TESTOVÁNÍ ODUHLIČENÉ VRSTVY OCELI METODOU BARKHAUSENOVA ŠUMU

BARKHAUSEN NOISE TESTING OF SURFACE DECARBURIZATION OF STEEL

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Introduction

- Fatigue life time of industrial constructions is mostly defined by their surface conditions – different technological processes developed to increase the surface strength.
- Decarburization is an opposite unfavorable process of surface softening, when the carbon is diffused from the depth of the material (any process of high temperature treatment of steel and cast iron semi-products without protective atmosphere).
- International standard ISO 3887 determines 3 *destructive* methods of decarburization detection: (i) metallographic analysis, (ii) measurement of the micro-hardness profile at the material cross-section, (iii) direct carbon content evaluation by a chemical or spectrographic techniques.
- The industry needs a reliable method of *non-destructive* testing.

Sample preparation

- Spring steel ČSN 414260 (EN 54SiCr6) with high content of carbon (0.54% C, 0.68% Mn, 1.47% Si, 0.017% P, 0.009% S, 0.61% Cr, 0.05% Ni, 0.07% Cu, 0.032% Al). Plate samples of 110x30x3 mm^3 size. Two identical samples were prepared for each annealing time and each surface treatment and were measured from both sides.
- Annealing in air at 800^oC with different durations to induce the decarburization; reference sample – annealing in vacuum.
- Annealed surfaces were covered with iron oxides. Two more series were treated for removing the heat scale by industrial methods of acid pickling and sand blasting
- X-ray diffraction analysis; standard hardness HV10kg and microhardness HV0.1kg; wave dispersive spectrometer.

Decarburized layer evaluation

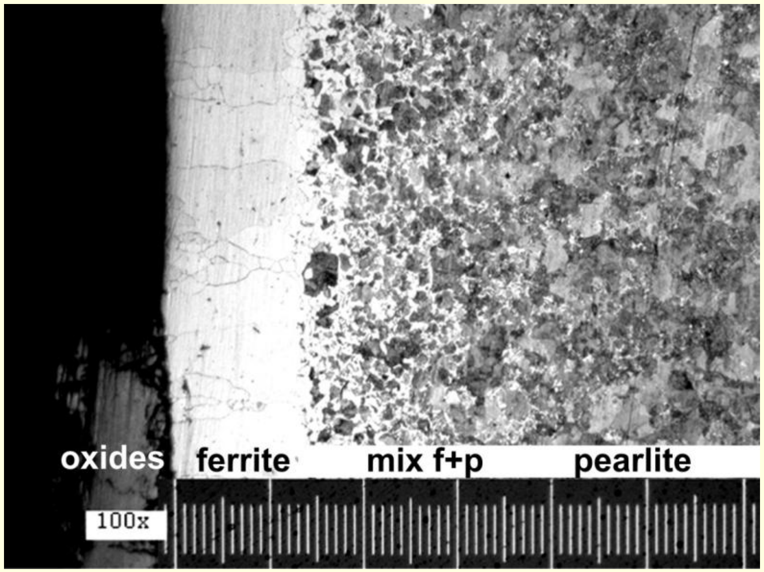
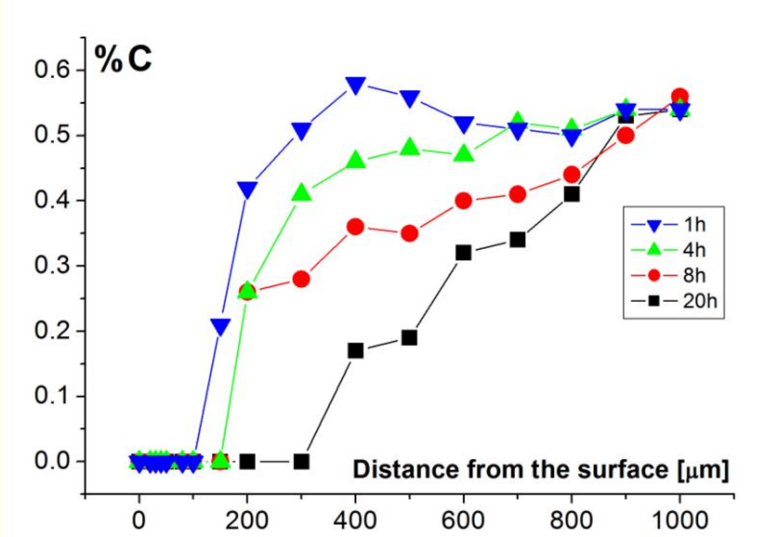


Table 1: Vickers hardness and depths of the surface layers.

