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INSPECTION OF WIRE ROPES IN TAPERED SOCKETS

DIAGNOSTYKA LIN STALOWYCH

Presently there are no totally reliable methods of inspecting wire rope ends in tapered sockets. Magnetic testing techniques were applied hitherto and certain rope sections were never inspected, as the measuring head could not be moved right along to the rope termination. A new measuring instrument is presented in the paper. It offers a unique possibility of investigating rope end sections in engineering structures where ropes act as structural members, such as those widely found in underground and open-cast mining sectors.

Key words: diagnostics, magnetic testing

Nie ma obecnie pewnej metody badań zakończeń lin stalowych w uchwytach stożkowych. Do tej pory badano linę metodą magnetyczną, z pozostawieniem nieprzebadanych niewielkich odcinków ze względu na brak technicznych możliwości dojazdu głowicy pomiarowej do jej końca. W artykule zaprezentowano możliwości wykorzystania nowatorskiego urządzenia do badania lin w zakończeniach w diagnostyce cięgien linowych stosowanych m.in. w górnictwie węglowym i odkrywkowym.

Słowa kluczowe: diagnostyka techniczna, badania magnetyczne

1. Introduction

Engineering structures in which ropes act as structural elements are considered to be economical and modern (Pałkowski 2001). They are indispensable in large-span structures, where the tension members have to carry considerable dynamic forces, as in the following;

- machines used in open-cast mining (dumping conveyors),

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- mine hoists,
- suspension bridges,
- masts and stacks with guy ropes,
- sports halls where roofs are supported on tension elements,
- ski lifts and ropeways,
- overhead power transmission lines,
- passenger transport facilities.

The key elements in those structures are wire ropes. While in service, their actual working condition in hard to assess. Time sequences relating to the rope condition can be then made use of to determine the service life of ropes. There are several factors that might affect rope performance and condition. At each stage the rope condition can be assessed by way of diagnostic procedures involving magnetic inspection supplemented with other techniques of non-stationary signal processing, such as wavelet analysis. Diagnostic algorithms used in rope inspection help to assess the real condition of the tested rope, to retrieve its back history and to predict the possible changes.

Apart from their obvious advantages, structures with tension elements have come disadvantages too. There are some major difficulties still to be overcome: anchoring of the tension elements (ropes), force transmission from the tension members onto the foundations and the whole engineering structure, finding the appropriate geometry of the structure and pre-stressing of the tension element. The last but not least problem involves the assessment of rope condition at terminations. No absolutely reliable method of inspecting rope ends in tapered sockets is available yet. Up till now magnetic inspection was applied though some short rope section were never inspected as the measuring head could not be moved close enough to the terminations.

2. Structures with tension elements used in mining — inspecting rope end sections

Ropes in tapered sockets at the ends are used as guide ropes in mine hoists. Such ropes are also found in open-cast facilities, including loading and dumping conveyors (Fig. 1).

The main technique for assessing the condition of rope end section (Fig. 2) involves the visual inspection for broken wires in the outer layer and traces of corrosion or rope deformations. This method, however, requires skilled and experienced inspectors and the results can be considered in qualitative terms only (Tytko, Koszyk 2002). Magnetic particle inspection allows for checking the outer rope surfaces only while supersonic techniques might be applied prior to the structure assembly. In industrial applications this method is therefore not practicable. Attempts were also made to utilise X-ray tommography, ultrasonography and resistance-based methods, yet all these proved too expensive for applications in industry.

