Possibilities of manual eddy current control for measuring the depth of contact-fatigue cracks on the surface of rolling rails

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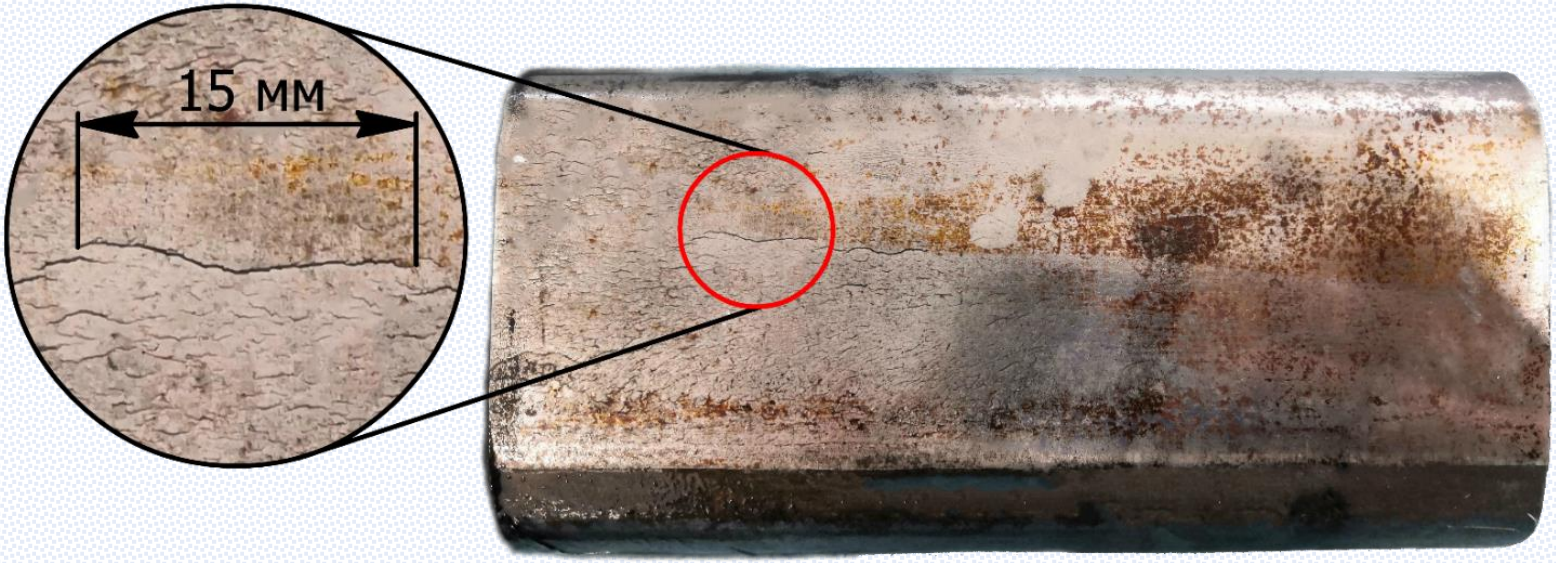
RELEVANCE OF THE TOPIC



Pic. 1 – The rolling surface of the rail with contact fatigue cracks

Pic. 2 – Rail grinding train operation

PURPOSE AND OBJECTIVES OF THE STUDY

The aim of the work is to create a technology for assessing the depth of contact-fatigue cracks of the rolling surface of rails by the eddy current method.

