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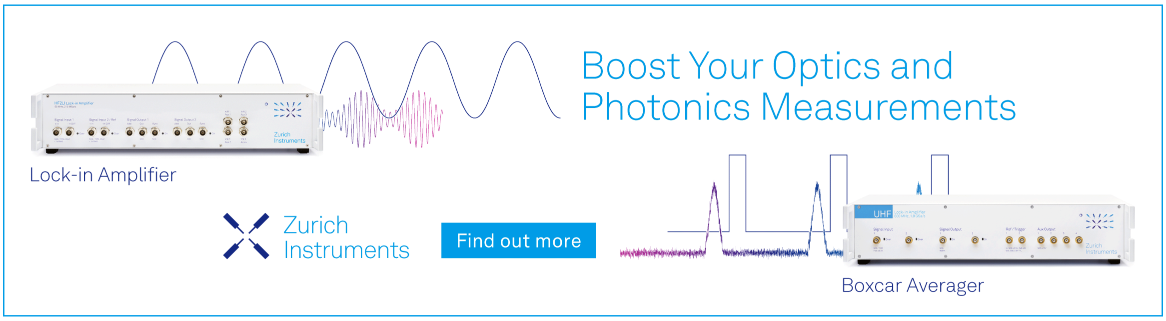

Practical Implementation of the Algorithm for Processing Signals Obtained by Magnetic Flaw Detection of Rolled Steel

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Abstract. Various mathematical methods are used to process the signals obtained by using magnetic flaw detection of rolled steel. In the article [1], a method for increasing the resolution of magnetic flaw detection is proposed.

INTRODUCTION

Electrical signals were obtained in a laboratory setup using anisotropic magnetoresistive sensors of the AMRD type [2]. The magnetoresistive effect is a change in the electrical resistance of a material under the influence of an external magnetic field. As a rule, in metals and alloys at room temperatures, the increase in resistance when the field is applied does not exceed 1%. In ferromagnets, the resistance value depends not only on the magnitude of the external magnetic field, but also on the orientation of the magnetization vector of this field relative to the direction of the current in the material or on the mutual orientation of the magnetization vectors of neighboring magnetic films. This magnetoresistive effect is called spontaneous (ferromagnetic) resistance anisotropy or anisotropic magnetoresistive (AMR) effect.

This practical implementation can be used both in practice in production conditions and for training young specialists. Using publicly available PC software packages, we can read in an easy-to-understand format and then process it using the proposed method or another.

EXPERIMENTAL TECHNIQUE

The main problem in signal processing is to obtain the initial data from the laboratory setup in a form that is understandable for analysis. The source data was a kind of unstructured file. The signal is noise-like over small time intervals. Before applying the method [1], it is necessary to perform preliminary processing.

A flaw detection unit for non-destructive testing of the R65 rail by the magnetic method was designed.

In Fig. 1 the functional block diagram of the measuring system is shown. scanning with the use of thin-film matrix converters during the longitudinal movement of the rail and magnetization by a solenoid.

The system consists of a solenoid for longitudinal magnetization and two cassettes designed for non-destructive testing of the rail head (upper cassette 1) and its sole (lower cassette 2).

The measurement system consists of sensors assembled in cassettes, a multi-channel preliminary differential amplifier, a multi-channel ADC and a device for collecting, displaying and storing experimental results implemented on a personal computer PC.

The algorithm is based on calculating the difference between two adjacent extremes of the signal. Since the direction is, the positive differences correspond to other similar signals. Negative differences are excluded.

