4.5.34. APPLICATION OF TRANSIT THERMAL PROCESSES FOR EDDY-CURRENT THERMAL FLAW DETECTION AND DETERMINATION OF PHYSIC-MECHANICAL PARAMETERS OF ARTICLES WITH COMPLEX STRUCTURE

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Taking into account reasonability of application of eddy-currents for initiation of unstationary thermal process in articles of complex structure consisting of electro-conductive and dielectric materials, paper provides solution and analysis of problems corresponding with boundary conditions of second type for classical types of thermal exposure of $\delta(t)$ type– Dirac function, $h(t)$ type – Heaviside unit function and rectangular radio-pulse of finite duration easily implemented by means of electromagnetic inductor for heating of articles.

In the result of solution of these problems, dependences of variation of article specified temperature on generalized dimensionless parameter featuring generalized time (called as "Fourier number" (F) in the heat conductivity theory) are obtained.

Regularities of specified temperature variation on inner and outer surfaces of articles depending on thickness and other geometric dimensions, electro- and thermo-physical parameters of material, as well as frequency of eddy-currents with pulse exposure of various types are defined.

It is shown that coefficient of temperature (or heat) conductivity depending on physic-mechanical parameters and article material structure can be determined univalently by the duration of time required to achieve maximal temperature on the surface of article. If maximum of first derivative of transit temperature characteristic is fixed, temperature conductivity measurement time is reduced significantly in several times. It is established that value of the Fourier number $F = 0.33$ corresponds with bifurcation point, while ratio of temperatures measured in fixed moments of time t_1 and t_2 is defined by condition $T_1/T_2 = \sqrt{t_1}/t_2 = \text{const}$ for articles having no internal defects of continuity like delaminations, pores and others. Violation of this equation is used for detection of continuity defects in articles of layer structure or in multi-layer sheet articles. It is demonstrated that for $h(t)$ exposures on multi-layer thin0sheet article of complex structure at generalized parameter $F < 0.33$, it is possible to determine the temperature conductivity coefficient only, while at $F > 0.33$, selective testing of metal plates thickness and temperature conductivity is possible.

In the event of exposure by rectangular pulse of given duration, selective testing of geometric and thermo-physical parameters of article is possible by two values of temperature on the article surface measured at the moment of pulse end and in steady mode.

Paper describes new high-accuracy methods of selective testing of geometric parameters and physic-mechanical properties of article material and provides recommendations on elaboration of eddy-current thermal methods of nondestructive testing of quality of articles with complex structure.

References:

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