ASSESSMENT OF PRE-DEFECT STATE OF INHOMOGENEOUS SURFACE LAYER OF STRUCTURAL MATERIALS ON THE BASIS OF DISPERSION ACOUSTIC EFFECTS OF RAYLEIGH SURFACE WAVES

Mokryy O.[1], Semak P.[1], Romanyshyn I.[1], Semak S.[2],

[1] Karpenko Physico-Mechanical Institute of the NAS of Ukraine, Naukova str. 5, 79060, Lviv, Ukraine
[2] Scientific-Technical and Educational Center of Low-Temperature Studies, Ivan Franko National University of Lviv, Dragomanova str. 50, 79005 Lviv, Ukraine

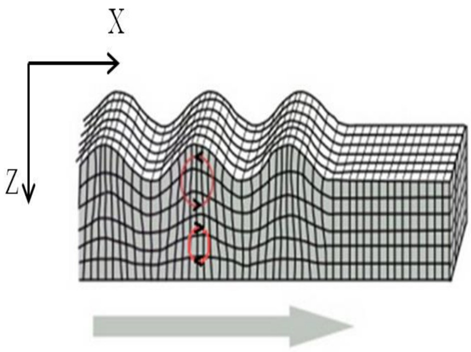
An urgent task of fundamental materials science and technical diagnostics is to evaluate the parameters of the pre-defect state (damage, plastic deformation, etc.) of the inhomogeneous surface layer of structural materials by non-destructive methods.

To solve this problem, it is reasonable to use Rayleigh surface waves, not only in the traditional sense (based on the use of propagation velocity and attenuation as informative parameters), but also in a broader sense, which is based on the use of modulation, nonlinear, dispersion, dissipative acoustic effects that occur during material degradation much earlier than traditional (change of propagation velocity and attenuation). Since the velocity, attenuation and "structure" of the Rayleigh wave are related to the mechanical, thermal and other characteristics of the sample`s surface layer in which it propagates, these parameters can be used to obtain information about the state of the sample`s surface layer.

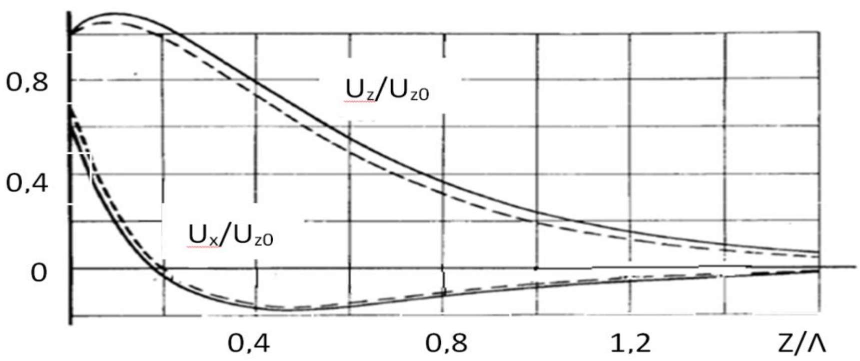
This paper considers the physical model of a sample with an inhomogeneous surface layer, the interaction of the parameters of this layer with the Rayleigh surface wave and the penetration depth, which depends on the frequency of the probing wave. The information technologies of estimation of material condition parameters by means of probing its surface acoustic waves of different frequency, registration of transmission waves on the basis of rigidly connected piezoelectric transducer of tandem type (emitter and two receivers are rigidly connected and located on one line) and processing of registered signals taking into account the dispersion effects (dependence of the wave propagation depth on the frequency) are resulted.

The results of experimental approbation of the developed method on the steam power plant and on the coated sample, as well as comparison of the results with metallographic studies are given. The obtained estimates of the inhomogeneous distribution of parameters by the non-destructive method showed good correspondence with the estimates by the destructive metallographic method.