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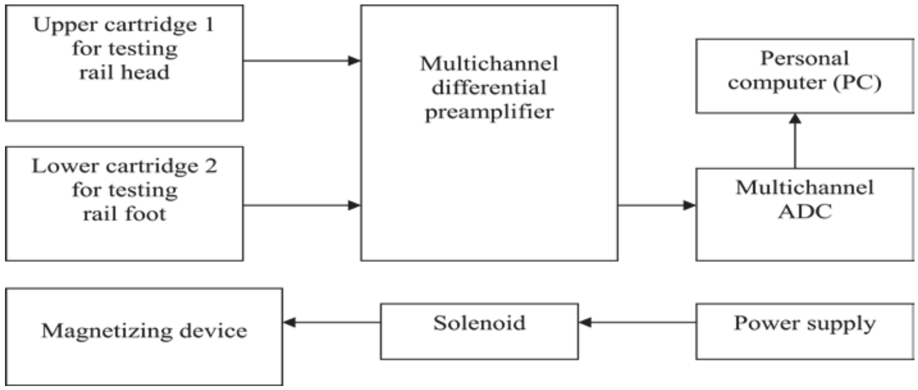

FIGURE 1. Functional block diagram of the measuring system

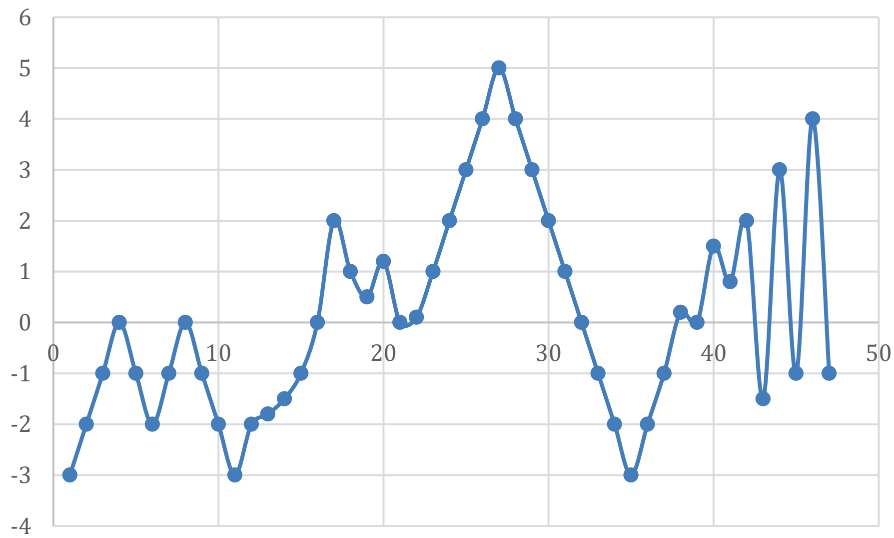

FIGURE 2. A fragment of the scan data graph

Figure 2 shows a signal simulating the real one from the sensors of the UMT installation [3] operating in production.

After processing this array of data, they were moved to the Excel package and the scan result reproduced in this package is shown in Fig. 2.

The values of the samples inside the window are sorted in ascending (descending) order. The value in the middle of the ordered list is sent to the output. In the case of an even number of samples in the window, the output value is equal to the average of the two samples in the middle of the ordered list. The window moves along the signal and the calculations are repeated.

The described algorithm can be represented by the formula 1.

$$S_n = \sum_{i=1}^{n} y_i \tag{1}$$

Where: n - is the averaging depth.

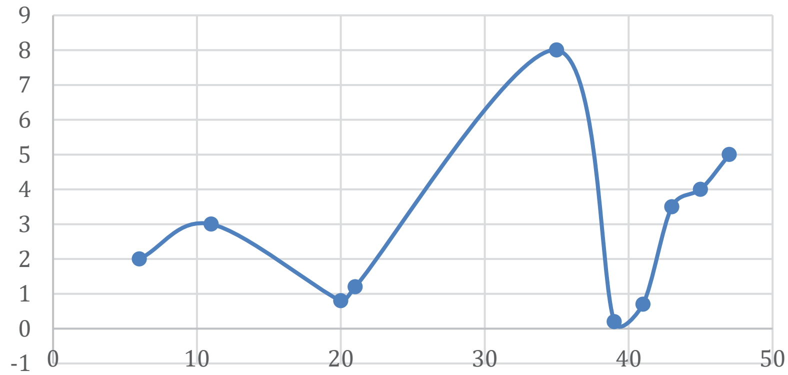

FIGURE 3. A fragment of the scan data graph after processing

After applying the selection according to the proposed method, this graph in Fig. 3 takes a simpler form, which allows you to more clearly separate the useful signal from the noise. As you can see from the graph, the interference disappeared, but the useful signal remained. The simplest way of applying this algorithm is shown.