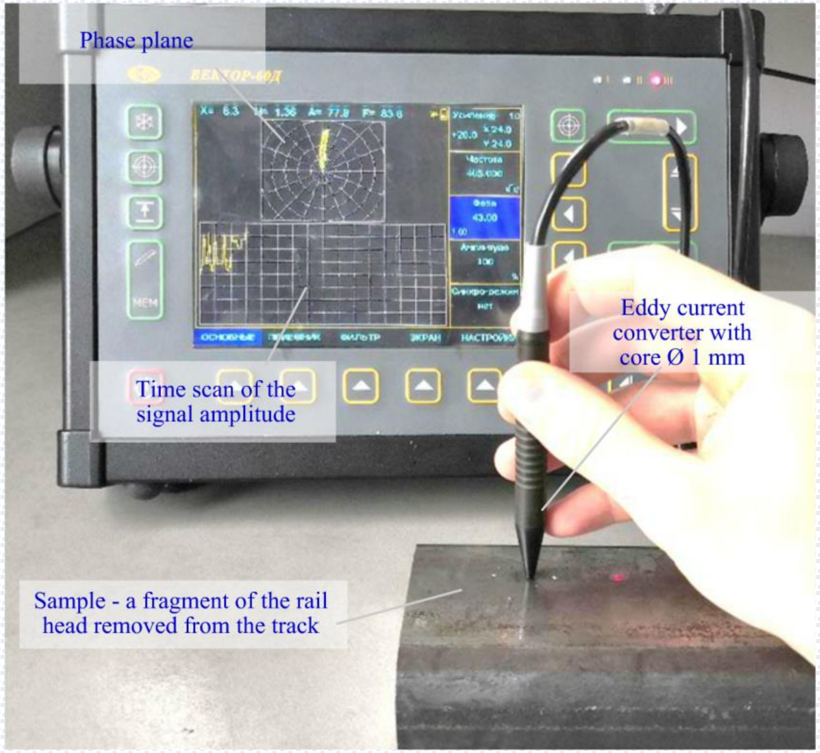
To achieve this goal , the following tasks were **solved**:

1) Experimentally establish the dependence of the parameters of the eddy current converter signal on the crack depth for different frequencies of the excitation current.

2) To determine the interfering factors and ways of detuning from their influence: the deviation of the transducer from the perpendicular to the surface and its curvature, the change in the properties of the material of the surface layer as a result of the riveting.