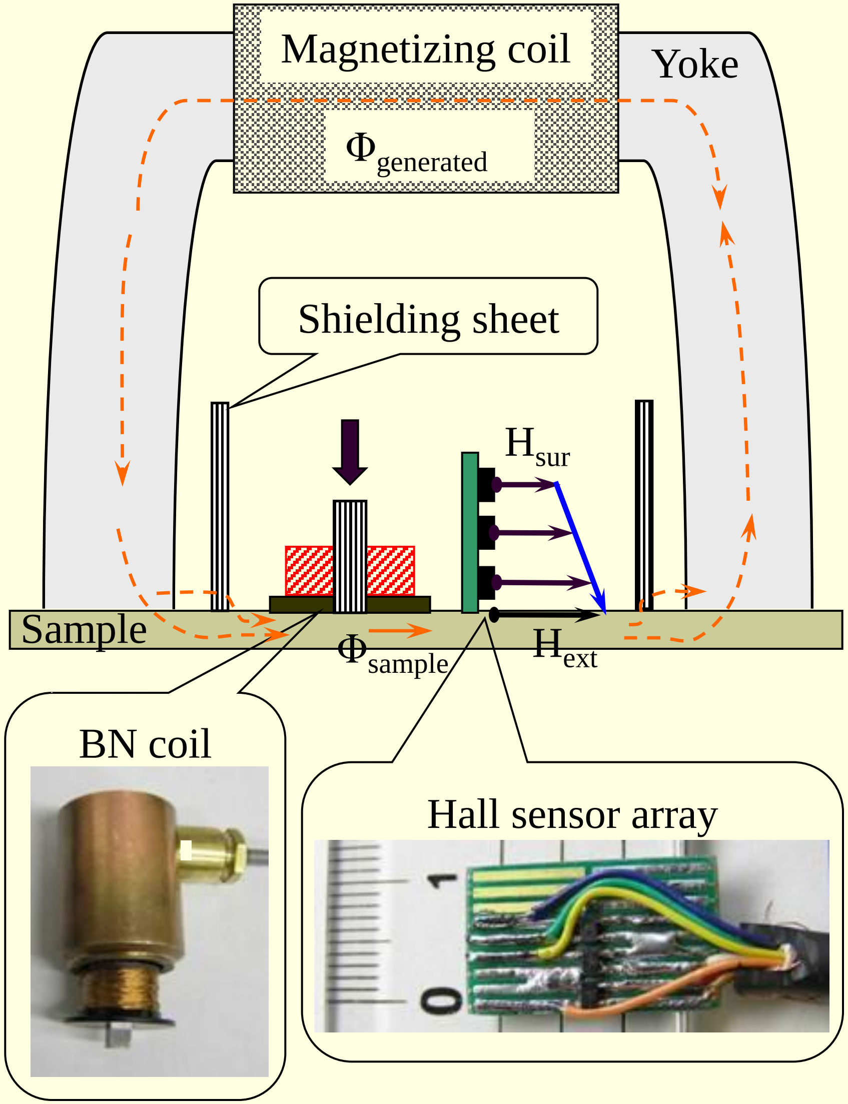
Annealed in		vacuum	air	air	air	air
Duration, h		2	1	4	8	20
HV0.1kg	Surface	250	171	145	160	131
	Core	260	268	288	305	270
Depth of layers, μm	Oxides	0	30	140	165	260
	Ferrite	0	110	170	200	350
	Mixed f+p	0	175	360	510	650

Metallographic picture of cross-section of the sample annealed at 4 hours. The scale division is 100 μm.

