AUTOMATION OF EVALUATION OF MEASUREMENT IN DEFECTOSKOPY OF POWER STEAM GENERATOR

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Automated assessment of steam generator tubes by eddy current method is associated with classification of indications into classes which correspond to the responses of the measured signal of steam geneator construction elements as are supports, defects of tube material and artificial defects of calibration tube.

Contribution concentrates on the description of automated assessment of defectoscopic measurement. Suitable choice of methods of detection and location of indications, classification of indications into classes and quantification of defect parameters are very important.

1 Introduction

Nondestructive defectoscopy plays an important role in testing of machine equipments, of gas-pipes, in aeronautics and especially in nuclear power engineering. Eddy current method is worldwide used for routine testing of various parts of nuclear power plant, e.g. of building-up of reactor envelope, steam generator tubes, etc.

Nondestructive diagnostic method by eddy current method is based on alternating magnetic field created by the probe coil. The magnetic field induce alternating magnetic field in the testing material which induce eddy currents. Magnetic field induced by eddy current has an opposite direction to the field in the coil. Superposition of both magnetic fields results in the change of coil impedance. One of eddy current method applications is sensing and assessment of impedance changes of a coil which is moving inside the electrically conductive tube of steam generator. The change of impedance is caused by deformation of eddy current paths which correspond to steam generator construction elements, to imperfections of tube profile, to anomalies caused by material inhomogeneity, by tube impurities and by the defect alone. Electrical signal can reliable describe properties of tested material.

2 Principle of the system of automated data assessment.

We can describe the structure of system suitable to the evaluation of measurement records using block diagram in fig.2., whose structure is similar to the sequence of manual evaluation.

As the input data or parameters there are two informations:

- knowledge of evaluation record structure, which parts correspond to the indications of construction elements of tested object (support, collector, transition between tested and measured tube. Every record contains also signals from the same tube containing artificial defects with well-known parameters. The typical arrangement of mentioned elements with signals records at measured frequency 100kHz is in fig.1,
- dimensions of construction elements (without the support, thickness of steam generator envelope). These parameters at known frequency of signal sampling enable to assess average speed of probe motion and then to determine the length of tube, relative position of supports and to assess position of defect.

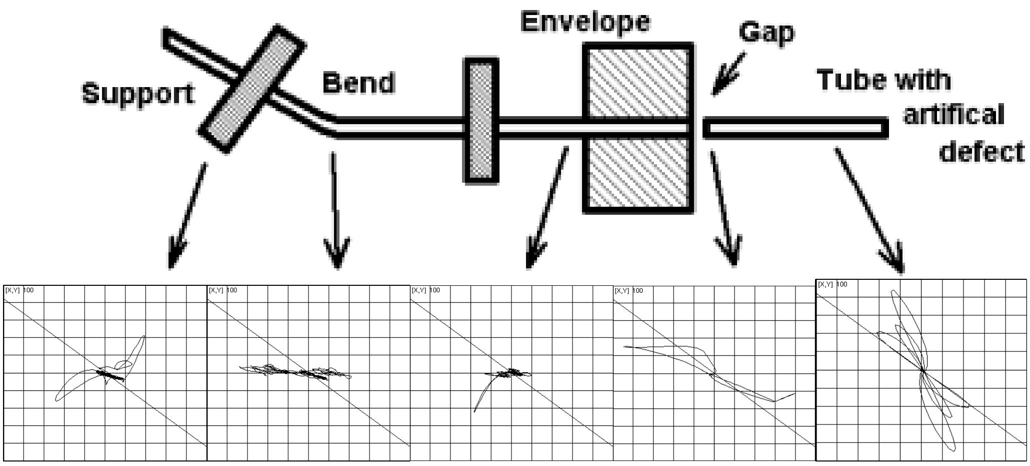

Fig.1 Arrangement of construction elements of steam generator

The process of testing is controlled by the block of assessment control that assures sequential reading-up of measurement data on tubes once after another as they have been created, to assure interruption of evaluation in case of message reading-up about change of measurement system parameters (change of setting, replacement of measuring probe etc.). It is necessary to assure reinitialization of input parameters (parameters for data transformation and for measurement) before each sequence of evaluation.

It is possible to divide module of parameters initialization into three separate parts:

- calculation of parameters for filtered records creation according a formula

$$\underline{X}_f(t) = \sum_i \underline{A}_i . \underline{X}_i(t) \qquad (1)$$

where $\underline{A}_i$ are complex constants calculated according to different criteria and $\underline{X}_i$ (t) is two-dimensional vector of signal components.

It enables to filtrate effects of construction elements (supports) or to filtrate influence due to the inaccurate leading of the probe through the center of the tube caused by the variability of tube profile [1].

- Unification is in principal a linear transformation of signals so that parameters of time curves according to the 100% artificial orifice on the calibrated tube would have the same values for all channels (at different frequencies) and for filtered signals.
- Calibrated curve is constructed by the regression methods over n-tuple of pairs (known percentual drop, tilting).

The evaluation is accomplished in three steps, it is the transformation of input data that enables creation of auxiliary data acquired by original records filtration.

- Unification of records should be so that the parameters of indication (slewing and magnitude) would reach defined values in place of artificial defect - 100% defect on the calibrated tube.
- Estimation of position of expected indications (steam generator contains tubes of different length with different number of supports).
- Final step means searching and classification of other indications.

At the localization of indications, that correspond to the defects or to some mechanical or material anomalies, output of information to the protocol, storing of graphical information into memory and printing is performed.

The most important parts of system are modules for localization of indication position and for measuremnt of 2D curves parameters.