Physical bases of measurement methods



Polarization of the surface acoustic wave



Distribution of displacements along the depth in the surface acoustic wave

((Viktorov I. A., 1981)

$$V_R \approx V_t \cdot \frac{0.72 - \frac{V_t^{\,2}}{V_L^{\,2}}}{0.75 - \frac{V_t^2}{V_L^2}} = \sqrt{\frac{C_{44}}{\rho}} \cdot \frac{0.72 - \frac{C_{44}}{C_{11}}}{0.75 - \frac{C_{44}}{C_{11}}}$$

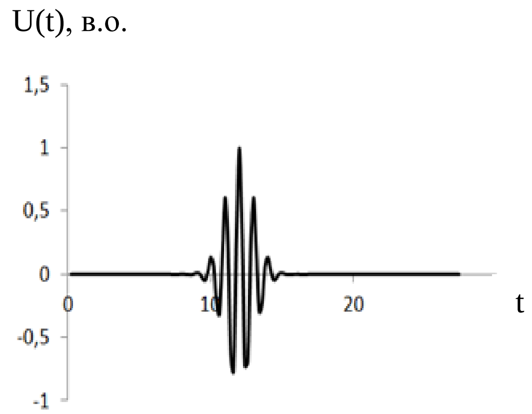
V_R – velocity of Rayleigh acoustic wave;

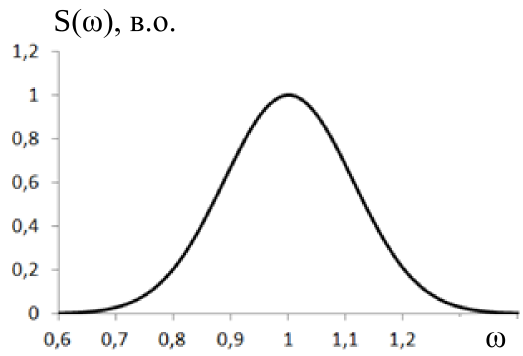
V_L – longitudinal acoustic wave velocity;

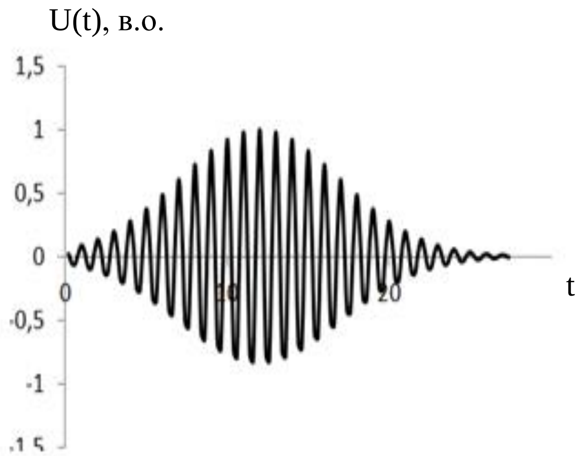
V_t – transverse acoustic wave velocity.

