EDDY CURRENT INSPECTION OF STEEL CASTINGS WITH ROUGHLY FINISHED SURFACES

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Radiographic (RT) and ultrasonic (UT) methods usually are used for flaw detection in railway rolling stock casting components. At the same time both methods have some serious disadvantages. RT method is expensive, creates unhealthy radioactive emanation and is low productive for testing components with the different thickness due long time for RT apparatus retuning. UT method is not efficient for testing surfaces with different curvature, low sensitive to surface flaws and need very good surface for good acoustical contact with transducer [1,2].

The goal of this paper is to show the eddy current (EC) method possibility to detect surface breaking flaws in casting components with rough surface. Long time EC method was supposed to be not applicable for such product inspection due high noise from the surface inhomogeneities. Another problem is low frequency signal trend during EC probe scanning due the magnetic property changes. To reduce the surface inhomogeneities influence multiplexed array EC probes are proposed [3]. But these probes are very difficult and can’t be used with conventional EC device.

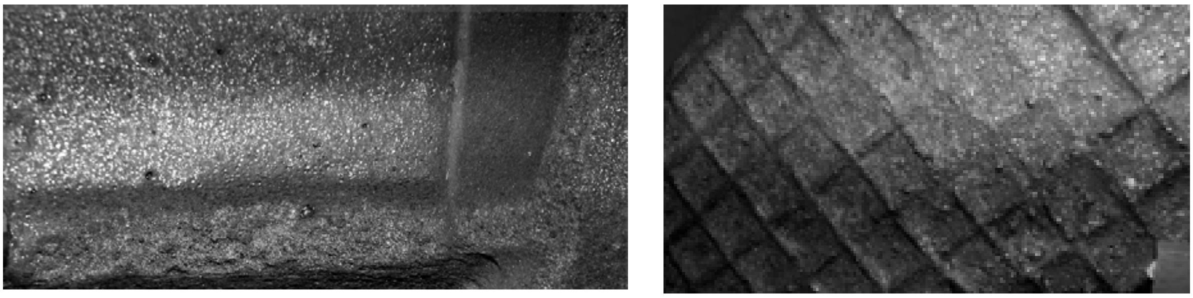
In Russia and Ukraine EC inspection of railway rolling stock casting components is stipulated by the regulatory documents [4,5]. According to these documents the next components are tested:

- wheel pair and tug unit;
- bogies of freight, refrigerator and passenger cars;
- brake linkage units;
- automatic couplers.

Due regulatory documents [4,5] the VD-12 NF, VD-15NF, VD 113, VD 213 (Russia) [4] and VD 30 [5] (Ukraine) eddy current devices are supposed to be used. The majority of these devices are based on the phase method of eddy current signal response processing. For roughly finished surfaces inspection the absolute compensated EC probe with coil placed on 4,5 mm ferrite core is applied. But practical experience show that these devises can be used satisfactorily only for wheel pair inspection. The task of flaw detection in steel casting components with these devices can not be solved with enough reliability. Preliminary experiments show that the main causes of known methodology limitations are high noise level from typical for cast components roughness of tested surface and low-frequency signal response trend conditioned by magnetic properties inhomogeneity, different surface curvature and insufficient probe lift-off suppression.

To work out the presented problem more effective inspection technologies based on the application of selective multidifferential eddy current probes [6,7] and modern eddy current device VD 3-71 [8] were proposed. Preliminary experience of VD 3-71 device application shows its possibility to solve difficult task of flaw detection in high noise conditions. In particular, it was shown the effectiveness of differential summation of signal samplings for full suppression of low-frequency signal variations and trend and increasing of signal to noise ratio in presence of stochastic noise.

