ANALYSIS OF DEFORMATION PROCESS OF METAL MATERIALS UNDER LOADS OF VARIOUS TYPES BY AMD-METHODS

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Metallic materials are commonly used in practical applications objects. Their state plays a leading role in the process of operation. The condition of materials is influenced by various external influences. Such influences manifested in the process of manufacture and in the operation should be attributed primarily to processes of diffusion. They substantially change the physical parameters of the surface layers. Therefore, the actual task of assessment of health products and predicting their behavior. To monitor the status of materials by means of acoustic waves (AW) was proposed for solving this task, i.e., to use AMD-methods [1]. GHz- range was chosen to ensure sufficiently high resolution.

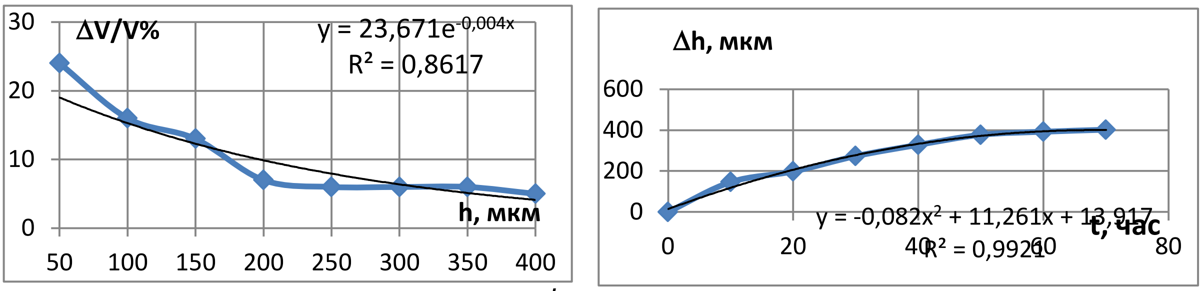

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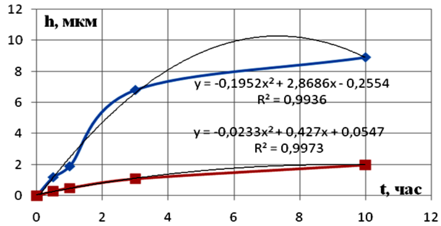
Figure 1 - a) The dependence of the absorption level of AW in the surface layers of steel (38ХМЮА) depth of nitriding layer (t^0 process 560^0C); b) The dependence of the thickness of the layer with altered properties on the time of nitriding (at $t^0 = 500^0$C) obtained by the change of speed υ_R of surface acoustic waves in steel (40ХНМА).

The essence of the work was to develop methods for studying the state of the materials and in the assessment of the level of exposure of diffusion processes using the AMD methods. The objects of the study - model materials and steel of various types. It is experimentally shown that AMD-methods sensitive to diffusion effects. For example, the processes of carburizing and nitriding of steels demonstrates the dependence of the number of characteristics of acoustic waves (AW) on the parameters of diffusion processes. These settings include, first, the concentration of a substance- diffusion, temperature and time of process. In Fig.1 shows the examples of the dependence of the absorption level of AW in the surface layers of steel on the depth of the nitriding layer and the dependence of the thickness of the layer with altered properties on the time of nitriding obtained by the change of speed υ_R of surface acoustic waves in steel. The parameters of the processes of carburizing and nitriding were evaluated using AMD-methods [2] based on the measurements of acoustic characteristics of materials (level of attenuation □V/V%, velocities of acoustic waves, □$_R$, elastic modulus).

As parameters of the deformation process we have chosen the values of the speed of surfactant □$_R$□□ the decay rate of these waves □□V/V% □ [4,5]. T obtained based on the thickness of the layer with altered properties from the concentration of the substance - diffusant, the temperature and time of the process, and the strength characteristics. The thickness of the diffusion layer was estimated by the parameter □V/V%. The results of the model experiment are shown in Fig.2. An example model study of the diffusion process AMD methods. In the experiment, we determined the thickness of the SiO_2 - films obtained by oxidation of silicon in an atmosphere of water vapor. To change the speed values of the surfactants (and the corresponding dispersion according to [4]) calculates the layer thickness h (μm), which, as follows from the graph was varied from 2 to 9 microns.



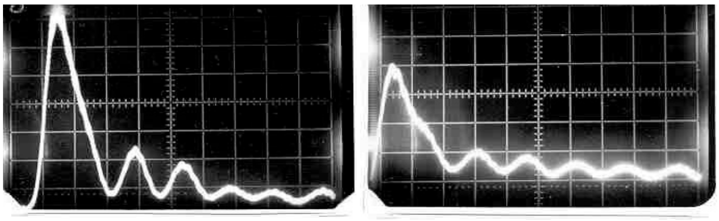
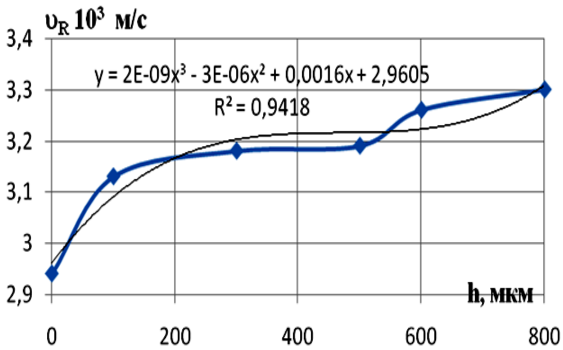


