

5.3.7. THERMAL STABILITY OF PARAMETERS OF PIEZOELECTRIC TRANSDUCERS AS FACTOR DEFINING REPRODUCIBILITY AND TRUSTWORTHINESS OF ULTRASONIC TESTING RESULTS

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In 1961, authors have disclosed dependence of the incident angle α of ultrasonic beam excited by angle piezoelectric probes (hereinafter referred to as the "PEP") in steel and other metals on the ambient temperature t ; the higher is rated value of angle α_0 , the more significant is this dependence [1]. Necessity of studying the thermal stability of PEP parameters is conditioned by the fact that more than 2.5 thousand of ultrasonic flaw detectors with PEP's having $\alpha_0 = 70^\circ$ and designed for operation within the range of t from -40 to $+50^\circ\text{C}$ are applied in Russia.

As PEP parameters depending or possible depending on t under generalized expression for amplitude of echo-signal from a defect [2], the following is referred: $K_n(t)$ – double conversion coefficient; $f(t)$ – frequency of excited oscillations; $C_{11}(t)$ and $\sigma_1(t)$ – velocity and coefficient of attenuation of longitudinal wave in the PEP wedge material; $\alpha(t)$; $2\sigma_1(t)r_1$ and $2C_{11}(t)r_1 = 2\Delta t_n(t)$ – attenuation and average time longitudinal wave passes distance r_1 in the PEP wedge; $\Lambda_p(t)$ – duration of reverberation noises in the PEP wedge.

Dependences $K_n(t)$, $f(t)$ and $C_{11}(t)$, $\sigma_1(t)$ were studied with specially manufactured specimens of steel and organic glass located in thermostat with temperature varied within the range of 40 to $+50^\circ\text{C}$. It is established that K_n and f does not vary practically within the said temperature range, C_{11} decreases at the same time by ≈ 3.14 m/s-deg., which agrees with [1, 3], while σ_1 increases in average by ≈ 0.025 dB/cm-deg., which is accompanied by variation of absolute sensitivity K_A .

Dependences $2\Delta t_n(t)$, $K_A(t)$, $\alpha(t)$, and $\Lambda_p(t)$ were studied with 10 angle PEP's with $\alpha_0 = 70^\circ$ manufactured by seven domestic and foreign companies. It is established that, within the temperature range from 40 to $+50^\circ\text{C}$, $2\Delta t_n$ varies not more than by 1 μs ; sensitivity K_A with reference reflector in the form of concave cylindrical surface of calibration block SO-3 falls down significantly (by 7 – 12 dB); angle α varies within the limits of $\approx 5^\circ$ at $\alpha_0 = 60^\circ$ and within the limits (7 – 12) $^\circ$ at $\alpha_0 = 70^\circ$; herewith, under calculations, directivity characteristic width $\Phi(\alpha)$ varies in ≈ 2 times.

Temperature dependences of angle PEP's parameters result in temperature variations of the main parameters of ultrasonic testing like *beam incident angle α , directivity characteristic $\Phi(\alpha)$, equivalent K_e , conventional K_y and usable S_n sensitivities, longitudinal scanning index Δ_{cl} , dead zone M* , and, as a consequence, of the results of measurement of measured characteristics of detected defects like *detectability coefficient K_d , location coordinates H and L , conventional dimensions ΔX , ΔL* .

Unlike to other parameters, angle α and, hence, sensitivity cannot be adjusted (restored) during variation of temperature in the process of testing, other than by means of PEP's replacement into another ones [4].

Creation of a material for angle PEP's wedge with propagation velocity of longitudinal wave that does not depend practically on temperature within the range from 40 to

+50°C was and remains the main direction of PEP parameters stabilization and, hence, provision of reproducibility and trustworthiness of results of ultrasonic testing [5].

References:

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