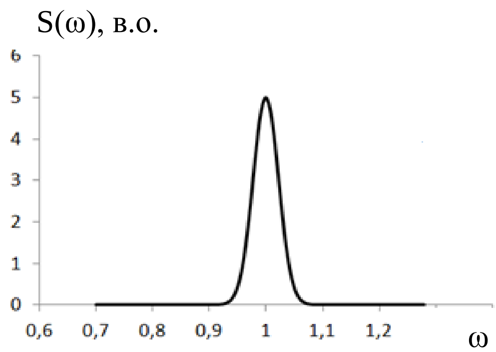
Acoustic signal

Spectrum

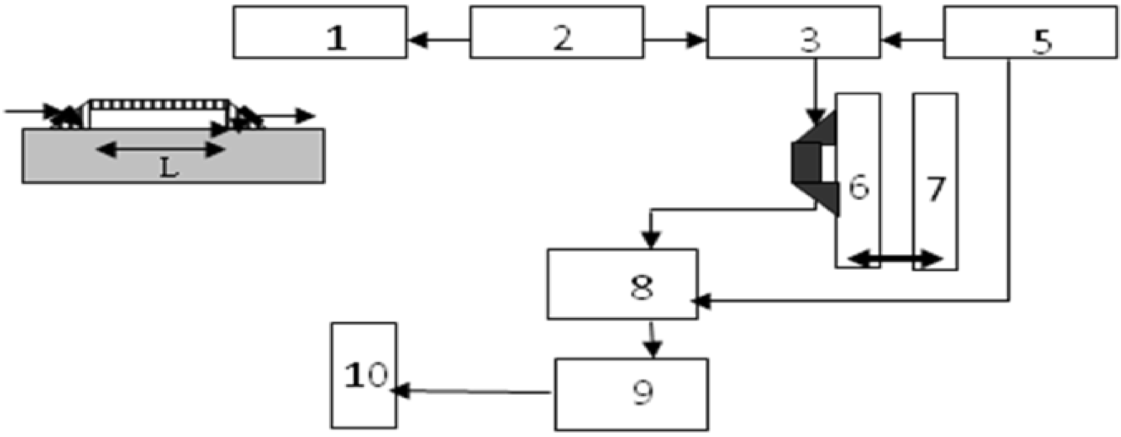








Method for determining the dispersion of the surface acoustic waves velocity:



1 – frequency meter;

2 - generator;

3 – modulator;

4 – synchronization unit;

5 – bipulse generator;

6 – object of control;

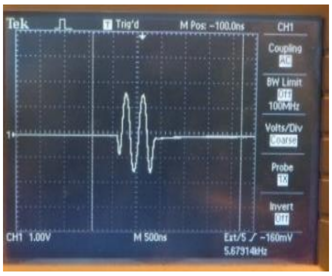
7 – comparison sample;

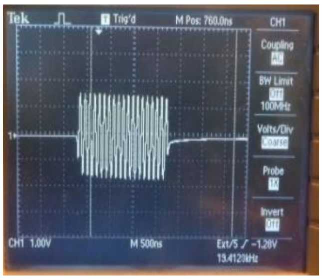
8 – amplifier;

9 – oscillograph;

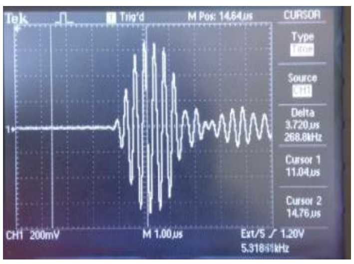
10 – computer;

11 – transformer.

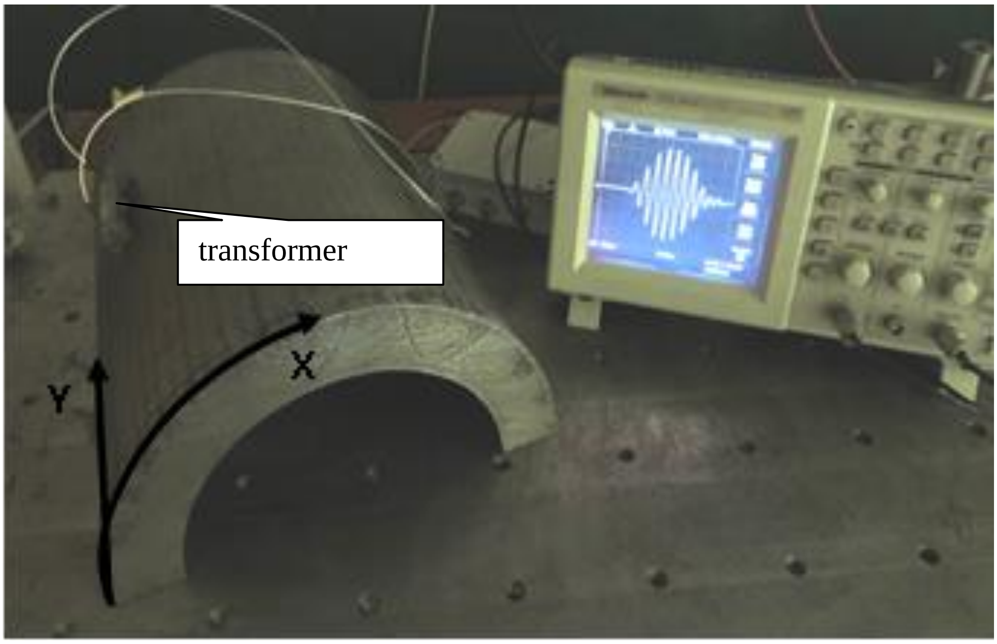




Acoustic pulse excitation signals



The received signal from the surface acoustic wave



Cutting of a paragon with the converter and means of registration of an acoustic wave.