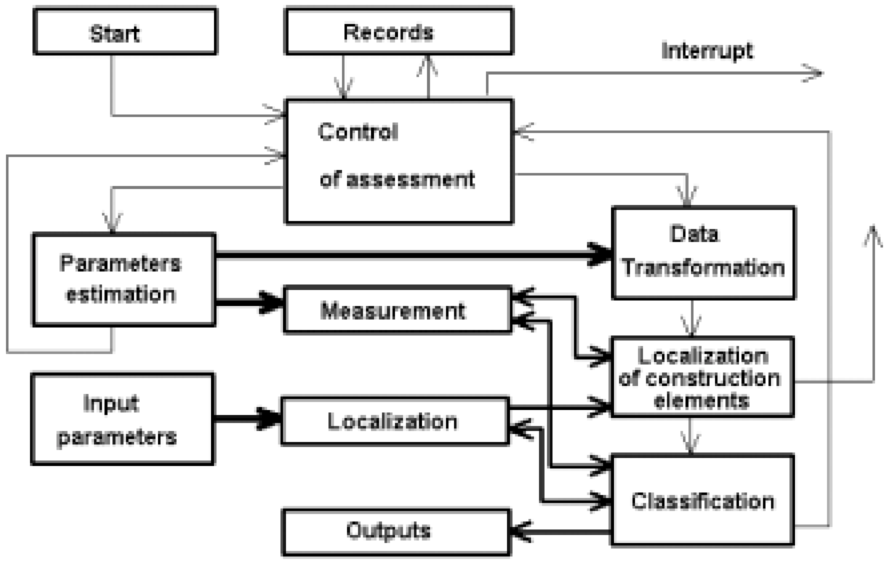

Fig.2 Block diagram of system for data evaluation

For automated assessment of records it is necessary to assure the reliable detection of all parts of signals which can be potential locations of indication occurrence responding to the selected construction elements of steam generator (e.g. support plate) and especially to the location of defects . The use of wavelet transformation for the assessment of position above mentioned indications is a very perspective method [3].

There is an example of algorithm application in fig. 3, where time curves of records from tube containing eight support plates and other elements in accordance with fig. 1 are given, that means time curves of x- and y- component of signal. In the grey-level diagram there is a value of coefficients of wavelet transform presented. Areas with the highest level of colour shade (white colour) represent high value of complex coefficient of wavelet transform, that means high correlation of chosen wavelet function with the part of analysed signal. Location of the brightest shades in vertical direction indicates level of decomposition (scale) at which the highest correlation occurs.

Then the couple of values (value of coefficient and level of decomposition) characterizes indication from point of view of size and of type of indication. From the location of maximum of wavelet transform coefficients in horizontal direction and from the level of decomposition it is possible to assess approximately location and neighbourhood round this location in the initial record, the area, which contains segment of signal corresponding to the responsible type of indication.

For classifying of indications by eddy current methods the representation of indications using 2D curves is used very frequently. The shape of curve depends on the type of indication (fig. 1). Neural networks have the ability of generalization and universal approximation. This is a result of general approximation theorem. They were successfully used in the defectoscopy using eddy current [2],[7]. For classification feed-forward supervised NN are mostly used. The most popular is the multilayer perceptron (MP). The input space of signature vectors of indications must be separable into disjunctive subspaces (clusters). It depends on the suitable choice of data representation of 2D curves. Training of typical feed-forward MP is quite difficult because it is difficult to obtain a big amount of real data of indications. We are forced to use the data of artificial indications. Probabilistic neural networks (PNN) can also be used in the problems of classification Their design is straightforward and does not depend on training. Results of solving this problem can be found [2], [4].

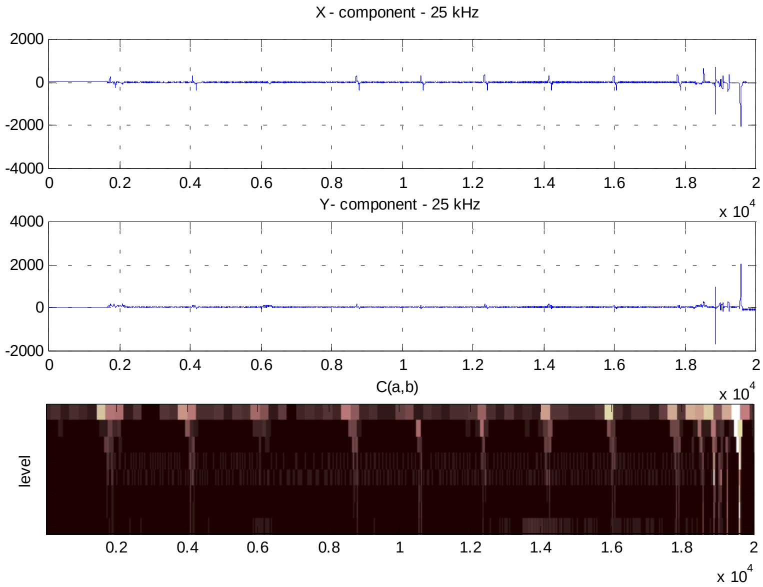

Figure 3. An example of signal analysis with the detection of constructional elements of steam generator

We can use two parameters [5], namely tilting of 2D curves and maximal range of bridge diagonal voltage for quantification of defect parameters using a differential probe. The first parameter corresponds to the percentual drop of material and the second one characterizes volume of missing material (size of defect).

3 Conclusion

The contribution presents one of possible conceptions of automated evaluation of defectoscopic testing . Parts of mentioned conception has been software implemented and tested on concrete measurement records on tubes made from material used in steam generators of nuclear power plants with imitations of defects, construction and other elements.

4 References

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