WORK UP OF LIMIT STATE CRITERIA FOR HYDROGEN CONTAINING SOLID MATERIALS WITH ACOUSTIC MICROSCOPE DEFECTOSCOPY METHODS

Kustov A.I. [*]**, Migel I.A.**
[*] Voronezh State Pedagogical University, Lenin street 86, Russia 394043
Voronezh Military Air Engineering Institute, Starikh Bolshevikov street 27, Russia 394064

Introduction

The problem of reveals the limit state of solid materials including the hydrogenous ones has become urgent recently. The state of the material when it is close to the loss of stability is called limit. Different limit criteria are applied depending on the operation conditions (force of the temperature, stress, etc.). They are often different characteristics of physical – mechanical properties. Therefore, the state is limit on the reaching which the material inevitably changes its properties on engaging some structural parameter. It is necessary to reveal such states at the possibly initial stages. First the local structure changes inner stress, physical-mechanical parameters (e.g. the velocity of acoustic waves (AW)) can be used as the limit criteria.

The paper deals with the study of process modifications of the elastic-mechanical characteristics of materials, the damage accumulation, the output of the limit state criteria for them.

Results and discussion

The limit state reveal at the initial stages can be carried out by sensitive to microinhomogeneous methods. The limit criteria are possible to be evaluated according to the quantity, form, and distribution in volume of such inhomogeneities. Acoustic microscope defectoscopy methods actively developing in the in the atest 15 – 20 years can be referred to such methods [1,2]. They allow both to get subsurface acoustic images of object microstructures and to define their physical – mechanical characteristics. Therefore, it was suggested to apply a scanning acoustic microscope (SAM) of the reflective type [3] for the nondestructive control of the hydrogenous materials.

In Fig. 1 the acoustic image of subsurface layers of the steel sample (08X21H6M2T), subjected to corrosion is presented. The pitting with the special dimensions of 3 – 15 μm are visualized with high resolution. Besides, the depth of demonstration of the defects, their dimensions and quantity in the raster allow to judge by the limit state. It was not possible to reveal such inhomogeneities both at the optical images and with the help of some other scientific methods. The other example of the output of the limit state criterion is connected with the appearance in the hydrogenous metals of the cracks of flocken type.

The material reliability is evalu-ated conce-rning its dimensions, dynamics of development, increase velocity.

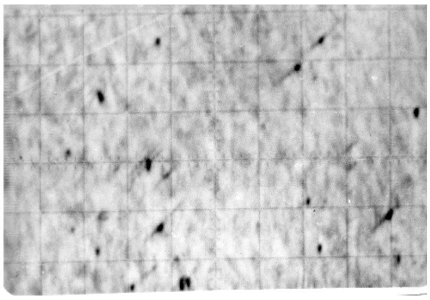

Fig.1. (The pitting, scale 35 μm/div., Hg, Z=-7 μm).

In Fig.2 the acoustic microscopy image of a microcrack in the austenite class steel at the depth of ~ 40 μm is presented. It is also possible to apply acoustic microscopy methods based on the use of V(Z) – curves for the study of the limit state of the materials in a solid state [4,5].

It makes it possible to calculate the values of velocities SAW and to define the quantity of the coeffi – cient changes of AW fading in the

Fig.2. (Microcrack, scale 20 μm/div., Hg, Z=-40 μm).

material at the relative modification $\Delta V/V$ of height of the main maximum of the V(Z) – curves. The elastic – mechanical characteristics of material change at the diffusion into hydrogen material, which manifests itself in the changes of velocity SAW υ_R and the level of $\Delta V/V$.

The control technology of limit state with appliance of V(Z) – curves consists of the analysis of their form transformation. The values of velocities of surface acoustic waves (SAW) and the change of the level of their fading were calculated due to the special dependencies. The limit state of material conclusion was made according to the dimension of local fluctuations of physical – mechanical parameters. The example of inhomogeneity distribution in the investigated object, with the appliance of the V(Z) – curves is presented in Fig. 3. As a model in this case the glass with microdefects included was used. The number and dimensions of microdefects are one of the criteria of limit state.

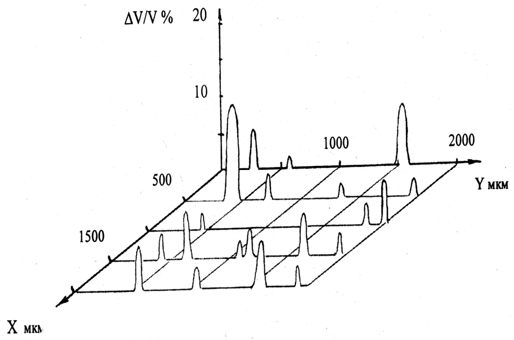

Fig.3. It is an example of the inhomogeneity distribution watch and dimension measure of microdefects in the glass object, inside raster 2x2 mm^2.