Profiles of carbon content measured by wave dispersion spectrometer.

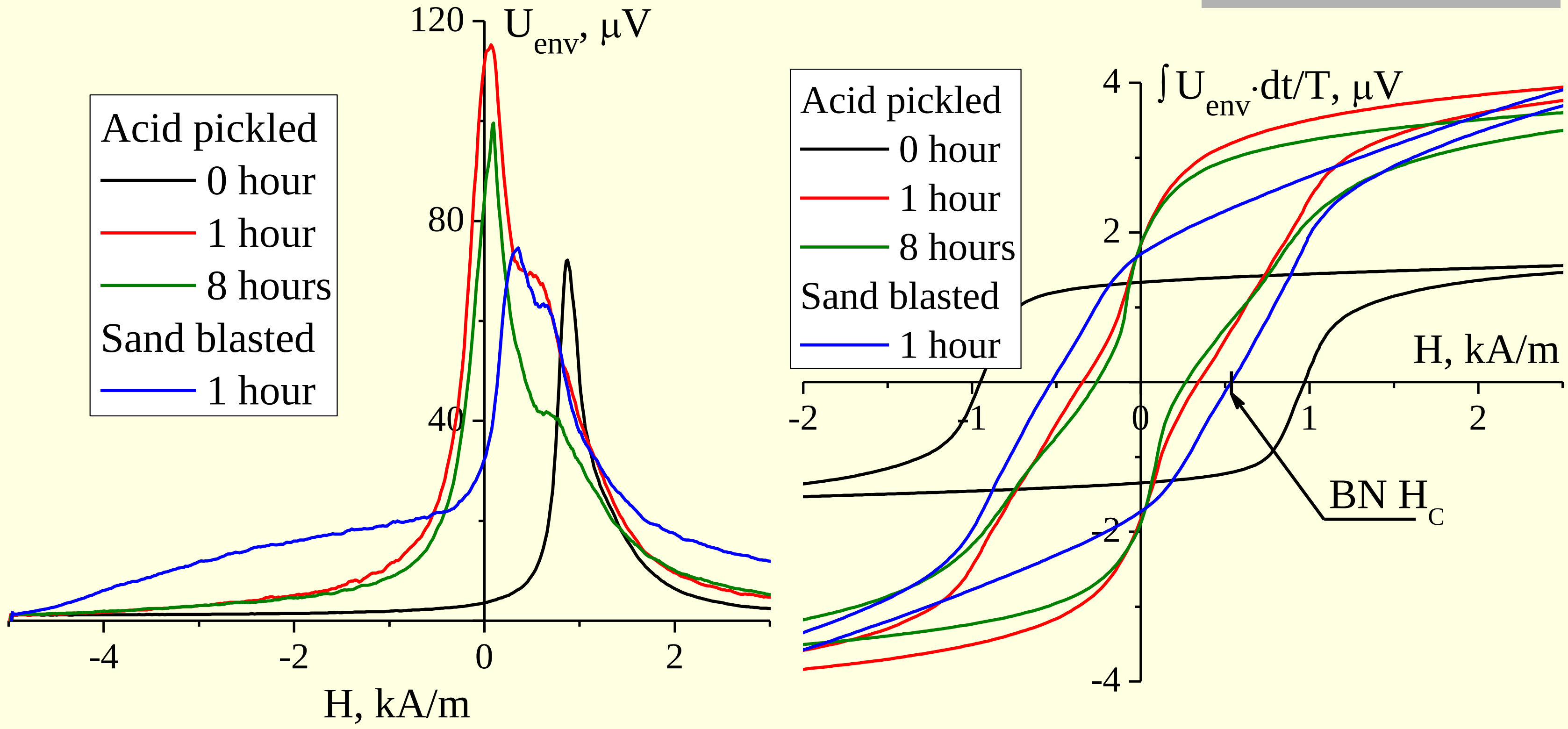


Magnetic measurement



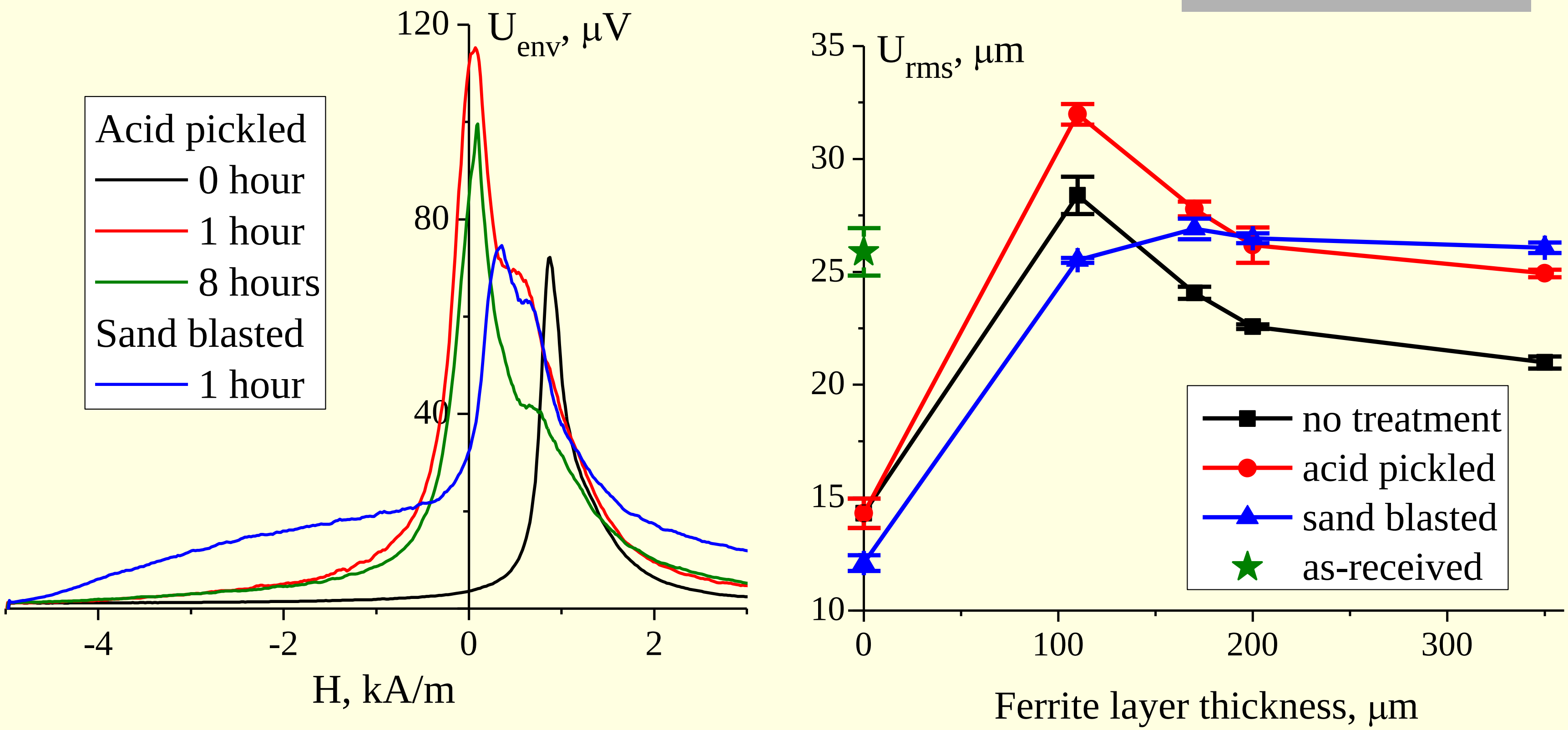
- 3 Hall sensors at 1.5-4-6.5 mm above the sample
- BN: surface-mounted pancake coil with Fe-Si laminated core
- 500 kHz sampling, 2-50 kHz bandwidth
- sets of various BN parameters were evaluated with and without the direct field determination
- shielding approach *[O.Perevertov, Meas. Sci. Tech.* ***20*** *(2009) 055107]*

