SUMMARY

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VECTOR POTENTIAL OF A MAGNETIC FIELD OF A FEED-THROUGH EDDY CURRENT PRIMARY RING TRANSDUCER OF A PARAMETRICAL TYPE AND A TRANSFORMER TYPE THAT ARE LOCATED IN A CONDUCTIVE PIPE.

Diagnosing of a technical condition of the trunk pipelines (gas pipelines) demand a determination of an actual thickness of a wall of the pipeline, detection of defects of type of infringement of integrity and definition of profile of its surface.

Eddy current method give the possibility to define the superficial cracks with small disclosing and the defects of stratification of the pipeline metal. If we are using an eddy current and a magnetic testing methods the primary transducer of a parametrical type or a transformer type usually have (can have) a form of the cylindrical coil with a rectangular shape of cross-section and is orientated (located) in alignment with a testing pipe. Therefore the actual is problem of calculation of a magnetic field a feed-through eddy current primary transducer of a parametrical and a transformer type that is located inside of a testing pipe the calculation model of which is show on fig. 1 where the following designations are accepted:

Accept such denotations: a_1 and b_1 – the sizes (width and height) of cross-section of an energizing coil; a_2 and b_2 – the sizes (width and height) of cross-section of a test coil in case of a transformer transducer; r_1 and r_2 – internal and external radiuses of an energizing coil; r_3 and r_4 – internal and external radiuses of a test coil; h_1 and h_2 – ordinates of a test coil; r_5, r_6 and d – internal and external radiuses and a thickness of a testing pipe; μ and γ – absolute magnetic permeability and specific electric conductance of a pipe; R and H – radius and height of the screen. We suppose that the areas into and outside of a pipe are not ferromagnetic ($\mu = \mu_0$ – permeability vacuum) and have specific electric conductance accordingly γ_1 and γ_3 .

Then Laplace transforming a vector potential of a magnetic field in cylindrical system of co-ordinates of r , α and z for all areas of research are define by expressions:

into a pipe

$$\tilde{A}_1 = \mu_0 \tilde{\delta}_{01} \sum_{i=1}^{\infty} \sum_{k=1}^{\infty} \frac{a_{i1} b_{k01}}{n_i^2 + m_k^2} J_1(n_i r) \cos m_k z, + \tilde{\delta}_{01} \sum_{k=1}^{\infty} \left[C_{11}\, \mathrm{I}_1(p_1 r) + C_{12}\, \mathrm{K}_1(p_1 r) \right] \cos m_k z;$$

in the body of pipe

$$\tilde{A}_2 = \tilde{\delta}_{01} \sum_{k=1}^{\infty} \left[C_{21}\, \mathrm{I}_1(p_2 r) + C_{22}\, \mathrm{K}_1(p_2 r) \right] \cos m_k z;$$

outside of pipe

$$\tilde{A}_3 = \tilde{\delta}_{01} \sum_{k=1}^{\infty} \left[C_{31}\, \mathrm{I}_1(p_3 r) + C_{32}\, \mathrm{K}_1(p_3 r) \right] \cos m_k z,$$

where $\tilde{\delta}_0 = \tilde{\delta}_{01}$ – the Laplace image of a density of current in a energizing coil of transducer; J_1 – Bessel's function of the first sort of the first order; $n_i = \lambda_i / R$; $\lambda_1, \lambda_2, ..., \lambda_i, ... -$ roots of the equation $J_1(\lambda) = 0;$ I_1 i K_1 – modified of Bessel's cylindrical functions of the first order of the first and second sort; $p_1^2 = m_k^2 + p\gamma_1\mu_0;$ $p_2^2 = m_k^2 + p\gamma\mu;$ $p_3^2 = m_k^2 + p\gamma_3\mu_0;$

$a_{i1} = \dfrac{2Y_1}{R^2 J_0^2(\lambda_i)};$ $Y_1 = \int\limits_{r_1}^{r_2} J_1(n_i r) r dr;$ J_0 – Bessel's function of the first sort of a zero order;

$$b_{k01} = \frac{4}{m_k H} \sin \frac{m_k b_1}{2}; \; m_k = (2k-1)\pi / H .$$

After disclosing of limiting and boundary conditions (15) for definition of unknown coefficients C with different indexes we will receive:

$$C_{11}=\frac{\mu N_1 P_1\,\mathrm{I}_1(p_2r_5)+\mu N_2 P_1\,\mathrm{K}_1(p_2r_5)-P_2D_1}{P_2\,\mathrm{I}_1(p_1r_5)};\quad C_{12}=0;\quad C_{21}=\frac{\mu N_1 P_1}{P_2};\quad C_{22}=\frac{\mu N_2 P_1}{P_2};$$

$$C_{31}=\frac{\mu P_1\,\mathrm{K}_1(p_3R)[N_1\,\mathrm{I}_1(p_2r_6)+N_2\,\mathrm{K}_1(p_2r_6)]}{P_2[\mathrm{I}_1(p_3r_6)\mathrm{K}_1(p_3R)-\mathrm{I}_1(p_3R)\mathrm{K}_1(p_3r_6)]};$$

$$C_{32}=-\frac{\mu P_1\,\mathrm{I}_1(p_3R)[N_1\,\mathrm{I}_1(p_2r_6)+N_2\,\mathrm{K}_1(p_2r_6)]}{P_2[\mathrm{I}_1(p_3r_6)\mathrm{K}_1(p_3R)-\mathrm{I}_1(p_3R)\mathrm{K}_1(p_3r_6)]},$$

where I_0 and K_0 – modified of Bessel's of a cylindrical functions of a zero order;

$$D_1=\sum_{i=1}^{\infty}\frac{2Y_1 b_{k01}J_1(n_i r_5)}{R^2J_0^2(\lambda_i)(n_i^2+m_k^2)};\quad D_2=\sum_{i=1}^{\infty}\frac{2n_iY_1 b_{k01}J_0(n_i r_5)}{R^2J_0^2(\lambda_i)(n_i^2+m_k^2)};$$

$$N_1=\mu_0 p_2M_1\,\mathrm{K}_0(p_2r_6)+\mu p_3M_2\,\mathrm{K}_1(p_2r_6);\quad N_2=\mu_0 p_2M_1\,\mathrm{I}_0(p_2r_6)-\mu p_3M_2\,\mathrm{I}_1(p_2r_6);$$

$$M_1=\mathrm{I}_1(p_3r_6)-\mathrm{I}_1(p_3R)\mathrm{K}_1(p_3r_6)/\mathrm{K}_1(p_3R);\quad M_2=\mathrm{I}_0(p_3r_6)+\mathrm{I}_1(p_3R)\mathrm{K}_0(p_3r_6)/\mathrm{K}_1(p_3R);$$

$$P_1=D_2\,\mathrm{I}_1(p_1r_5)-p_1D_1\,\mathrm{I}_0(p_1r_5);$$

$$P_2=\mu_0p_2\,\mathrm{I}_1(p_1r_5)[N_1\,\mathrm{I}_0(p_2r_5)-N_2\,\mathrm{K}_0(p_2r_5)]-\mu p_1\,\mathrm{I}_0(p_1r_5)[N_1\,\mathrm{I}_1(p_2r_5)+N_2\,\mathrm{K}_1(p_2r_5)].$$

The results that have received is expedient for use if define the own and mutual, the main and induced inductances of a feed-through eddy current primary transducer and their sensibilities to parameters and defects of testing research.