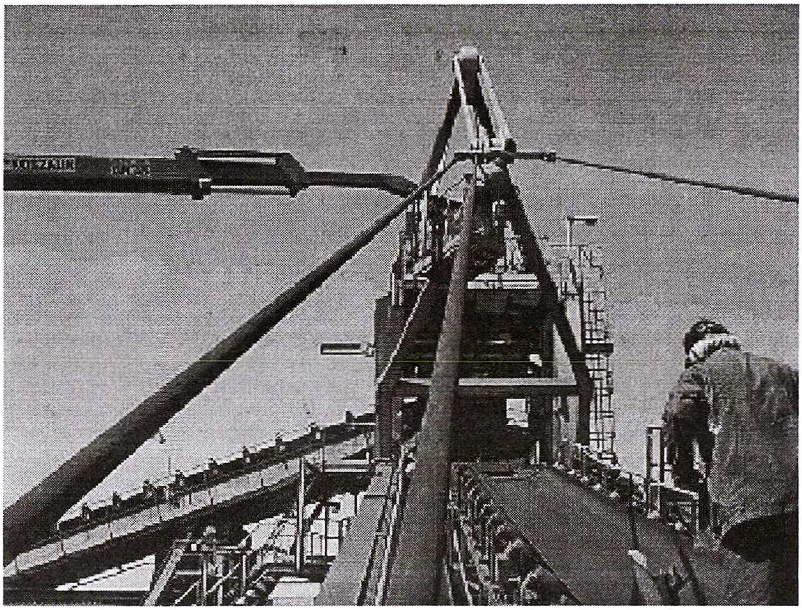

Fig. 1. Ropes in loading and dumping conveyors

Rys. 1. Cięgna liniowe zwałowarko-ładowarki

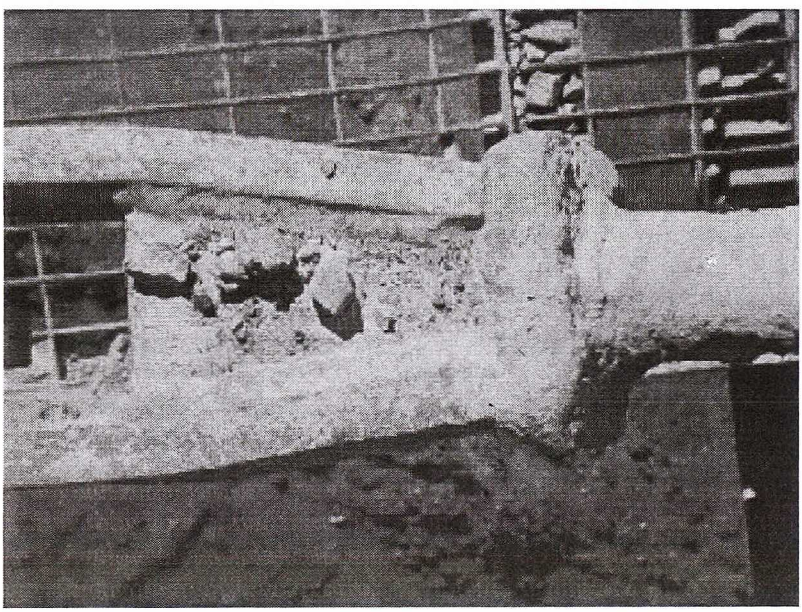

Fig. 2. Rope end sections in tapered sockets

Rys. 2. Zakończenie cięgna w uchwycie stożkowym

3. New instrument for rope inspection — engineering objectives

On the basis of patent specification (Hansel, Kwaśniewski, Lankosz 2001) the new instrument for testing the rope end section was engineered and the main objectives were set forth:

- it must be assembled in industrial buildings,
- rope diameter variations must be determined in qualitative and quantitative terms,
- inspection as close to the termination as possible,
- the required metrological properties must be ensured.

The measuring instrument with a rotating sensor in shown schematically in Fig. 3.

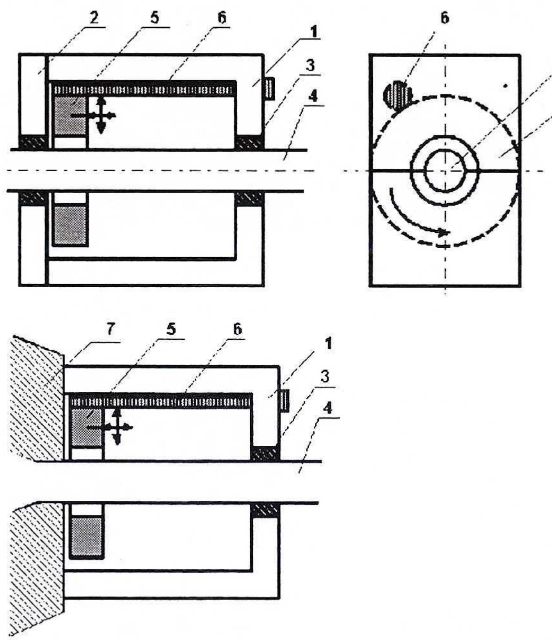

Fig. 3. New instrument for inspecting rope ends in tapered sockets

Rys. 3. Schemat urządzenia do badania w stożku

The instrument for wire rope testing is made of a two-part frame in which magnetic circuits are placed. There is a permanent magnet (1), a pole piece and profiled inserts 3 to fit the rope diameter. The magnetic circuit is shorted through the rope 4 and the tapered socket. In the circuit there is a measuring sensor 5, set in rotating or vibratory motion by the drive 6. Wherever a defect is spotted, the magnetic field round the rope 4 is disturbed, and the field disturbance is detected by the sensor 5, which in turn will convert the disturbance into an electric signal. This signal is further processed in the device not indicated here. It could be either a voltage recorder, flaw detector or recorder, or a computer.