BN envelope



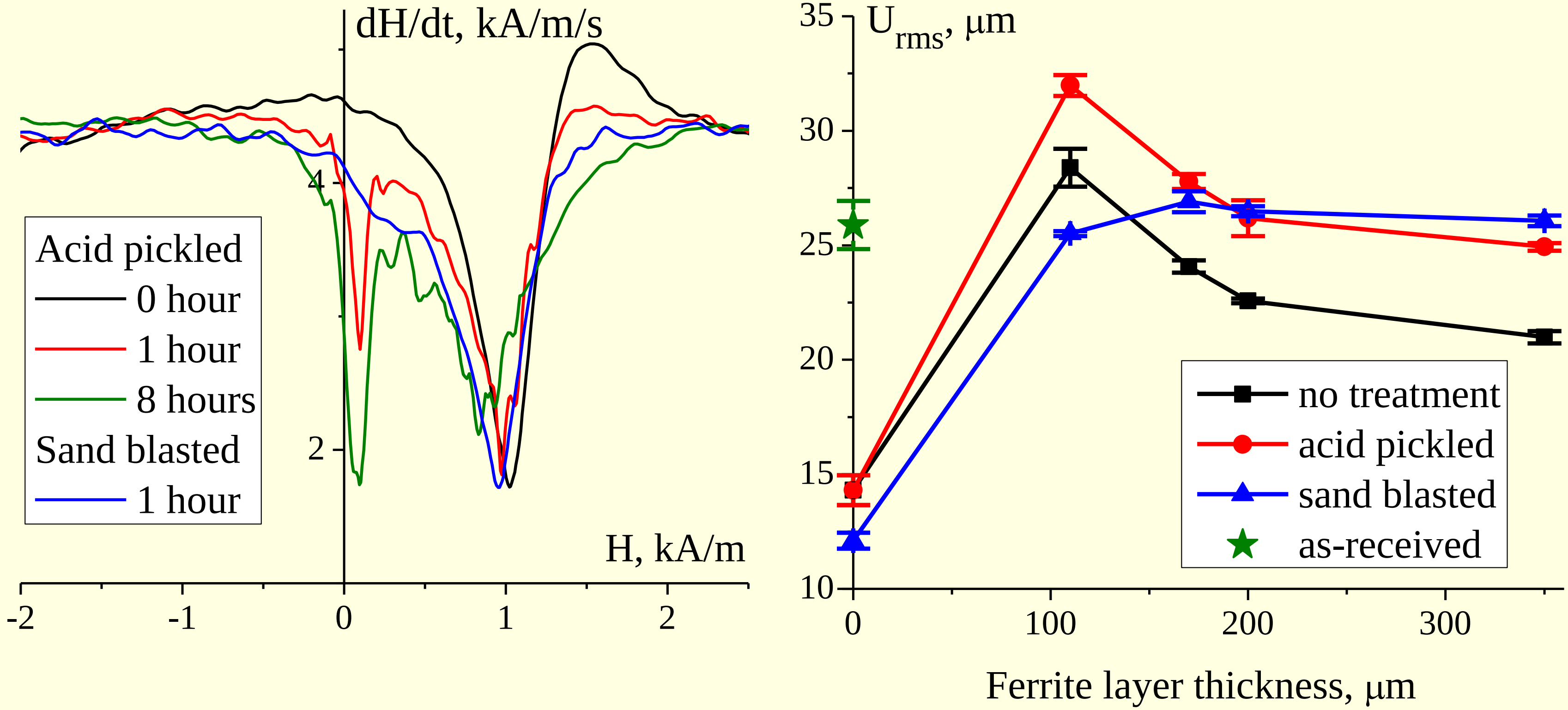
(Left) Typical BN envelopes for different annealing times and methods of surface treatment. (Right) The corresponding BN loop normalized to the magnetization period.