3) To assess the reliability of the assessment of the depth of a crack spreading at an angle to the surface, in the presence of several closely spaced cracks (a defect of the "grid of cracks" type).

SCOPE AND LIMITATIONS OF EDDY CURRENT CONTROL



Pic. 3 – The rolling surface of the rail with contact fatigue cracks

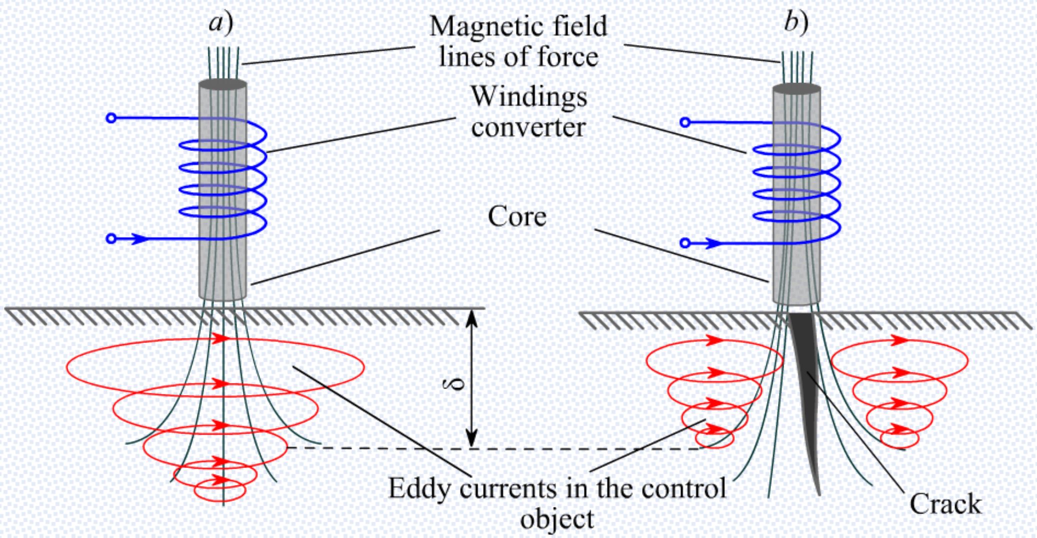
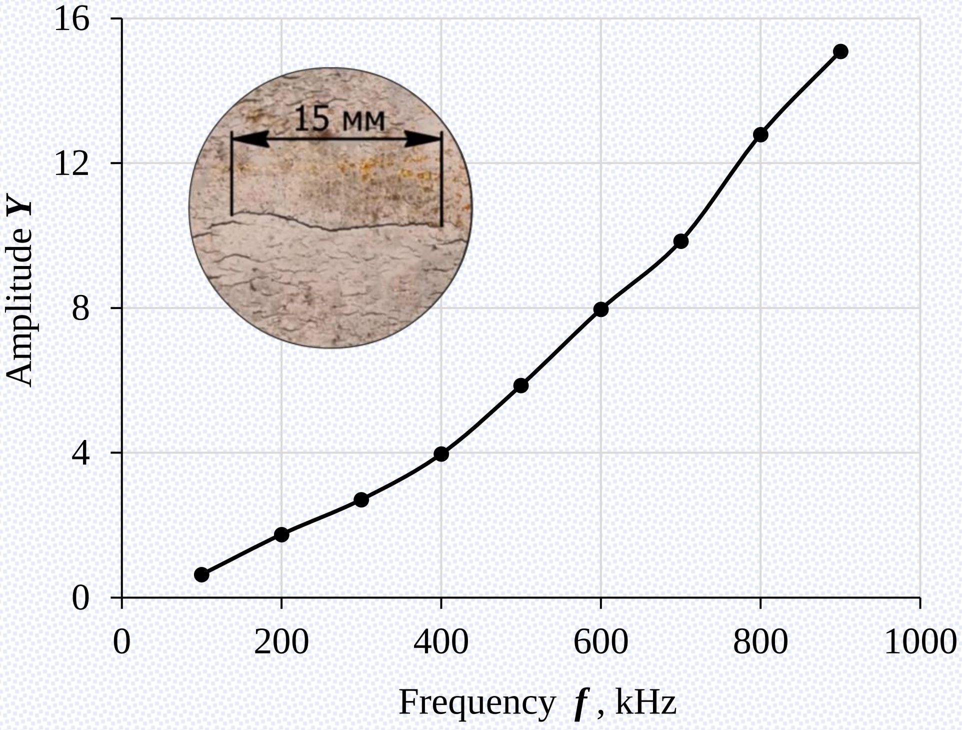


