Inspection of Train Hollow Axles by Measuring AC Field Vector

Tomasz Chady, Grzegorz Psuj, Jacek Kowalczyk and Ireneusz Spychalski
Department of Electrical and Computer Engineering
West Pomeranian University of Technology, Szczecin
Szczecin, Poland
tchady@zut.edu.pl, gpsuj@zut.edu.pl

***Abstract*—In this paper a new electromagnetic nondestructive system for inspection of train hollow axle is presented. The system allows to observe changes of vector AC fields in order to enhance the probability of proper classification. The performance of the system is verified using hollow axle sample with artificial notches of different depths. The experimental results are presented and discussed.**

Keywords—nondestructive testing; vector field measuring; hollow axle testing;

I. Introduction

The last developments of high-speed trains railway industry put more pressure on improvements of safety inspections procedures. This results in higher demands of introducing new complementary inspections methods or developing system combining testing techniques. One of the most crucial elements for the maintenance of adequate safety level of the high-speed trains are axles. For the minimization of risk of the danger failures of the wheelsets number of inspections have to be carried out during the exploitation of train axles. The most common methods utilized by railway industry for manual inspections are visual, ultrasound and magnetic penetrant testing [1]-[4]. However, application of those techniques in evaluation of train's key components during the exploitation period is limited. They mostly require removal of the wheelset from the wagon bogie and the full disassembly of the wheelset in order to facilitate access. The ultrasound technique is frequently utilized in automatic inspection systems [4], but it is insensitive to the surface breaking defects. Therefore, it is impossible to achieve a full range evaluation of the axles. For this reason, a new electromagnetic system designated to hollow axles testing is introduced in this paper.

II. Measuring System

The proposed electromagnetic system for nondestructive inspection of train hollow axles consists of: a PC class computer with data acquisition board (DAQ), a power amplifier, preamplifiers and lock-in amplifiers. The block diagram of the system is presented in Fig. 1 and the photo in Fig. 2. The PC computer working as a system's server runs a dedicated software under NI LabVIEW environment. The system is capable of acquiring complex response signals. The evaluation of hollow axle is carried out using both real and imaginary components of the signal. The system can be controlled locally as well as remotely via Ethernet using TCPIP protocol. The remote control is carried out using application working under any environment by a set of dedicated text commands. This makes the system flexible for the future development. The detailed description of the system and the transducer will be presented in final version of the paper.

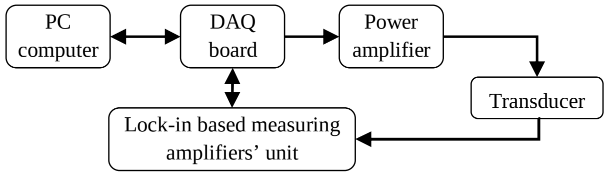

Figure 1. Block diagram of the electromagnetic system for nondestructive inspection of hollow axles.

Figure 2. Photo of the electromagnetic system for nondestructive inspection of hollow axles.

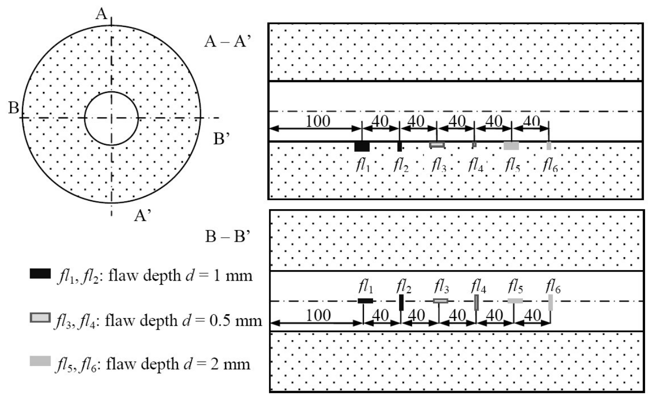

Figure 3. Cross-section view with dimension of the hollow axle sample utilized in the experiments.

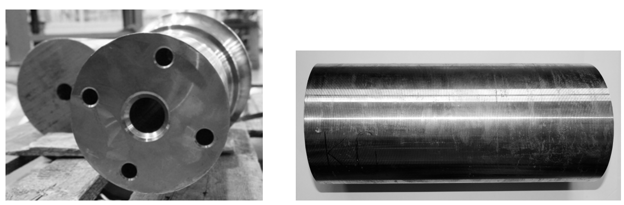

Figure 4. Photo of the hollow axle samples.

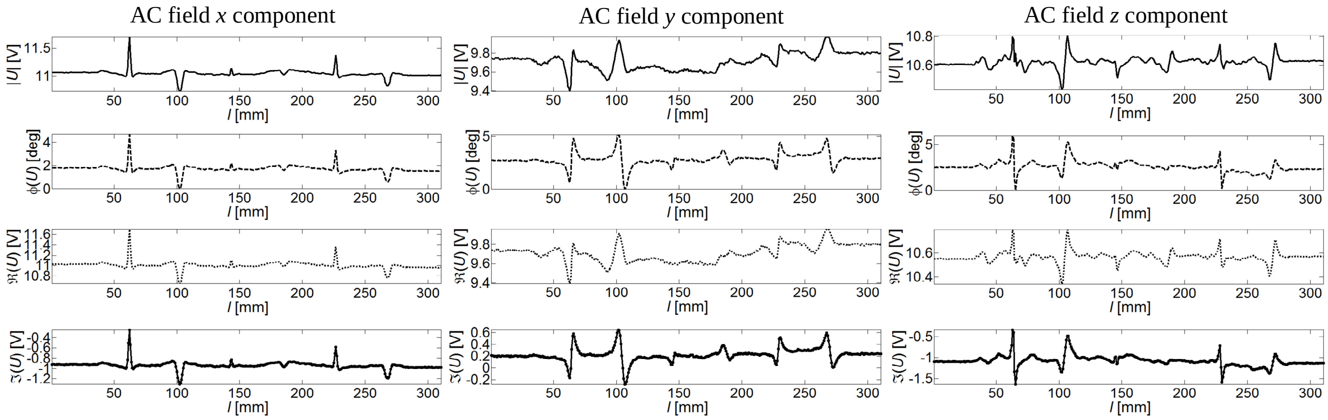

Figure 5. Results of the measurements obtained for hollow axle sample with artificial defects during 1-D scanning; presented signals: magnitute, phase, real and imaginary part of all three observed AC field components.