Waves with a frequency of 2, 3, 6.4 MHz were used.

The surface acoustic wave propagated parallel to the axis of the paragon.

Pipe diameter – 273 mm

Wall thickness – 39 mm

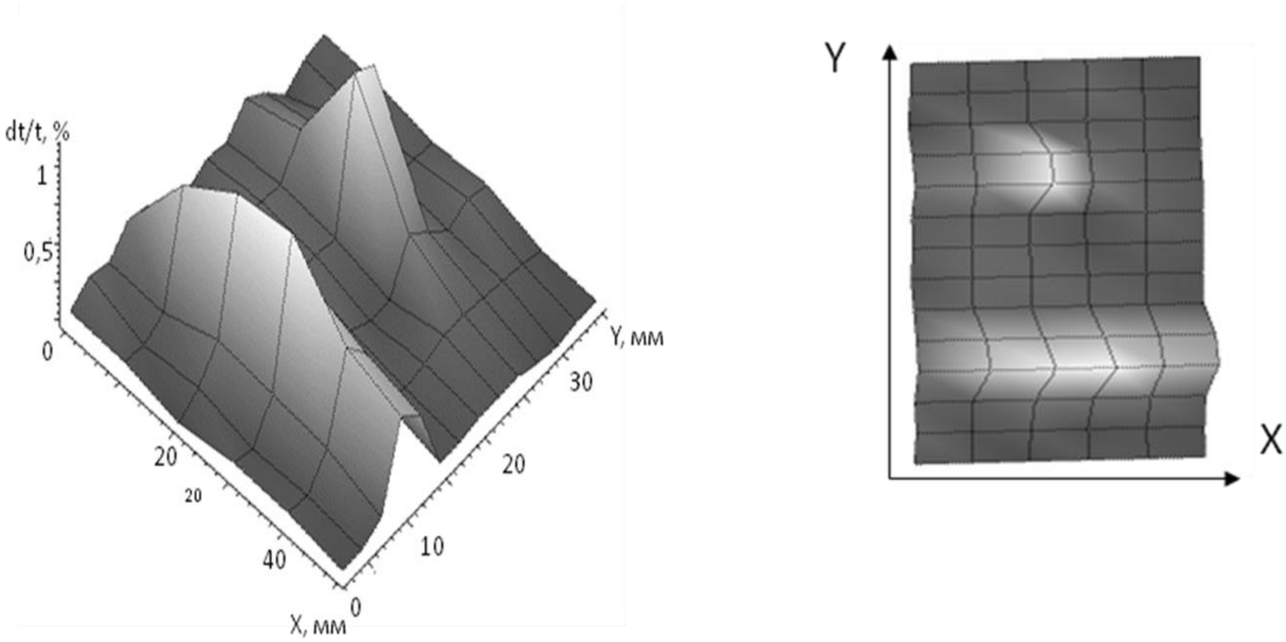
Length – 440 mm

Material – 12X1MF

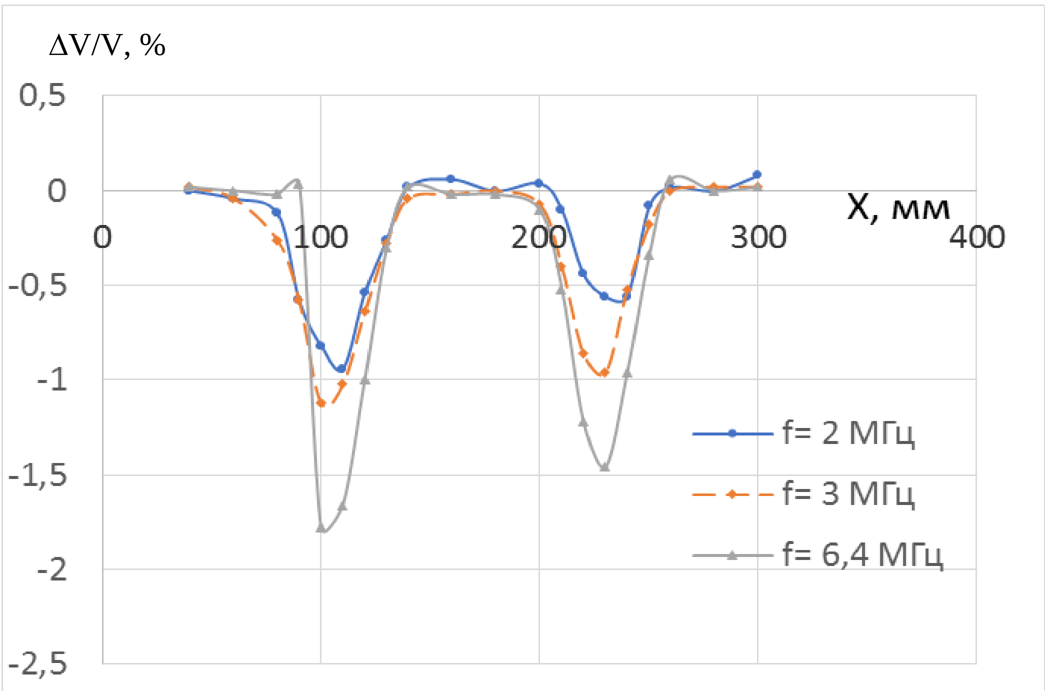
Operating time – 100 000 h.

Chemical composition:

C	Cr	Mo	V	Si	Mn	S	P
0,1	1,1	0,26	0,17	0,26	0,54	0,26	0,015

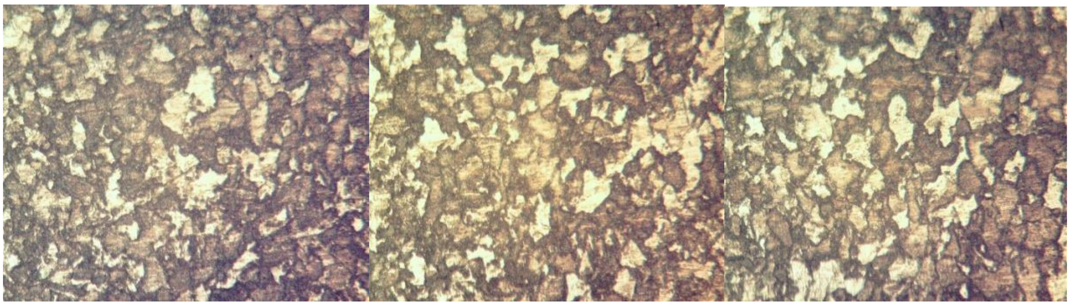


The distribution of the speed of the surface acoustic wave with a frequency of 3 MHz.

