4.5.25. PROBLEM OF MODELLING OF PROPERTIES OF HETEROGENEITIES OF SOLID MEDIUMS. RESULTS AND PROSPECTS

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In practice of theoretical and experimental researches realized for a justification of developed procedures and facilities of ultrasonic methods of a non-destructive testing, the physical postulate about association of ultrasound penetration degree through boundary of two mediums from a ratio of medium impedances laying on each side of boundary is extensively used. However, numerous data collected for some decades of ultrasound methods of a non-destructive testing active introduction in different fields of industrial production, transport technologies and in other directions have shown that use only of such approach in many cases either does not allow to realize interpretation of ultrasonic monitoring measuring results at all or can result in considerable mistakes at estimation of the quantitative and quality indicators of monitoring. To eliminate indicated contradiction development of contact interaction models supposing incomplete transfer of elastic displacement while holding transfer of elastic stresses were carried out for development of hypothesis of contact conditions violation at the boundary of two solid mediums in approximation of “linear slide”. Generally, for a quantitative assessment of violation degree of elastic stress transfer value of contact rigidity or elasticity, being a tensor of the second rank and having nine independent elements (a matrix of 3×3 size) can serve. Depending on symmetry of mechanical properties of mediums on boundary the quantity of the independent elements taken into account for exposition of transfer of an elastic wave, can be diminished. So, in case of a flat symmetry on flat boundary of solid mediums, it is possible to restrict it only to two elements of a tensor responsible for transfer of normal and tangential component of elastic displacement. The phenomenological model of estimation of contact rigidities elements quantitative value is offered. This model allows taking into account not only frequency of ultrasound, but also mechanical and geometrical parameters of interacting sections of boundaries. In particular, for boundaries of cracks the imperfections formed by sections of interaction of rough surfaces relief, one can use as such parameters: radiuses of curvature of microirregularities, average distance between microirregularities, roughness parameter R_z and other values, for example such as the static pressure providing compression of opposite "shores" of a crack under action of internal stresses in a material. By obtained analytical relations it was possible to estimate limits of change of values of normal and tangential contact rigidities parameters corresponding to limiting cases: “welded” rigid contact and to case of “free” boundary. Thus it has been shown, that when only parameters of tangential contact rigidity tends to infinitesimal value it corresponds to passage to conditions of rigid mediums contact through a thin fluid interlayer, that, as a whole, was not ensured earlier by application of traditional boundary conditions. Thus proved wide practical possibilities of boundary conditions in approximation of the “linear slide” were used for solving of problem of elastic waves interaction with multilayered obstacles with flat, and also with curved cylindrical and spherical boundaries. The basis of mathematical tool for solution of such problems is the method of “transmission matrix”.

For the quantitative performances of ultrasonic fields, scattered by indicated above multilayered discontinuities, systems of reflection and transmission coefficients, and also

the complete and differential scattering cross-sections obtained by considering of transformation of wave types at boundary surfaces effect were used. At numerical estimations it is shown, that the variation of parameters of contact rigidity in physically significant limits largely influences on angular and spectral performance features of scattered fields. In particular, for flat layers the possibility of appearance of differences in an informational signal is shown depending on a direction of sonic test. For roundish-shaped heterogeneities the possibility of noticeable increasing of dispersing properties for shell-type objects is shown. Thus parameters of an interior medium (nucleus) do not influence on informational signal noticeable as they "are masked" by effects of scattering on an exterior layer. Numerical estimations were carried out for longitudinal and transverse incident waves of different polarizations and over the frequencies range and values of physical properties of mediums actual for problems of non-destructive testing of metals in ferrous and non-ferrous metallurgy. As planar and volumetric lattices of structural compact reflectors were used also. For last-mentioned values of reflection and transmission coefficients, and also quantities of effective velocities of the elastic waves spreading in formed compound mediums also were evaluated. For a lot of cases it was possible to realize comparison the theory results with results of natural experiments and earlier known results for objects such as single cavities and layers and to show their satisfactory concurrence.

Thus, development of new models of heterogeneities of metals and other materials with more composite structure has allowed more realistically interpreting of ultrasound testing results for different objects, that as a whole positively affects reliability of measuring operations results at non-destructive testing. Premises for expansion of reference reflectors class used in adjustment of sensitivity of corresponding equipment for non-destructive check have been created simultaneously. In particular, for crack heterogeneities with finite "transparency" for ultrasound one can use as substituting models of reference reflectors two-dimensional and three-dimensional lattices of compact plants such as spherical or cylindrical cavities with the relevant parameters.

The important results have been obtained additionally at the analysis of the wave processes appearing in the field of mediums, adjoining to boundaries of solid mediums on which realization of boundary conditions in approximation of "linear slide" for flat and deflected boundary surfaces is supposed possible. For example, it has been shown, that under certain combinations of physical properties of mediums, parameters of contact rigidities spreading Lowe and Stoneley waves gain dispersing character that is necessary to take into account under estimation of their potential informative possibilities.

Results of estimation of reflecting properties of crack imperfections such as "adhesion" at transmission of surface waves through heterogeneity represent special worth for practical purposes. Explicit reflection and transmission coefficients obtained allow evaluating expected level of informational signal subject to conversion of incident wave energy part to energy of "quasisurface" waves spreading along an imperfection and waves, emitted from "edge" of a crack.

The further perspectives of refinement of designed models are concerned with engaging of new physical mechanisms which are taking into account features of contact phenomena, appearing under interaction of adjoining shores of a crack, and also in view of other features of heterogeneities structure distinguishing, for example, by asymmetrical structure, etc.