Let us consider the possibility of eddy current method application for roughly finished surfaces inspection on the case of the lateral frames and the above-spring frames inspection. Mentioned component are made from 20GL steel by casting to ground and have R_Z 320 surface roughness. After normalization this steel has small-grained ferrite-perlite structure. The detected cast flaws are supposed to be cut with the next repairing by welding. The typical condition of casting surface is presented on figure 1 where typical for cast surface pricks with rounded edges, gas roughness conditioned by gas cissings on the formwork boundary (a) and prominent grid markings from formwork (b) are clearly visible.

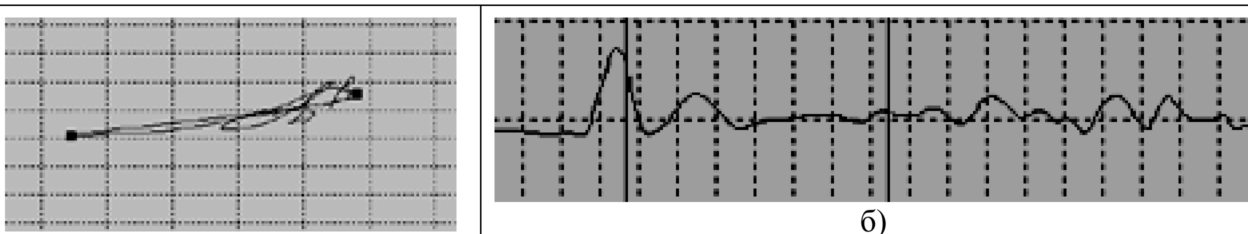


a b

Fig. 1. Typical cast rolling stock lateral frames surface condition.

During comparative investigations the standard eddy current PN10-TD were compared with different size Leotest type multidifferential EC probes MDF 0701, MDF 0901 and MDF 1201 [6,7]. The first two numbers indicate the diameters of EC probe operational area in millimeters. The coils placed on the ferrite cores with diameters from 1,2 to 3,5 mm were used in these probes. For investigations special samples with R_Z 320 roughness and artificial flaws were prepared. In addition the component fragments with natural crack and pores were selected out from manufacturer. The investigations show that MDF 1201 EC probe demonstrate the best signal to noise ratio during the inspection of samples with rough surface. The standard PN10-TD type EC probe show pure sensitivity and don't was considered in subsequent work.

The MDF 1201 type EC probe impedance (a) and time-base deflection mode (b) signals obtained on the operational frequency 17 kHz are presented on fig. 2 - 4. Fig. 2 represents the signals obtained from 0,6 mm depth and 10 mm length crack without the differential signal processing. On time-base defectogram (fig. 2,b) the noise connected with tested surface irregularities also is visible.



a) б)

Fig. 2. Crack signal responses obtained without differential signal processing.

Fig. 3 represents the signal from the same crack after the differential signal processing with 10 signal samplings. The comparison of signal on fig. 2 and 3 show the effectiveness of differential signal processing for slow signal changes suppression. The differentially processed signal reverse the sign during the scanning the flaw zone.

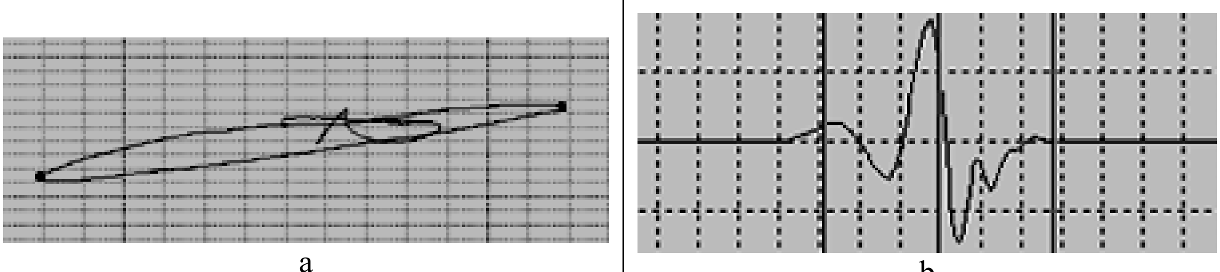


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Fig. 3. Crack signal responses after differential signal processing.

