THE STUDY OF PHYSICAL - MECHANICAL PROPERTIES OF HYDRIDES AND OTHER MATERIALS IN A CONDENSED STATE BY FAULT DETECTION ACOUSTIC MICROSCOPY METHODS

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Introduction

One of the urgent problems of science today is the problem of control over physical-chemical and physical-mechanical properties of metal hydrides, carbonaceous nanostructural materials and other materials in a condensed state.

The paper deals with the results of experimental researches of materials in a condensed state by fault detection acoustic microscopy methods. The essence of these methods lies in layer visualization of subsurface structures of the objects being studied with the following analysis of the images being received as well as in measurement of values of acoustic wave velocities and calculation of the elastic constants of the material. The nondestructive research method being used are not limited by the nature of materials – the objects may be dielectrics, metals, crystalline and amorphous substances including hydrides and nanomaterials. Metals, mainly steels were chosen as model objects for experimental research. The properties of such solid mass materials are influenced by chemical composition, structure, phase structure, thermal and deformation effects.

Results and discussion

Using acoustic visualization method [1,2] it was possible to obtain the images of the samples steel structures at different depths from the surface. The example of one of the images is presented in Fig.1. In it with the magnify in 320^x the structure of martencite steel is seen. After deformation and thermal effects the structure is being transformed. Acoustic microscopy method of V(Z)-curves [3] essentially widens possibilities of obtaining information about the material being studied. It enables to obtain typical curves for the given material, which stipulated by its elastic-mechanical constants. The example of such a curve for steel of austenite class is represented in Fig.2.

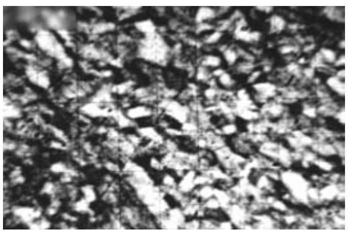


Fig.1.

This curve allows by means of characteristic distances ΔZ_N between maximums which lie to the right from the main one to count the values of the velocity υ_R of the surface acoustic waves (SAW) [4]. If the value of the velocity of acoustic waves υ_l in immersion liquid and the working frequency f of acoustic microscope are known, it is possible using the experimentally determined interval ΔZ_N to calculate:

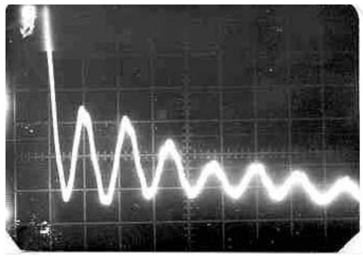


Fig.2.

$$\upsilon_R = \upsilon_l \left[1 - \left(1 - \frac{\upsilon_l}{2 \cdot f \cdot \Delta Z_N} \right)^2 \right]^{-1/2}$$

For most of the materials being studied the table values of the density ρ_s and their Poisson coefficient ν can be used or determined by one of the known standard methods [4]. In this case it is also possible to calculate the values of the elasticity modules of the material being studied in the local zone with the help of the expressions:

$$E = \upsilon_R^2 \cdot \frac{2 \cdot \rho_s \cdot (1+\nu)^3}{(0{,}87 + 1{,}12 \cdot \nu)^2}$$

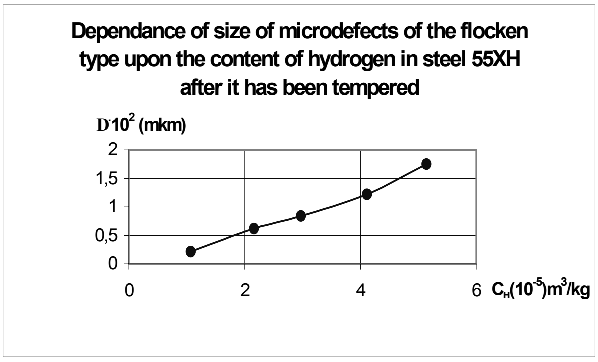
and $$G = \upsilon_R^2 \cdot \rho_s \cdot \left(\frac{1+\nu}{0{,}87 + 1{,}12\nu} \right)^2$$

The level of localization or diameter of the research zone can be calculated using the formula:

$$d = 2{,}5 \cdot \lambda_R \cdot \left(\frac{1+\cos\theta_R}{\cos\theta_R} \right),$$ where λ_R – is the length of the surface acoustic waves of reighley type , θ_R – reighley angle.