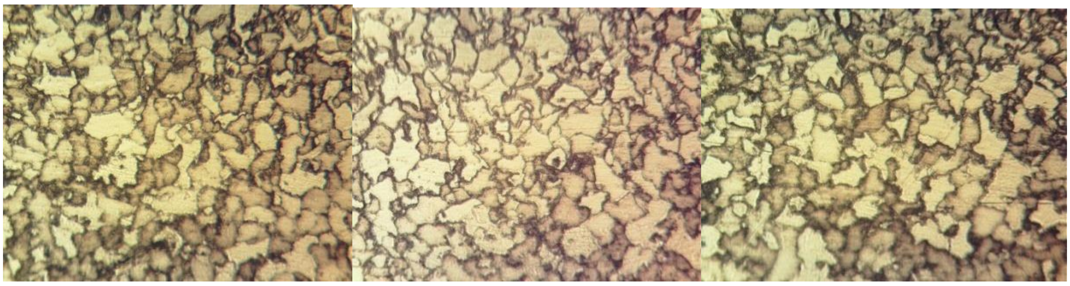


Frequency dependence of the surface acoustic wave velocity along the X axis. (Y=150 мм).

Metallographic studies of the threshold.



Photos of microsections of comparison sites



Photos of microsections of sections with anomalous velocity

The correlation between the change in the surface acoustic wave rate and the structure of the metal (decarburization, decay of cementite, etc.).

Determination of areas with anomalous local velocity of the surface acoustic wave can be used to identify damaged sections of the steam.