Fig. 4 represents the signals obtained from 2 mm diameter pore after differential processing. These results show the possibility of local flaw detection and confirm the differential processing effectiveness.

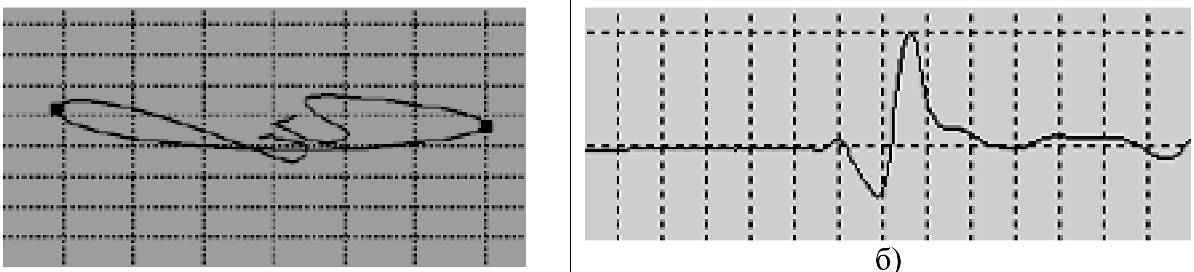

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Fig. 4. Pore signal responses after differential signal processing.

Completed investigations allow to improve the cast component inspection technology [4,5]. On rolling stock lateral frames there were discriminated the next individual inspection zones: external and skidding aperture internal corners, the upper flanges and reinforcement ribs, the places of axle-box fitting, the inclined belt, the edges of technological aperture, the corners and edges of spring aperture reinforcement ribs. For the above-spring frames the step-bearing zone is carefully inspected including the edges of external and internal end collar, the bridges from external end collar to upper bar belt. Beside this the upper belt of above-spring frames, the edges of technological aperture, the lateral wall zones and the power belts also are tested.

Scanning scheme for the inclined belt (a) and lateral frames technological apertures (b) are presented on fig. 5.

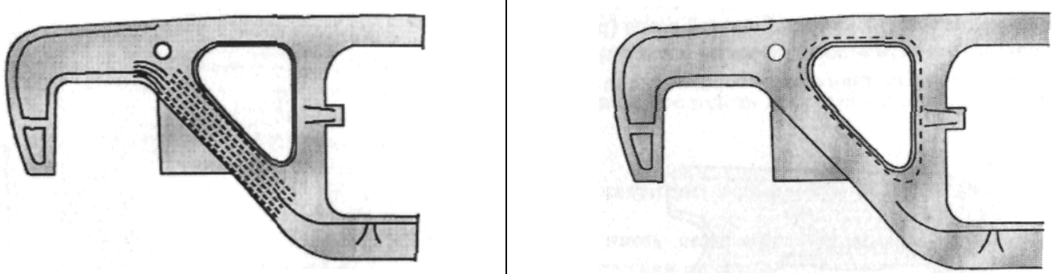

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Fig. 5. Scanning scheme for lateral frames inspection.

Fig. 6 displays scanning schemes for step-bearing zone above-spring frames. The scanning is recommended to perform along radial and circular trajectories.

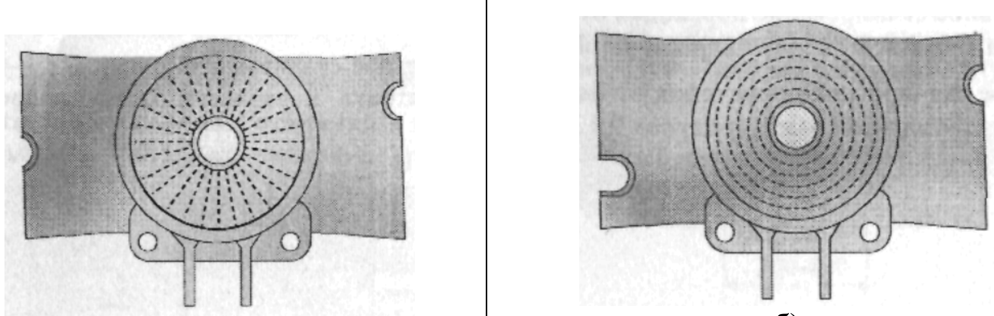

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Fig. 6. Scanning scheme for step-bearing zone inspection.