It is possible to estimate the value and some other sample characteristics, for example the hydrogen concentration, according to the changes of the velocity SAW and the relative height ΔV/V of the maximum V(Z) – curve [6].

The dependencies both between the hydrogen concentration and the number of the microcracks emerged, and the values of velocity SAW on depth of the hydrogen penetration into the sample, period of diffusion, etc. are received at that. The limit hydrogen concentration in this material can be evaluated concerning the value of velocity SAW from the received dependence for steel (Fig.4).

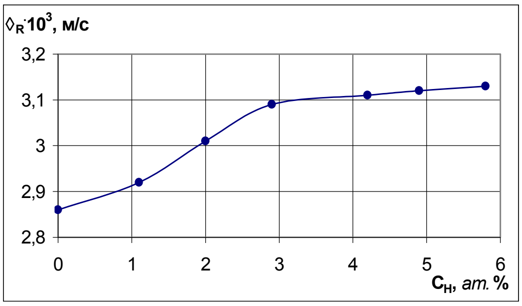

Fig.4. The dependence of velocity SAW in steel 55XH on the hydrogen concentration level.

The results of the experiments illustrating the possibility to define the thickness of the modified layer caused by hydrogen diffusion in the metal materials according to the value of velocity SAW or the ratio ΔV/V% were presented before. The difference between the initial and modified material according to these characteristics can reach 5 – 20%. And, finally, the limit state of material is defined considerably by the parameters of the mechanical influences on it including the number of load cycles. The accumulation of damage defects in the material takes place at the increase of the cycles of influence on the material. The process under consideration can reach the extreme parameter on the intersection of which the investigated object will be destroyed. It is possible to define this extreme parameter with the appliance of the V(Z) – curves. In Fig. 5 the result of investigations of the dependence of the value of AW absorption level (ΔV/V%) on the number of load cycles for steel 08X18H10T is presented. It can be seen from the picture that the sharp, practically line height of the absorption level is observed at the increase of the cycles to 3000. This proves the active flow of the processes of the structure reorganization. The absorption level is not changed up to 8000 – 9000 cycles, then a significant increase resulting in destruction (at 15000–17000 cycles) starts.

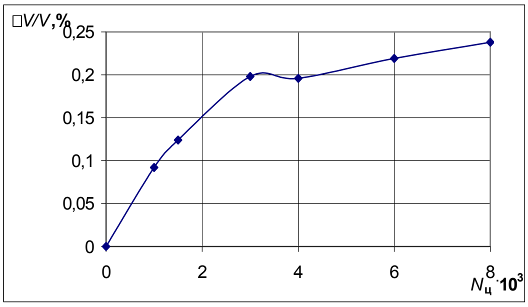

Fig.5. Dependence of the absorption level (ΔV/V%) on the number ($N_ц$) of load cycles for steel 08X18H10T.

Conclusion

The results obtained have proved the possibility of output of the limit state criteria of the hydrogenous materials by applying acoustic microscope defectoscopy methods.

References

1. Куэйт К.Ф., Аталар А., Викрамасинг Х.К. Акустическая микроскопия с механическим сканированием.// ТИИЭР, 1979, т.67, N8, с.5-31
2. Atalar A. An angular spectrum approach to contrast in acoustic microscopy // J.Appl.Phys.1978. V.49. N10. P.5130-5139.
3. Кулаков М.А, Кустов А.И, Морозов А.И. Сканирующий акустический микроскоп // Приборы и техника эксперимента, 1986, N 2, с. 194-196.
4. Кустов А.И. Обнаружение неоднородностей акустомикроскопическими методами // "Физика и химия стекла", 1998, т.24, № 6, с.809-816.
5. Кустов А.И., Мигель И.А. Суходолов Б.Г. Изучение влияния различных видов термомеханической обработки на структуру и свойства сталей и сплавов // Металловедение и термообработка металлов", 1998,№ 4, с.128-137.
6. Budanov A.V., Kustov A.I., Migel I.A. The study of the effect of hydrogen on physical-mechanical properties of steel by acoustic microscopy methods // Hydrogen materials science…, Science Series, II. Mathematics, Physics…, ed. M.D.Hampton, Dm.Schur, vol. 71 – 2002 - p.131-140.