BN rms value



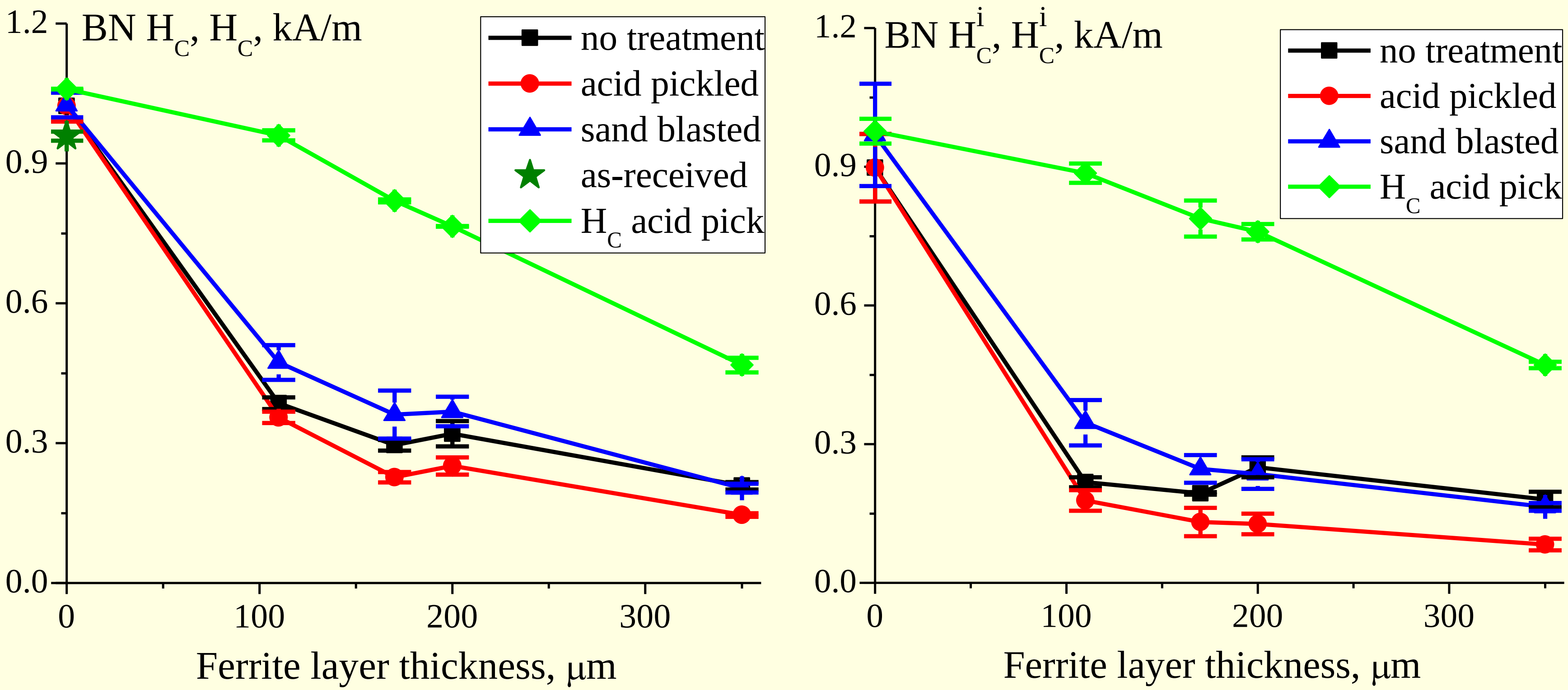
(Left) Typical BN envelopes for different annealing times and methods of surface treatment. (Right) Dependencies of the rms value of BN voltage on the ferrite layer thickness for all the sample series.