RESEARCH RESULT

The analysis of the results requires combining several processing methods for a satisfactory and understandable presentation of the final data. To do this, we apply an additional processing algorithm to increase the signal-to-noise ratio. In [4], data were obtained from a real installation. The data graph is shown in Fig. 4.

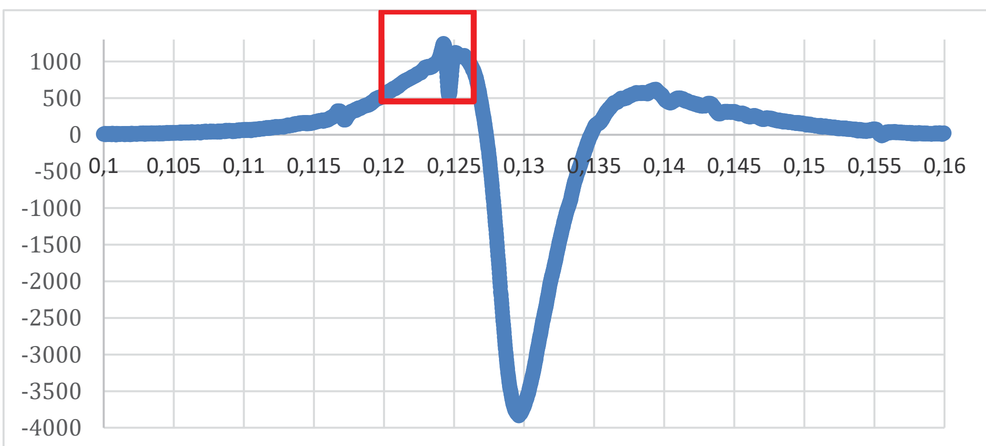

FIGURE 4. Original scanning graph

For a more visual understanding of the algorithm of the described method and its further implementation in automatic mode, a part of the above schedule was considered to implement the correct application in a more simplified format. A data fragment located in the region of 0.123-0.126 samples on the X-axis was selected. This fragment is shown in Fig. 5. To realize the difference in extremes, you need to get rid of low-frequency noise, which does not allow you to identify specific extremes. A simple median filter, which is a nonlinear FIR filter, was used as a filter.

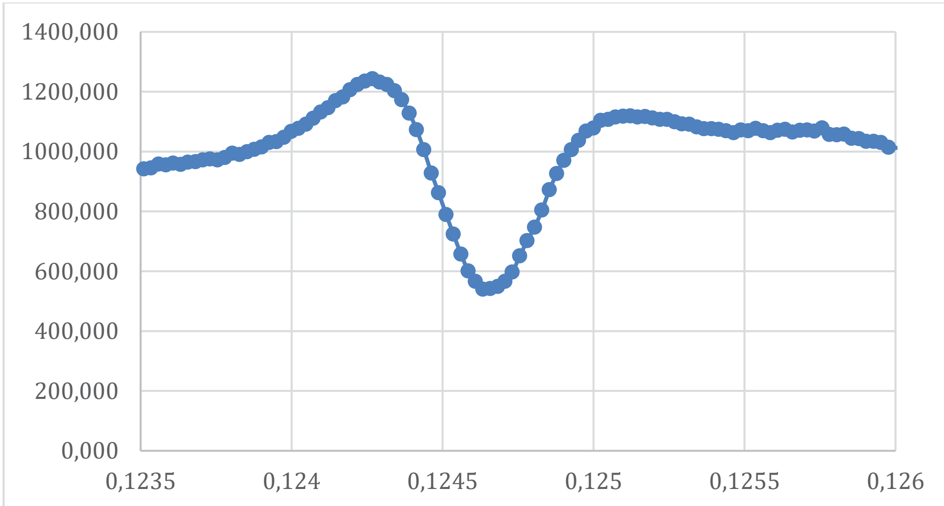

FIGURE 5. Fragment of the original scan graph

The results after applying several iterations of filtering can be seen in Fig. 6.