Figure 2 - The dependence of the thickness of the diffusion layer is SiO_2 (on silicon) by oxidation in H_2O at T^0 annealing 1200 ^{0}C (top) and 1000 ^{0}C (lower curve)

Figure 3 - The transformation V(Z)- curve in the steel 30ХГСМЛ ((υ_R = 3,18 $\cdot 10^3$ m/s, ΔZ_N = 14,68 μm, $(\Delta V/V\%)_{max}$= 37%, vertical scale 1 div.= 0.25 V, horizontal – 1 div.=12,2 μm) after carburizing at 940^{0}C, 2 hours.

And, changes in the shape of the V(Z) curve during deformation of the sample are shown in Fig. 3. For the studied steels (38ХМЮА, 40ХНМА, for example), at a temperature of carburizing, the diffusion layer consists of austenite, and after slow cooling from its decomposition products of ferrite and cementite. The effective thickness of the cemented layer is usually set to a value of the control parameter hardness (e.g., HRC 60) and varies from a fraction to several millimeters. Cementation was carried out at 940 ^{0}C for 2.5 hours (up to 0.8 mm layer). At the end of the process - leave with T^{0}C ~ 165-175^{0}C. The change in time of the ongoing process led to a change in the structure of the surface layers and, consequently, to a change in their acoustic characteristics. Similar results were obtained in measurements using the AMD-methods the characteristics of the materials that have passed the nitriding process. Nitriding is carried out in ammonia atmosphere, which leads to surface saturation with nitrogen and increase its hardness (saved to ~680 ^{0}C, i.e. at ~300-330 ^{0}C higher than for cemented materials). In order of magnitude, the obtained values of xi showed a good coincidence with the design (was ~100 μm).
The main steps of measurement of the diffusion effects on steel are presented in Fig. 4, 5 and Fig. 6, 7).



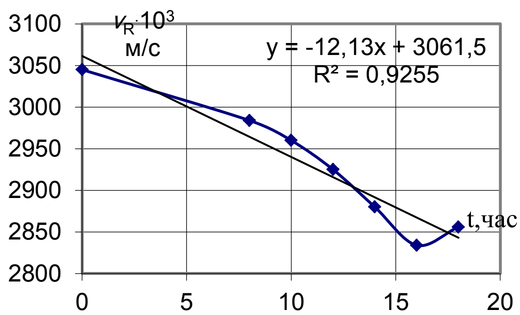
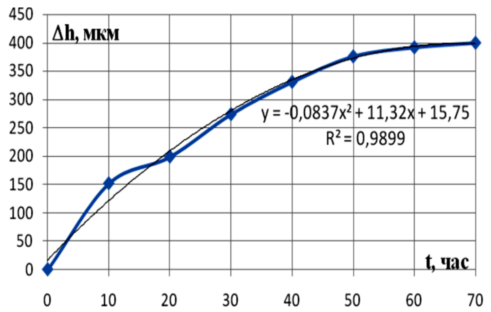


Figure 4 - Dependence υ_R on h in the cementation of steel (for example, 18HGT)

Figure 5- Change the speed of surfactants in steel (30ХГТ), depending on the time of cementation (for control surface for 16-17 hours speed υ_R is reduced by 7% from 3050 to 2840 m/s).



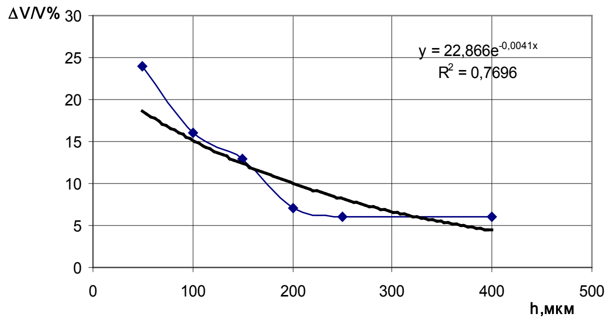


Figure 6 - The dependence of the thickness of the layer with altered properties on the time of nitriding obtained by the change of speed saw in steel (40XHMA), (T^0 of process 500^0C; the optimal time is 60 hours).

Figure 7 - The dependence of the absorption level of AW in the surface layers of steel (38ХМЮА) depth of nitriding layer (T^0 of process 560^0C). With the depth of ~250 μm steel is not subjected to the nitriding process.

The experiments confirm the high sensitivity of AMD-methods as parameters of the deformation process and their changes [6]. This fact allows one to monitor the processes of deformation, control the structure of materials, identify and characterize system defects and properties of solid materials.

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