Barkhausen rms value



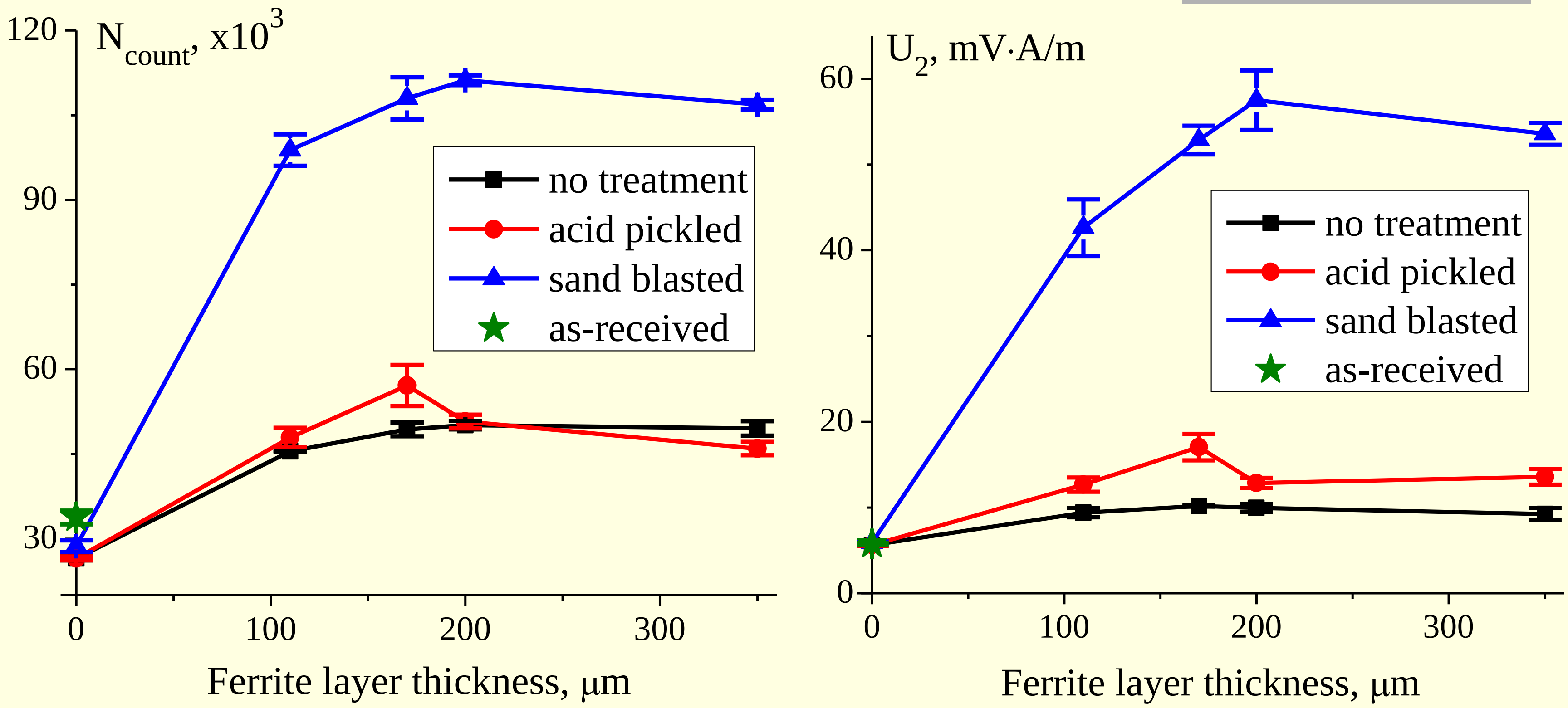
(Left) Surface field derivatives dH/dt as functions of the directly measured field. (Right) Dependencies of the rms value of BN voltage on the ferrite layer thickness for all the sample series.

Response to matrix - BN



(Left) Dependencies of the BN coercivity on the ferrite layer thickness for all the sample series. (Right) Similar dependencies for current method of field determination.

Response to matrix - BN



(Left) Dependencies of number of BN counts on the ferrite layer thickness for all the sample series. (Right) Similar dependencies for the introduced $U_2 = \int_{1k}^{5k} U_{env} dH$ *parameter.*

Conclusions

Applicability of the BN technique for evaluation of the decarburization depth of the industrial spring steel was investigated. The introduced parameter, BN coercivity, was proposed for practical use due to its stability, weak dependence on the surface treatment, and excellent sensitivity up to the decarburization depth of 170 μm. Two other parameters, the classical number of BN counts and especially the alternative second-peak based parameter U_2, were shown to be perfect indicators of the sand blasting treatment having good sensitivity with the decarburization depth of up to 150–200 μm.

Acknowledgments

Thank You for Your attention

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