Рис. 4 – Schematic diagram of eddy current control

Table 1 – Depth of penetration of eddy currents

Frequency of the converter current, *f* kHz	**Depth of penetration of eddy currents, δ, mm**
400	0,03
100	0,07
25	0,13

DEPENDENCE OF SIGNAL AMPLITUDE AND RESOLUTION ON FREQUENCY



Pic. 5 – Dependence of the amplitude of the converter signal on the frequency of the excitation current at one crack

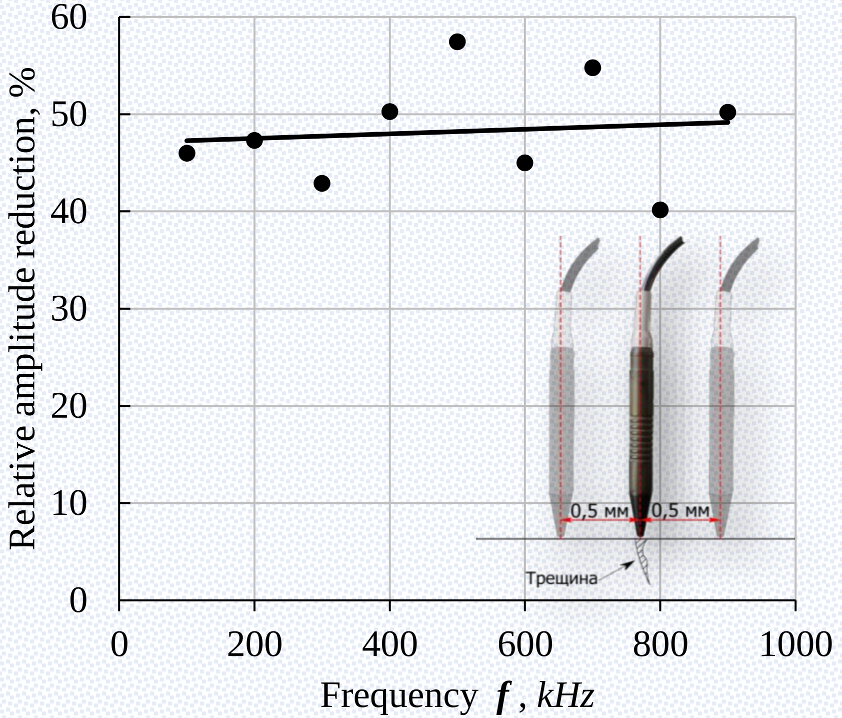
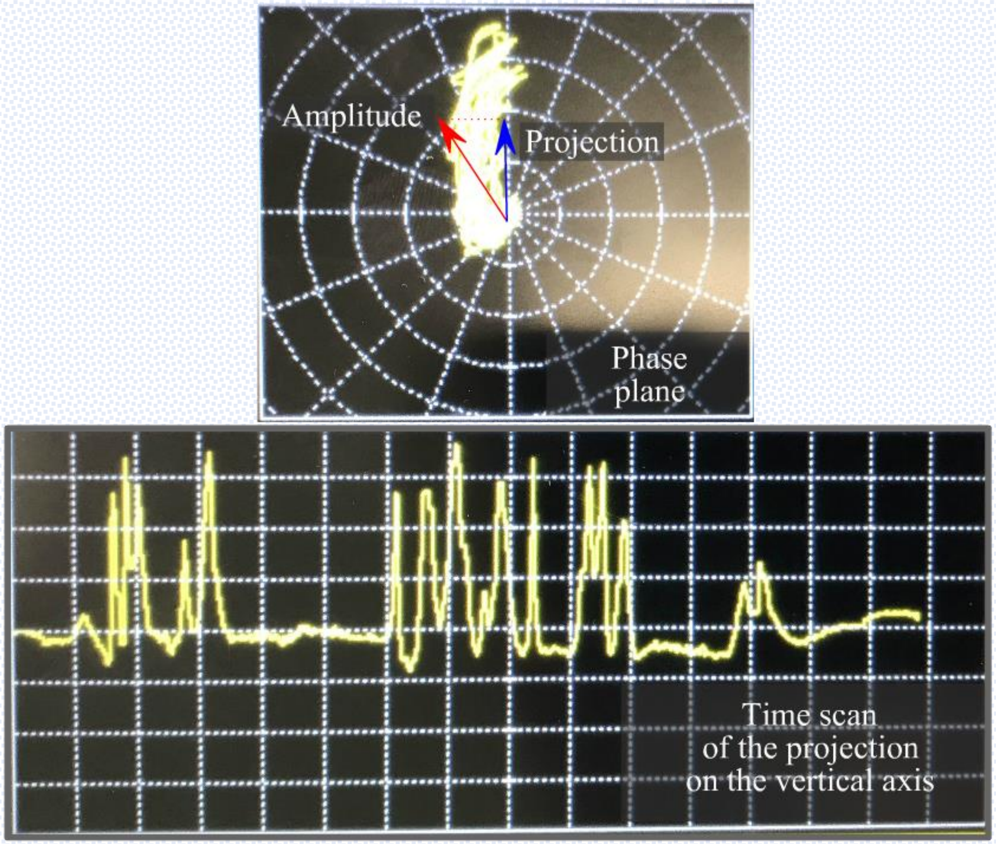
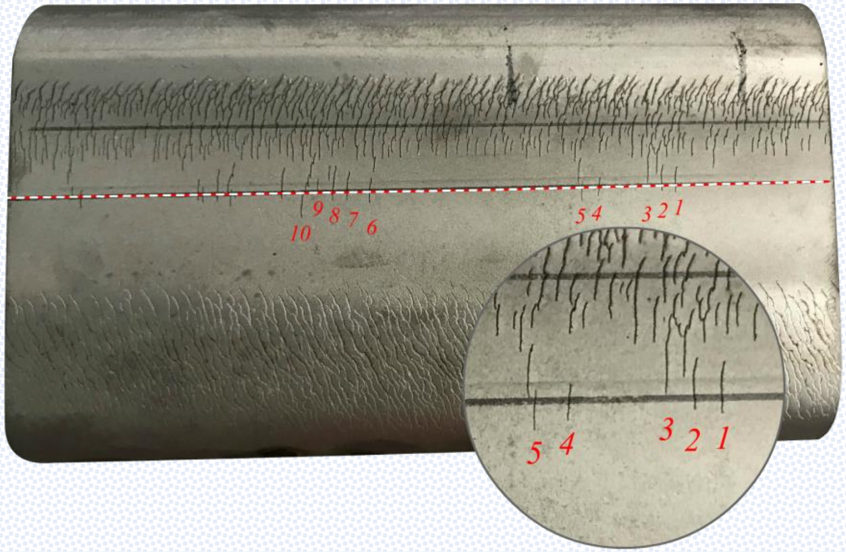


Рис. 6 – Dependence of the amplitude of the converter signal on the frequency of the excitation current on one crack

