4.1.11. TEST METHOD FOR DETERMINING RESIDUAL STRESSES IN MATERIAL OF DESIGN BY MAGNETIC METHOD

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One of the difficulties in industry is arising Residual Stresses in metalware. A number of methods have been elaborated to detect RS. Each of them has positive and negative sides. The purpose of this article is to describe of RS determination by magnetic express method. This test method has been chosen due to its effective control of bulky constructions with minimum time consumption.

The method is based on measuring the magnetic parameter of material and its conversion into stresses. The magnetic device "KRM-C-KK2M" has been used in this method. The magnetic parameter is related with principal RS by the following relationship (1):

$$Hc_i = (C + D\cos 2\beta)\sigma_{\max} + (C - D\cos 2\beta)\sigma_{\min}, \quad (1)$$

where Hc_i – magnetic parameter (Ampere/centimeter); C and D – coefficients, which depend on behaviors by controllable material; β – angle, which define the direction of component tensor stress σ_{max} relative zero direction "0"; σ_{max}, σ_{min} – maximum (most tensile) and minimum (most compressive) principal stresses on surface object investigation of control area.

The principal RS σ_{max} and σ_{min} are the result of this test method.

Zero axis "0" is defined on the control area. A magnetizer is placed concerning zero axis "0" at time of measuring.

The positions of the magnetizer of the magnetic device concerning zero axis "0" are schematically illustrated in fig. 1:

Principal RS σ_{max}, σ_{min} and angle β are calculated by expressions (2)–(3):

$$\begin{bmatrix} \sigma_{\max} \\ \sigma_{\min} \end{bmatrix} = \begin{bmatrix} C - D & C + D \\ C + D & C - D \end{bmatrix}^{-1} \begin{bmatrix} S1 \\ S2 \end{bmatrix}, \quad (2)$$

$$\beta = \operatorname{arctg}\left(\frac{t}{q}\right). \quad (3)$$

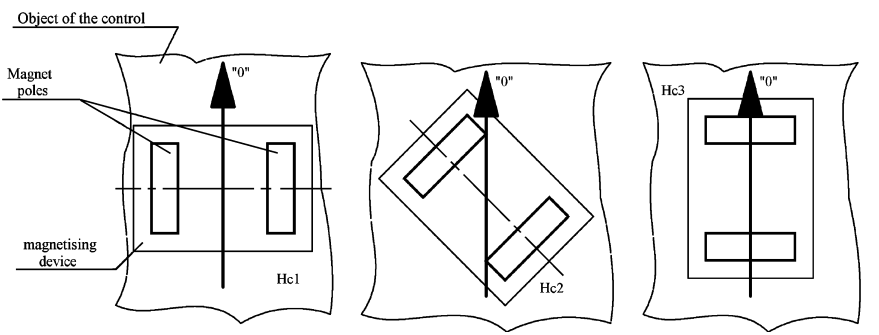

Fig. 1. Positions magnetizer concerning zero axis "0"

Where temps parameters p, q, t, $S1$ and $S2$ are calculated by formulas (4)–(5):

$$p = \frac{Hc1 + Hc3}{2}, \quad q = \frac{Hc3 - Hc1}{2}, \quad t = \frac{Hc1 + Hc3 - 2Hc2}{2}; \tag{4}$$

$$S1 = p + \sqrt{q^2 + t^2}, \quad S2 = p - \sqrt{q^2 + t^2}\ . \tag{5}$$

Parameters C and D are magnetic-mechanical characteristics of the material. The parameters are permanent for all area of construction. Coefficients C and D may be found by correlated measuring of magnetic parameters of material and residual stresses at some area of construction. RS can be found by hole-drilling strain-gage method (ASTM E-837-01^{e}).

The experiments for determining RS were conducted on a railway wheel. The results of the experiments presented in table 1.

The comparison of technological parameters of the test method and hole-drilling strain-gage method is represented in table 2.

This test method of RS determination was realized in a work situation in industrial conditions. The time of one measuring is 2–3 minutes. The experiments of RS determination were also on weld-fabricated bulky constructions such as ring of wagon dumper, superstructure of blast-furnace.

1. Experimental results

№ point	1			2			3		
Parameters of stresses	σ_{max}, (MPa)	σ_{min}, (MPa)	β°	σ_{max}, (MPa)	σ_{min}, (MPa)	β°	σ_{max}, (MPa)	σ_{min}, (MPa)	β°
Hole-drilling strain-gage method	410.5	–101.3	11	405.8	–73.2	8	380.8	–79.2	10
Magnetic method	315.8	–86.5	15	361.0	–89.3	11	341.2	–83.2	12

2. The comparison of technological parameters of the methods

	Test method	Hole-drilling strain-gage method
Test duration	2–3 minutes	35 – 45 minutes
Surface	No demand	Ra≤2.5 micrometre
Complexity of measuring (quantity of technological operations)	1	5
Consumable	Not necessary	Strain-gages, glue, emery paper