4. Laboratory testing

On the basis of patent specification, a laboratory model of the instrument was engineered (Kwaśniewski 2002), see Fig. 4. It consists of a two-part magnetic circuit 1 to be placed upon the rope 3 and the tapered socket 2. On the rope there is also a rotating head with the measuring sensor 4 controlled through the hand wheel 5. The measuring head can be moved along the rope.

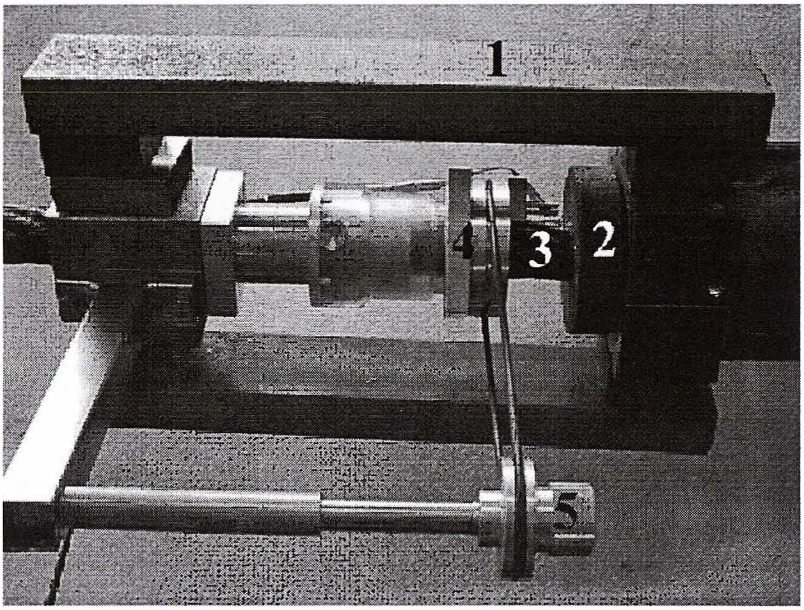

Fig. 4. Measuring head GPW (measuring head with the rotating sensor)

Rys. 4. Głownica GPW (głowica pomiarowa z wirującym czujnikiem)

The sensor measures the stray field as close to the socket as possible. When the magnetic circuit is in the position as indicated here, the measurements can be taken up to 40 mm from the tapered socket.

Flux distribution in the measuring head obtained using the FEM method is depicted in Fig. 5.

Magnetic field distribution around the modelled defect is shown in Fig. 6. The visibly changing amplitude of the induction vector has its maximum 5 mm from the tapered socket.

Magnetic field distribution around the real defect was measured with a Teslameter 912T (Hall generator) sensor and Matlab software (Matlab 1996) was used for visualisation of results. In the case considered here the following system of coordinates was assumed: x-development of the measuring plane along the rope circumference, y-distance from the tapered socket.