INVESTIGATION OF THE DEPENDENCE OF THE SIGNAL AMPLITUDE ON THE DEPTH OF CONTACT FATIGUE CRACKS

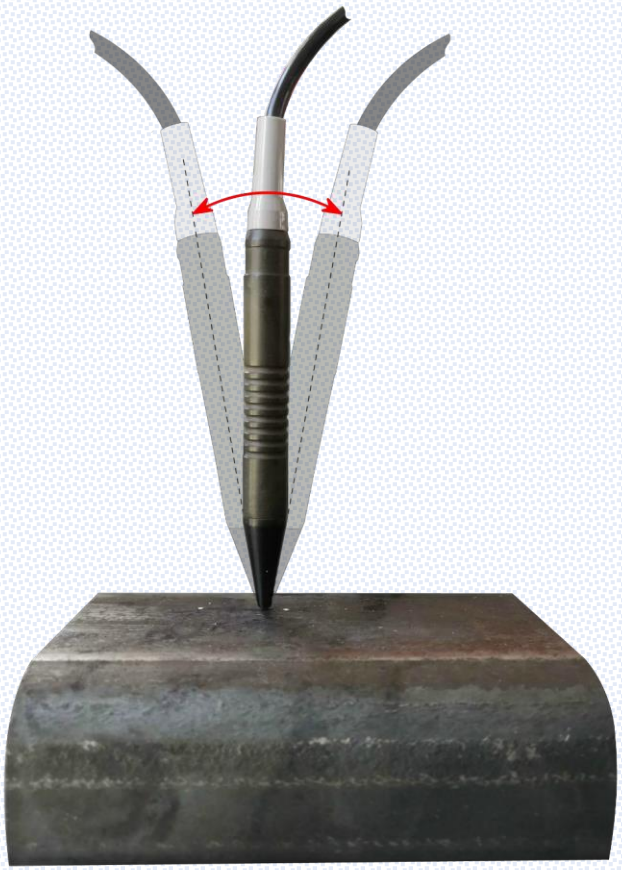


Pic. 10 – The results of scanning the sample on the phase plane and the time scan of the signals