Fig. 7 displays scanning schemes for technological aperture edges inspection in upper (a) and lower (b) belts of above-spring frames.

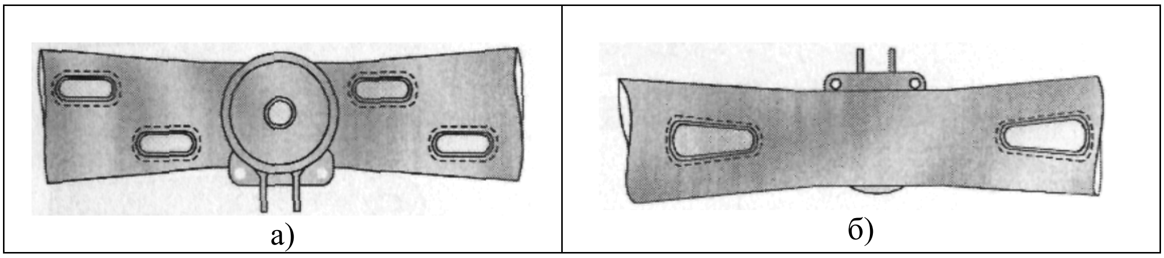

Fig. 7. Scanning scheme for technological aperture edges inspection.

Conclusion

1) Eddy current method with Leotest MDF type EC probes and VD 3-71 EC device can be effectively applied for surface flaw detection on steel castings with roughly finished surfaces.

2) Effective signal to noise ratio improvement during the inspection of roughly finished surfaces can achieved by differential signal processing (differential summation of signal samplings).

3) The proposed technologies are effectively used for railway rolling stock casting components inspection.

References

1. Vozdvizhenskij V.M., Shukov A.A., Bastrakov V.K. The cast quality testing. – Moscow: Mashinostroienie, 1990 (in Russian).

2. Gusev E.A., Karpelson A.E., Potapov V.N., Sosnin F.R. Ultrasonic and radiography testing. – Moscow: Mashinostroienie, 1990 (in Russian).

3. Meiland P. Novel Multiplexed Eddy Current Array for Surface Crack Detection on Rough Steel Surface. Proc. 9-th Europ.Conf. for NDT. - Berlin. 2006. - Tu.4.8.1.

4. Eddy current non-destructive method for railway carriage component inspection: guiding document RД 32.150-2000, Russian passenger railways department. - Moscow, 2000 (in Russian).

5. Instruction for nondestructive testing railway carriage components inspection by magnetic particle, eddy current, flux-gate methods and with tension evaluation. Ukrainian railways. – Kyiv, 2003 (in Ukrainian).

6. Uchanin V.N. Eddy current multidifferential probes and theirs application. Technical diagnostic and nondestructive testing. - 2006. - № 3 (in Russian).

7. Uchanin V., Mook G., Stepinski T. The investigation of deep penetrating high resolution EC probes for subsurface flaw detection and sizing // Proc. 8-th Europ.Conf. for NDT. – Barcelona. - 2002. – P. 312. (www.ndt.net. - February 2003. - Vol.8. - № 2).

8. Eddy current inspection of cast components with roughly finished surfaces / Lucenko G.G., Uchanin V.N., Buga V.I. et all // Proc. 9-th Conf. for NDT “Nondestructive Testing 2007”. - Kyiv. – 2007 (in Russian).