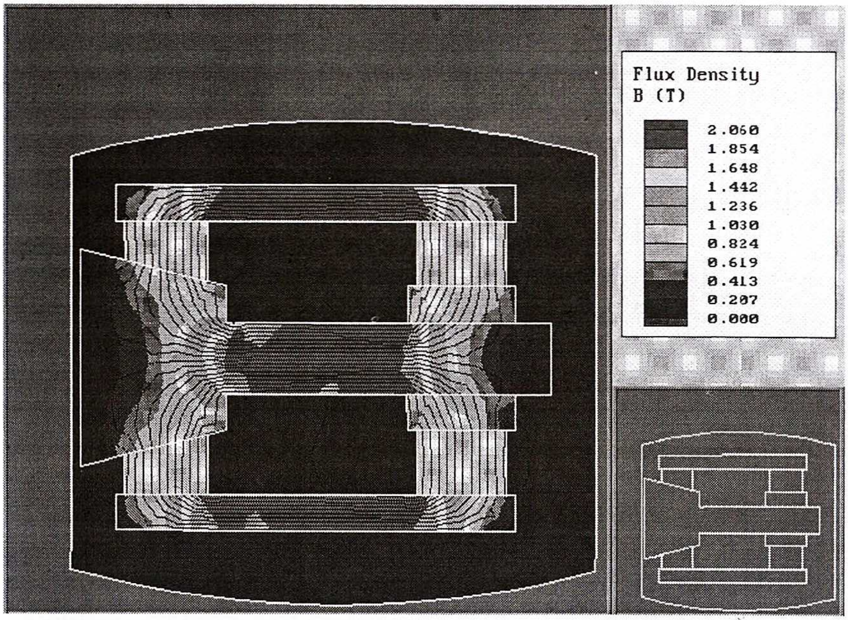

Fig. 5. Magnetic field distribution in the magnetic circuit

Rys. 5. Rozkład pola magnetycznego w obwodzie magnesującym głowicy

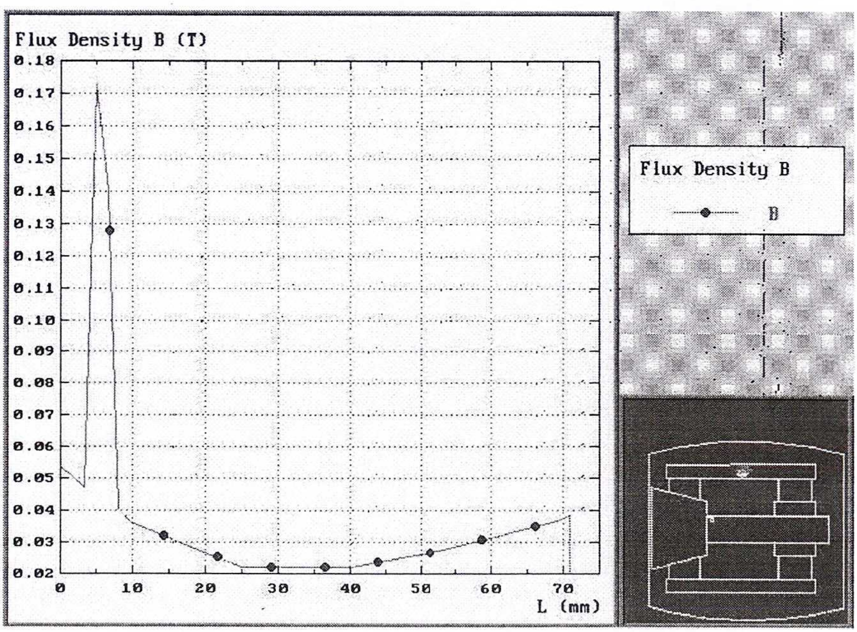

Fig. 6. Magnetic field distribution around the modelled defect

Rys. 6. Rozkład pola magnetycznego wokół zamodelowanego uszkodzenia

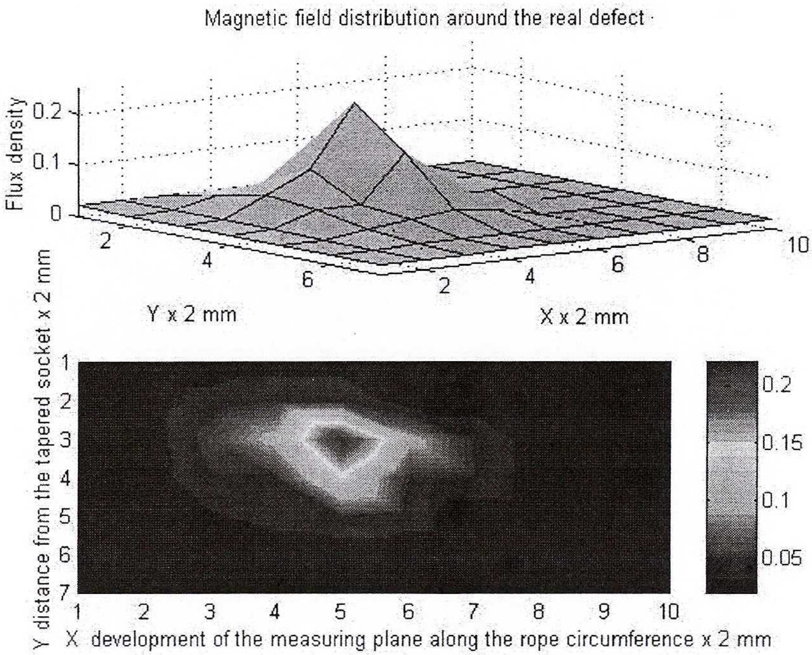

Fig. 7. Distribution of stray field induction around the defect

Rys. 7. Rozkład indukcji pola rozproszenia wokół uszkodzenia

This instrument might be used to measure the stray field distribution up to 40 mm from the taper (in one position of the magnetic circuit). At the distance 6 mm from the taper induction rapidly increases, which indicates the presence of the modelled fault.

The whole series of tests involving all types of rope defects should demonstrate all the diagnostic features of the new instrument for inspection of rope end sections in the light of the design and metrological objectives.

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