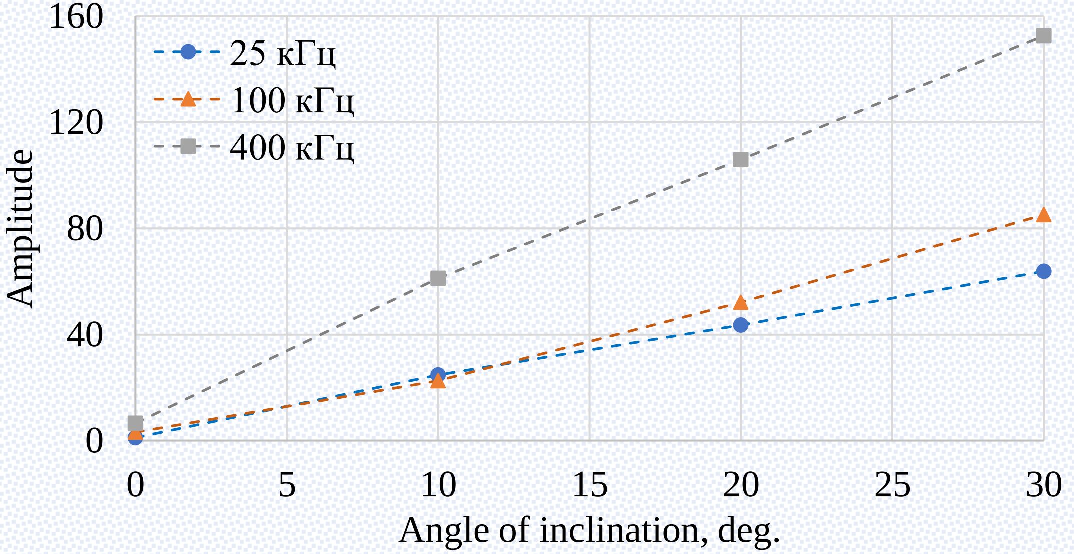


Pic. 11 – Marking of the sample with identified cracks

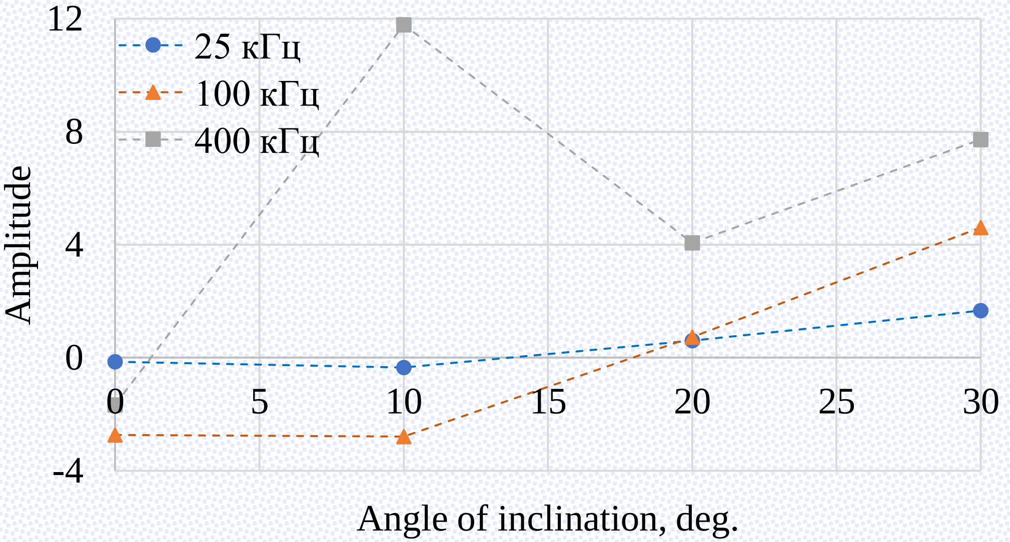
INFLUENCE OF THE ANGLE OF INCLINATION OF THE CONVERTER ON THE SIGNAL AMPLITUDE



Pic. 7 – Tilt of the converter relative to the vertical axis

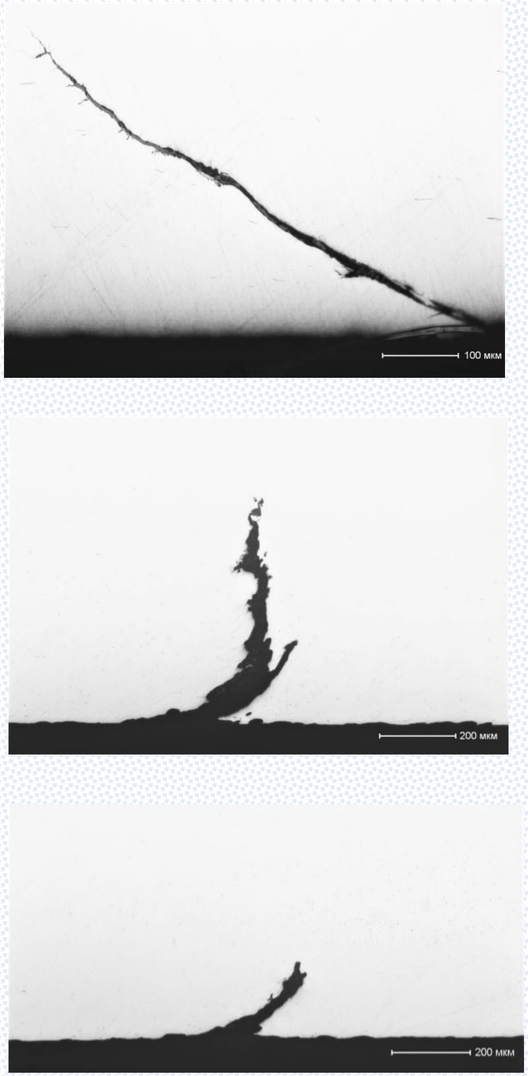


Pic. 8 – Dependence of the amplitude on the angle of inclination of the transducer



Pic. 9 – Dependence of the projection of the amplitude on the selected direction on the angle of inclination of the transducer

