MAGNETIC MINIDEFECTOSCOPE FOR NONDESTRUCTIVE INSPECTION OF FERROMAGNETIC BODIES

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The paper is devoted to the modeling, construction, and testing of new magnetic minidefectoscope for nondestructive diagnostics of cylindrical ferromagnetic bodies (wipes, cylinders, etc.) with the diameters from 14 to 40 millimeters. This defectoscope has universal construction, which enables to apply it for the inspection of steel ropes too. The geometrical parameters of defectoscope have been determined to have the possibility to specify the minimal longitudinal defects of 100 micrometers. The sensing unit has been realized as one channel sort. The defects details have been analyzed with help of special software. The sensitivity has been tested in the laboratory by etalon samples with determined defects. The results show the level of 0.8% for material cross section change can be unambiguously specified.

Keywords: electromagnetic field modeling, magnetic measurements, sensor, nondestructive testing

1 INTRODUCTION

The nondestructive testing systems are important for the prevention of accidents. Magnetic method known as the magnetic defectoscopy has presently recognized as the most objective way of ferromagnetic wire ropes, tubes and pipes inspection in the frame of nondestructive testing [1]. This method allows us to detect not only the surface breakages (broken wires, imperfections, cracks), but also the internal defects. The high accuracy of magnetic testing is directly connected with magnetization level of the inspected objects [2] and the quality of magnetic field sensors.

![Fig. 1. Model of magnetic nondestructive defectoscope.](image)

2 THEORETICAL

The physical principle of magnetic testing is based on the generation of secondary magnetic field, which is created by magnetized body. The flux lines of magnetized object do not all cross the defect area directly. It means generally that the longitudinal and radial components of magnetic field are observed around magnetized body.

The described new version of nondestructive device can be characterized in model by the yoke geometry. In previous paper we applied this yoke method and the sensitivity conditions. Geometrical parameters of magnetization head and sensing unit have been specified [1].

The mathematical analysis of nondestructive testing unit is based on Maxwell equations. FEM (Finite Element Method) has been performed in the combination with ANSYS software package. The first models have been realized in the frame of 2D geometry with cylindrical symmetry. In these cases the magnetic field is represented by the vector potential quantity. As regard the geometrical profile the defectoscope the application of 3D model with scalar potential formulation has been shown more accuracy. Fig. 1 demonstrates the example of 3D magnetized unit model.

3 FUNDAMENTAL PARTS OF DEVICE

The magnetic defectoscope for nondestructive testing of ferromagnetic ropes, wires, pipes and cylindrical bodies is generally completed from the following elements:

- source of magnetic flux realized by the set of permanent magnets,
- incremental measurement unit,
- sensing unit completed by one (two) sensor channels,
- interface box for data conversion and recording,
- PC for signal processing.

The magnetic minidefectoscope for nondestructive diagnostics of cylindrical ferromagnetic bodies (wipes, cylinders, etc) with the diameters from 14 to 40 millimeters is specified in Figs. 2, 3.

The sensing module is located inside between the poles of the magnetization head. In the sensing yoke are fixed Hall plates (Siemens KSY 14), which transform the magnetic field to electric voltage. The electrical signal is amplified by amplifiers in sensing module to ensure the maximal signal/noise ratio and subsequently transmitted to the interface box (A-D conversion) and measuring card of PC (DAQCard 6024E).

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4. EXPERIMENTAL TESTS

The sensing tests of new pipe defectoscope have been realized through the experiments with pipe etalon. This reference sample of steel pipe has been prepared with aim to confirm the indication limits the magnetic nondestructive diagnostics to internal defects. The analyzed object is completed from five welded equivalent parts of pipe where each pipe segment is characterized by six different artificial damages. The geometrical distribution of defects and completed etalon are depicted in Figs. 5, 6.

The holes have been produced inside radially from axis to have the sample with internal cracks, which are invisible from outside by eye. After preparation of breakages in each sample segment the pipe parts have been axially welded.

The experimental arrangements have been concentrated on the comparison of the original magnetic diagnostic unit and new equipment, which was developed at Institute of Physics, TU Ostrava. The concrete results are collected in Fig. 6.

The solid line describes the measurement realized by the newest version of magnetic defectoscope with complete set of permanent magnets, the dot one specifies the sensitivity of the same version of defectoscope but only 50% of permanent magnets have been used to generate magnetic flux. For the comparison the signal output from REMA 1 defectoscope is demonstrated by dashed line. The three sharp high peaks (Fig. 6) represent the welded area.

The modulation of output signal between welded areas characterizes the effects of the artificial damages. The signal differences in the frame of compared discussed diagnostic units are expressive. The detail of signal output from left side and middle one of pipe etalon are shown in Figs. 7, 8.

The one of the most important parameters of magnetic inspection device is signal repeating in the case that the same part of tested body has been measured once more. This parameter has been analyzed by ferromagnetic wires with 14 mm diameter (Fig. 10). These wires have been characterized by production cracks. The related signal output from magnetic minidefectoscope is presented Fig. 9. The same part (2 m long) has been inspected two times. In the first case the output voltage corresponds to the wire without artificial breakage, the second one describes the voltage signal related to the same of wire with artificial incision (Fig. 10).
5 CONCLUSIONS

Described defectoscope has the universal construction, which enables to apply it for the inspection of steel ropes too. The geometrical parameters of defectoscope have been determined to have the possibility to specify the minimal longitudinal defects of 100 micrometers. The defects details have been analyzed with help of special software. The sensitivity has been tested in the laboratory by etalon samples with determined defects. The results show that the sensitivity level of 0.8% for material cross section change can be permanently guaranteed.

Acknowledgement

This work was supported by the Grand Agency of the Czech Republic (#202/03/0776) and by the Ministry of Education, Youth and Sport (# ME 507, # ME 508).

REFERENCES