The worked out acoustic microscopy methods give the possibility to obtain both concrete physical-mechanical properties of materials in their condensed state and their correlation dependencies upon time, thermal and mechanical treatment regimes, chemical and phase compositions. These methods can in full measure be applied to studying metal hydrides and carbon nanomaterials as well.

As examples for a number of steels it is possible to consider dependencies of the number of originating defects of the flocken type, change of the velocity values of surface acoustic waves (SAW), characteristics of the absorption process (ΔV/V), sizes of appearing heterogeneities upon concentration of the diffunding hydrogen, time of relaxation, rate of deformation, etc. According to the results of acoustic visualization of the



structure of steel of the 55XH type it was obtained the dependence of sizes of flocken type defects which is represented in Fig.3 upon the content of hydrogen after the tempering of steel.

Fig.3.

Change of velocity values of surface acoustic waves (SAW) in the same type of steel according to the relaxation speed is represented in Fig.4. from which it is seen that during a little more than a day period a considerable (for 10 – 12%) drop of speed values is being observed. This phenomenon may be connected to the release of hydrogen which is especially significant in the first 20 – 40 hours for the given sorts of steel.

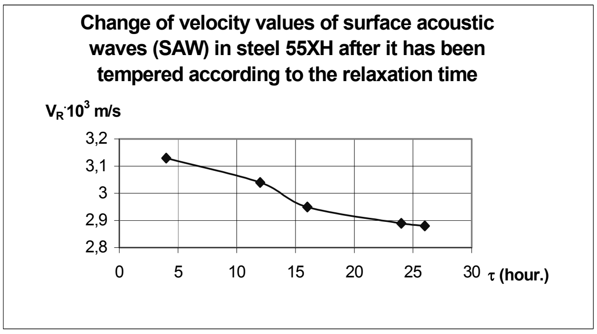


Fig.4.

The hydrogen release in steels leading to forming nonhomogeneous structures of the flocken type, intensifies absorption of acoustic waves in model objects. This process is manifested in the form of change of characteristics of fading of surface acoustic waves (SAW) and transformation of the height of the main maximum of the V(Z)- curves. Fig.5 shows the dependence of the relative height ΔV/V upon the hydrogen concentration in steel after the latter has been tempered.

Similar dependencies were also obtained for steel 40 XH. One should pay his attention to the measurement result of υ_R in this steel in

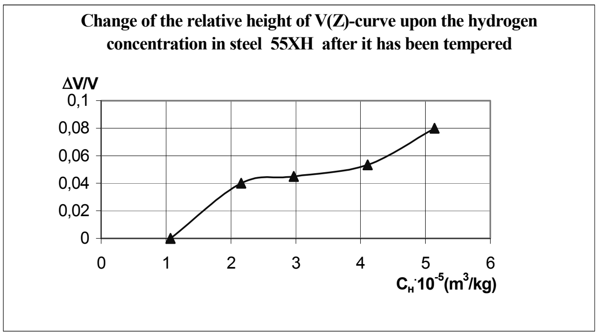


Fig.5.

accordance with the depth of sounding (Fig.6.) and the time of its sustaining in hydrogen (Fig.7.).

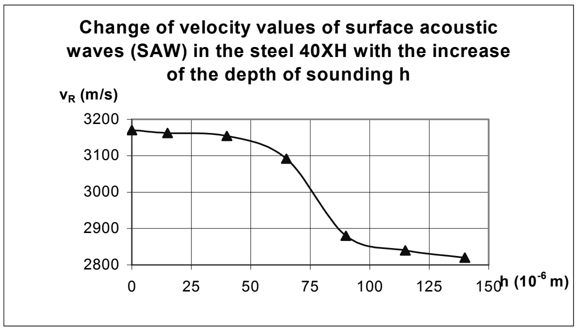


Fig.6.

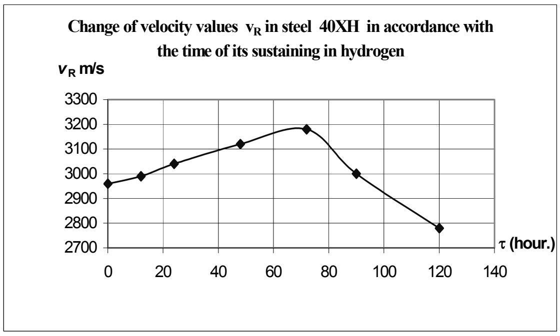


Fig.7.

Conclusions

Fault detection acoustic microscopy methods have prospects for studying the effect of hydrogen on condensed state materials, metal hydrides and carbonaceous nanomaterials.

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