INVESTIGATION OF THE DEPENDENCE OF THE SIGNAL AMPLITUDE ON THE DEPTH OF CONTACT FATIGUE CRACKS



Pic. 12 – Photos of grinds with cracks

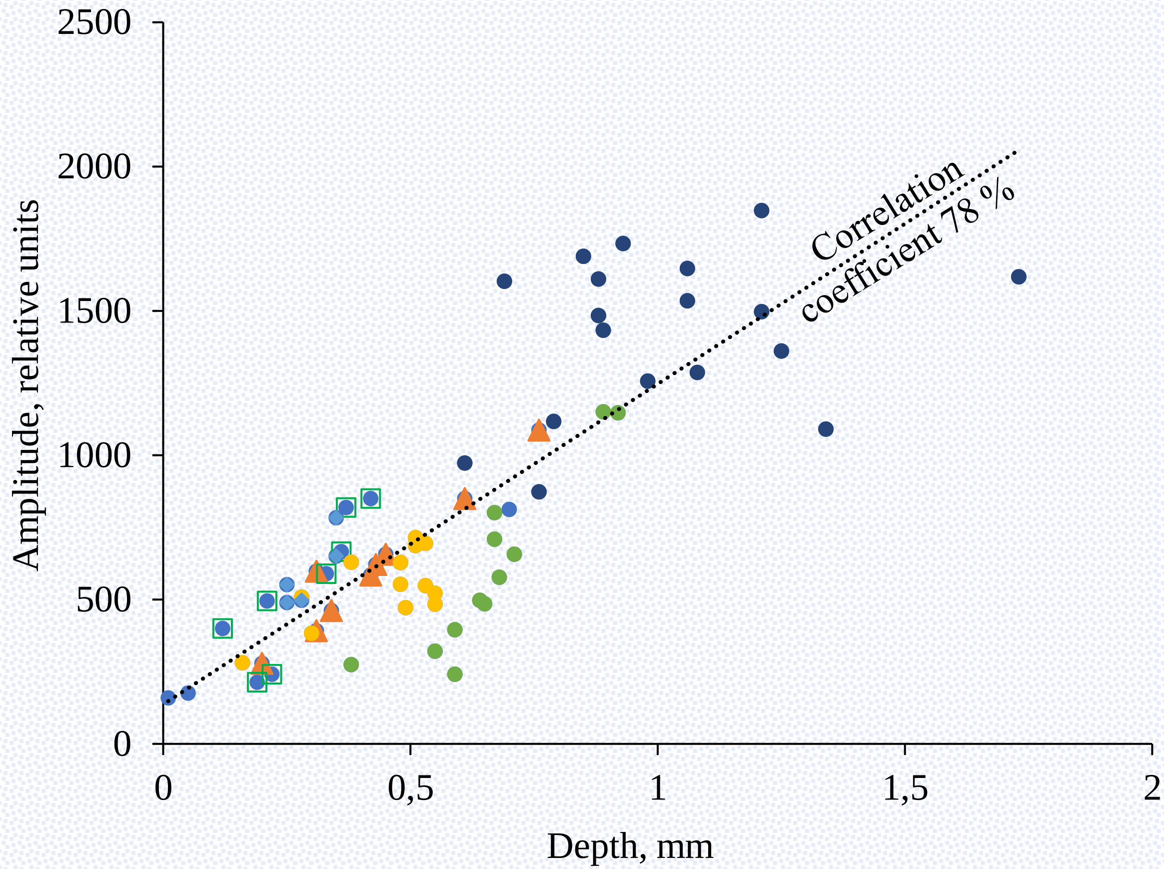


Рис. 13 – Dependence of the amplitude of the eddy current flaw detector on the depth of cracks for three samples

MAIN CONCLUSIONS

1. **The highest correlation coefficient** is observed at the excitation frequency of the converter 100 *kHz* and for all cracks in all samples is 0,78. At a frequency of 400 *kHz*, the value of the correlation coefficient does not exceed k = 0,5, which is due to the penetration depth of eddy currents less than two times and the sensitivity to the angle of inclination of the converter by 2 or more times.

2. The dependence of the crack depth on the signal amplitude was approximated by **a linear dependence** using the least squares method:

$$h = \alpha \cdot A + b,$$

where h is the depth, microns; A is the signal amplitude, relative units; α = 0,62 microns (σ_α = 0,05 microns - 1) is the proportionality coefficient; b = 0,1 mm (σ_b = 0,1 mm) is the displacement coefficient.

3. The error of measuring the crack depth by manual eddy current method at a frequency of 100 *kHz* in the range from 0,05 to 1,5 mm contains **additive and multiplicative components**. Boundaries with a confidence probability of 0,95 of the additive component ± 0,25 mm, multiplicative - ± 17%.