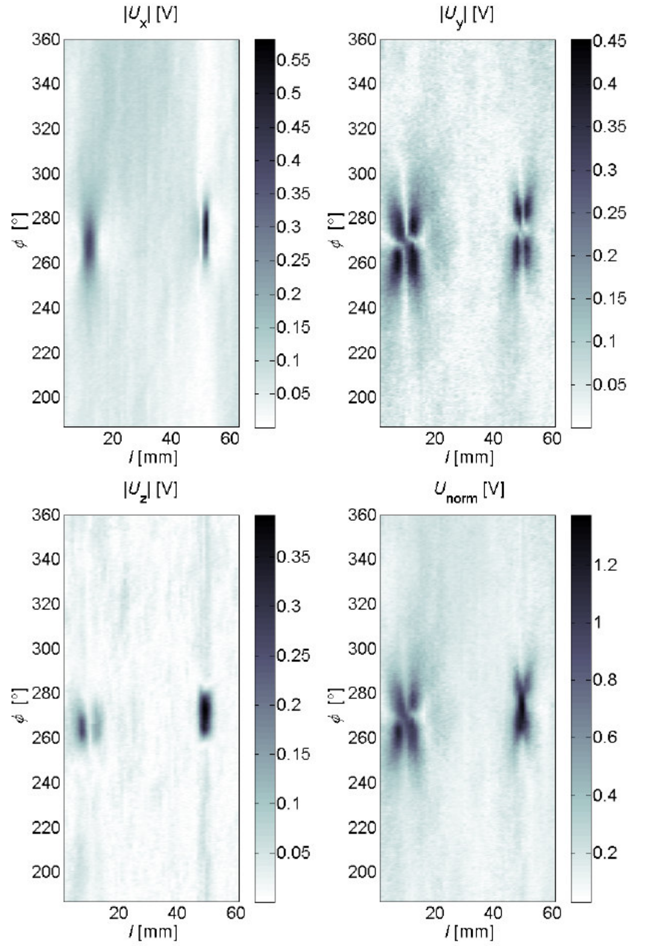

Figure 6. Results of the measurements obtained for hollow axle sample with artificial defects during 2-D (l, ϕ) scanning; presented signals: magnitute of three AC field components (U_x, U_y, U_z) and module $|U|$.

III. Testing Samples

In order to verify the performance of the system, real hollow axle samples were utilized (Fig 3. and Fig 4.). Several electro discharged machined notches were manufactured inside the axle. The notches have same width and length: 0.2 mm and 5 mm respectively. The depths of the flaws vary from 0.5 mm to 2 mm. The notches were oriented along (axial direction) and across (circumferential direction) axle's axis. The dimensions of the sample as well as the dimensions of the notches are presented in Fig. 3.

IV. Results of Mearuments

First, in order to evaluate the symmetry of the transducer and to select optimal values of parameters of the system, a number of preliminary experiments were carried out. Different excitation frequencies as well as different field strength were applied during measurements. The results of the test will be presented and discussed in the full version of the paper.

The final experiments were carried out with six EDM notches using the optimal configuration. Selected results of inspection obtained during 1-D scanning of the hollow axle sample in the axial direction are presented in Fig. 5. For each component the magnitude, phase, real and imaginary part of the measured voltage are shown. Scan was made from the side of 1mm flaws (see Fig. 3). It can be seen that all components allow to detect flaws. Next, the sample was scanned in two directions (axial and circumferential). The acquired images obtained for the fl_1 and fl_2 flaws representing magnitude of all three field components as well as the norm value are presented in Fig. 6. The full set of results, the detailed analysis and discussion will be presented in the final version of the paper.

Acknowledgment

This work was supported in part by EC sponsored project AxleInspect which is a collaboration between the following organizations: IDEKO S. COOP., West Pomeranian University of Technology (ZUT), VERMON SA, PHOENIX INSPECTION SYSTEMS Ltd, BALFOUR BEATTY RAIL TECHNOLOGIES Ltd, TWI Ltd and DANO-RAIL S COOP. The project is coordinated and managed by TWI Ltd and is partly funded by the EC under the Research for the Benefit of Specific Groups Project (ref: FP7-SME-2011-1-GA- 286573).

References

[1] *EN 13261:2009+A1:2010: E*, " Railway applications - Wheelsets and bogies - Axles - Product requirements"

[2] *EN 15313:2010: E*, " Railway applications - In-service wheelset operation requirements - In-service and off-vehicle wheelset maintenance"

[3] Rudlin J. R., Shipp, "Review of Rail Axle Inspection Methods", *International Seminar on Railway Axles*, Imperial College, London, September 2003

[4] J. Rudlin, A. Raude, U. Völz, A. Lo Conte, "New Methods of Rail Inspection and Assessment", 18th World Conference on Nondestructive Testing, Durban, 2012.