For equalizations of the third order phase space is three-dimensional geometrical space, a phase plane turns out at two co-ordinates, and at one variable is a phase line.

The method of trajectories of phases differs in geometrical evidence and in combination with other methods allows to get the complete picture of the character of possible changes in the system.

### CONCLUSION

Using the above-described methods for research, analysis and estimation of current status of material will allow to judge the actual state of metal without consideration and analysis of flows in its processes at any moment of time.

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