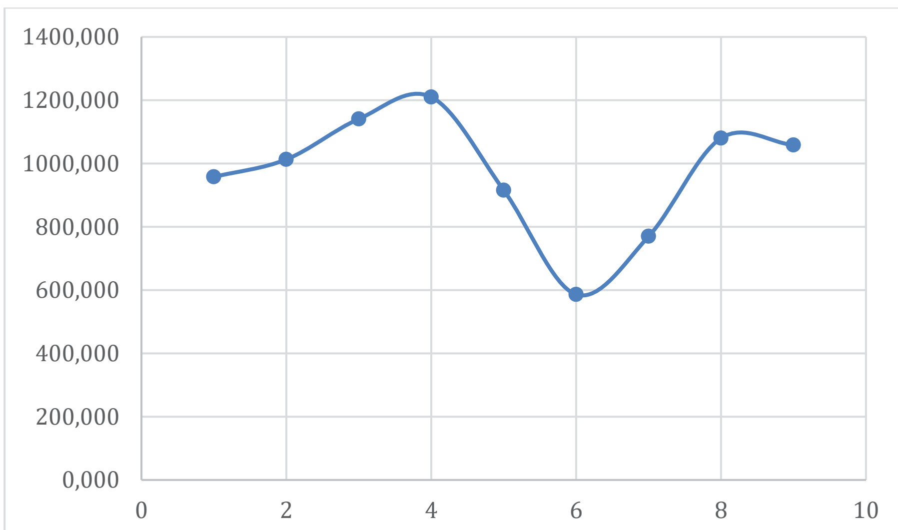

FIGURE 6. The result of filtering at the modified scale

DISCUSSION OF RESULTS

As you can see, after the filtering procedures, low-frequency noise was leveled, and the measurement results became more clear, which allows you to use the method [1] in the future, without fear of false recognition of extremes further when using the algorithm for finding extremes. This algorithm is implemented in Excel using mathematical and logical functions.

According to formula 1, primary processing, thinning and averaging are carried out, then according to formula 2, the extremes are found.

$$x_{n-1} - x_n = A_n$$

$$\textit{if (sign } (A_n) \textit{ not equal to sign} (A_{n+1}) \textit{ that } A_n \textit{ extremum.} \tag{2}$$

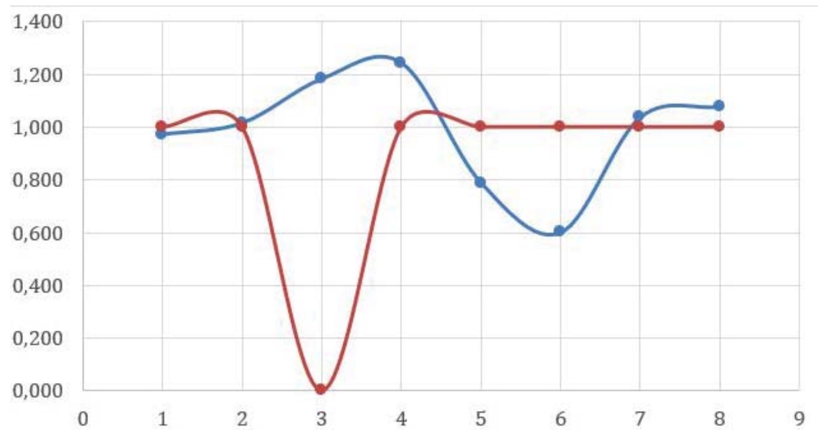

FIGURE 7. Result of applying the method

The result of the above described method was a pronounced peak in Fig. 7, which allows us to say that the local extremum of the minimum of the function on the graph is commensurate with the useful signal, which did allow us to assert the presence of a defect at this point.

CONCLUSIONS

The practical implementation of this method is possible by standard means of a personal computer in the Excel package. Further processing of the prepared signal using the method [1] allowed us to achieve an even higher signal-to-noise ratio.

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