1.5.21. OPTICAL NON-DESTRUCTIVE TESTING OF LIGHT SCATTERING MATERIALS

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Let us consider the passage of radiant flux through a plane-parallel plate of the scattering and absorbing light substance, inside of which there is a defect (dislocation) – a flat air layer with thickness d. Substance plate is characterized by the following constants: k_1 and k_2 – which are responsible for the scattering and absorption of light, n – the index of light scattering of refractive material in relation to the air. As for the air layer, these constants have the following values:

$$k_1 = k_2 = 0, \ \ n = 1.$$

Let's take the thickness of the plate equal to z_0 and assume that at a distance z' from the top plane of the plate and z'' the bottom is situated at the air layer.

A pass factor for the plate with a defect is

$$t = (1-\rho')\frac{t(z')t(z'')}{1-r(z')r(z'')}, \tag{1}$$

where $t(z')$, $r(z')$, $r(z'')$ are defined by a formula similar to (1).

To calculate the coefficients k_1 and k_2 (or R and L), needed in the expression (1) indicators of reflection r and transmission t of the samples of materials are measured. Knowing these figures, one can calculate the Stokes invariant, which is a constant for the substance, as it is valid for any thickness of the layer, including those with infinitely large thickness when $t = 0$. These invariants can be written:

$$\frac{1+r^2-t^2}{2r} = \frac{k_2}{k_1} = \frac{1+R^2}{2R} = \text{const} \tag{2}$$

L and R are expressed

$$L = k_1\sqrt{\left(\frac{k_2}{k_1}\right)^2 - 1}, \quad R = \frac{k_2}{k_1} - \sqrt{\left(\frac{k_2}{k_1}\right)^2 - 1}\,. \tag{3}$$

On the other hand L can be calculated using the expression

$$L = \frac{\operatorname{arch}\dfrac{1+t^2-r^2}{2t}}{z_0}\,. \tag{4}$$

To determine the influence of an air defect on the parameters of the luminous flux propagating in the light scattering material, the three-layer system must be considered (fig. 1). In this system, the middle layer is the planar air defect with d thickness.

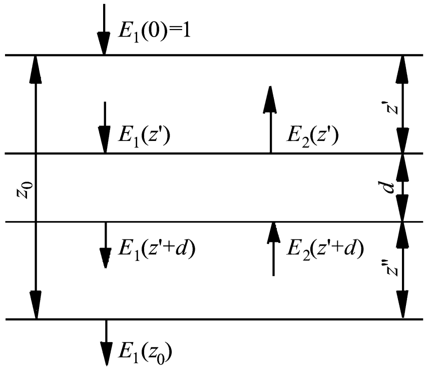

Fig. 1. The model of radiation passing through the material with a defect

Considering the passage of light radiation in 2-flows approach for one-dimensional case, it will exist on the borders of the air layer and have the following light balance:

$$E_1(z') = t(z') + r(z')E(z'); \quad E_2 = E_2(z'+d);$$

$$E_1(z'+d) = E_1(z'); \quad E_2(z'+d) = r(z'')E(z'+d). \tag{5}$$

The coefficients $t(z')$, $r(z', z'')$ of transmittance of light scattering layer with thickness z', reflectance and light scattering layer with thickness z' and z''.

Solving the system of equations (4), we obtain for the illumination of the flow on the lower plane of the air layer:

$$E_1(z'+d) = \frac{t(z')}{1 - r(z')r(z'')}. \tag{6}$$

The final illumination of the flow after a plate with a defect (air layer), you can submit with an expression:

$$E_1(z_0) = E_1(z'+d)\ \ t(z''). \tag{7}$$

In the case of defect-free material, the illumination of the flow after the plate is determined by transmittance coefficient for the entire plate thickness, i.e.:

$$E_1'(z_0) = t(z_0). \tag{8}$$

For calculation of the formula (7) the calculation of coefficients $t(z')$, $t(z'')$, $r(z')$, $r(z'')$ is required, which in their turn are determined by the Gurevich coefficients R and L. The coefficients R and L are calculated on the measure of the reflectivity r_g and transmission t_g of the sample of material. The measurements of r_g and t_g were conducted on the spectrophotometer SF-18, provided with a measuring ball.

Defect detection is determined by its contrast on the background (defect-free material). Numerically, the contrast is the contrast factor calculated by the formula

$$K = \frac{|E_d - E_b|}{E_b}, \tag{9}$$

where E_d and E_b – are the intensities of past radiation for defective and defect-free plots of controlled products.

We will consider that the sensitivity of IONK products with a defined wall thickness is determined by the possibility of detecting such defects that create a differential of intensity of a luminous flux equal to the minimum detectable for this equipment. Then, in order to find the sensitivity of the method it is necessary to investigate the dependences $K = f(d, z')$ that allow us to define the sensitivity of ONK when using any equipment and to find out the mechanism of detection of defects; z' in the Addiction – depth of the defect.