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Measurement of tight in steel ropes by a mean of thermovision

Jozef Krešák [a], Pavel Peterka [a,*], Stanislav Kropuch [a], Ladislav Novák [b]

[a] Testing Laboratory of Steel Ropes SKTC-147, Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University of Košice, Park Komenského 14, Košice, Slovak Republic
[b] Faculty of Electrical Engineering and Informatics, Department of Physics, Technical University of Košice, Park Komenského 2, Košice, Slovak Republic

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ABSTRACT

If tenseness in a wire causes its warming, the weakest place of the rope will react – it will became the warmest. If it is possible to predict the place/point of destruction of a rope or a chain by a means of tenseness causing warming, than it is also possible to search for disruptions on static ropes, but at suitable conditions. Destructive and non-destructive measurements were combined in order to detect disruptions on ropes and chains. Our experiments proved that at certain conditions the use of thermovision for detection of weak places on loaded ropes and chains is applicable. Above mentioned methodology was applied on static ropes in the place where it is not possible to perform regular NDT and at the places where ropes enter socket baskets.

1. Introduction

Steel and synthetic ropes are widely used in the technical practice. Inspection of technical conditions of moving steel ropes is practically solved by magneto-inductive defectoscopic methods. Measurements by these methods are problematic when applied on the ropes carrying various building constructions [11]. The biggest problem is a place where a rope gets off from anchoring. The paper points out new possibilities of using thermovision as a defectoscopic method in defectoscopic inspection of ropes. The advantage of thermovision is the possibility to apply it on ropes from non-ferromagnetic materials. The choice of the assessment method of the thermovisual measurements is based on the criteria indicated by the authors [1–5]. The paper presents measurements by thermovision as well as their evaluation performed in the laboratory conditions.

Infrared radiation is one of the non-destructive testing techniques for preventive and predictive maintenance [1]. Infra Red Thermography (IRT) has earned its popularity prior to other maintenance predictive techniques during the last few decades thanks to its various advantages. Contactlessness, simple interpretation and huge control coverage belong to the main advantages of the technique, but the most important is the fact it does not contain dangerous radiation. In particular, IRT was successfully applied in solving many real problems [2]. Easy handling and the sequence of measurement by a means of IRT appear as more effective and operative technique for the fast localization of a defect, even though the evaluation of a thermogram obtained by scanning is intricate. IRT was used for measuring pressure plants in petrochemicals industry [2]. Recorded thermograms of pressure plants showed besides thermal energy from the technology also thermal energy developed by the increase of the pressure in the walls of the pressure vessels.

We earned this piece of knowledge in the course of a number destructive testing of steel ropes, when sparkling during the destruction of the sample was observed as the manifestation of increased thermal energy in the place of destruction. We assumed there would exist functional dependency in the midst of increased tensity and the increase of thermal energy in the specimen. Several measurements were performed by a means of IRT on the basis of previous observations and we wish to present them here.

Our expectations had been confirmed, but when processing measured thermograms we come across a problem

* Corresponding author. Tel.: +421 556022816.
E-mail address: pavel.peterka@tuke.sk (P. Peterka).

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of their evaluation. Therefore the following chapter deals with the methods, which were taken, in consideration in the course of processing the thermograms. Our anticipations were validated. In the course of processing of the measured thermograms we came across the problem of their interpretation. The following chapter introduces the method taken in the consideration in the elaboration of the thermograms.

2. Experimental method

Algorithms for failure detection can be divided into two categories: specialised algorithms and general algorithms. General algorithm is an algorithm not specified for detecting failures in thermovision while a specialised algorithm is solely entitled for the usage in thermovision.

Thresholding is in common used technique for detaching an object from the background because of its fast understanding and simple implementation [3]. Thresholding is also widely used for detection of malfunctions and errors [4]. Histogram is a main tool used in thresholding for separation of processes. Let us assume that a histogram (grey colour levels) match the picture $f(x, y)$ compound of a bright object and a dark background. One of a means how to detach an object from background is to choose a threshold T which will separate these two modes. Threshold picture $g(x, y)$ from the picture $f(x, y)$ is defined as

$$g(x,y) = \begin{cases} 1 \text{ if } f(x,y) > T \\ 0 \text{ if } f(x,y) \leqslant T \end{cases} \quad (1)$$

In case a histogram in the tones of grey colour is calculated for the whole picture, then T is called global threshold. So if T is derivate from the nearest environment, then this value is termed as a local threshold. Two-step thresholding is an operation in which one T is being active while multiple thresholding operates with more than one T-rate [3,5].

Numerous thresholding techniques for the segmentation of an image have been designed and the reviews were published [6–10]. Sezgin and Sankur [10] classified these techniques into six categorise: (1) histogram shape-based methods, (2) clustering-based methods, (3) entropy-based methods, (4) object attributed-based methods, (5) spatial methods, and (6) local methods.

3. Results

One of the possibilities for application of thermovision is also monitoring of tenseness increase in dependence of increase of power behind the certain time in mountain massifs, constructions, machinery parts and electric transition systems.

The Testing laboratory of steel ropes performed the first measurements on the samples of steel ropes and chains by a thermovision camera. During the measurements one by one undamaged steel ropes and chains with two eyes in horizontal position were fasten into the tearing machine. The ropes and chains were gradually loaded until their destruction appeared. The ropes were loaded by the strengths from 10 kN up to 170 kN.

The increase of temperature from the outer loading was recorded continuously. When the required loading was reached, the snapshot from the measurement was made.

The paper introduces captured thermographs and the results of measurements of one sample of lifting accessories from steel ropes and one sample of lifting accessories from a chain.

The assessment of the thermographs was performed according to the above mentioned general thresholding algorithms.

For scoring of thermographs was chosen two-step thresholding by a means of which in all observing samples, when there was an increase of tenseness ($\Delta\sigma$), the temperature of the first threshold $T_{\mathrm{AR\,max}}$ and the second threshold $T_{\mathrm{LI\,max}}$ were read. The temperature $T_{\mathrm{AR\,max}}$ is the maximum temperature on the area of the whole sample thermograph besides the background of so called local threshold. The temperature $T_{\mathrm{LI\,max}}$ is the maximum temperature of the chosen area of the thermograph, so called local threshold.

We used thermocamera FLIR P60 for measurements. The camera has the following parameters: scale of measured temperature from −20 °C to + 2000 °C, graphic resolution 320 × 240 pixels, 24 degrees lens, sensing device is not cooling microbolometer and wave range is from 7 µm to 14 µm. The thermocamera does not have direct scale reading. Scale reading is performed through the computer and it is evaluated by the software. The thermocamera is fully radiometric; it allows evaluating every single pixel to other pixels on the screen. The records of every measurement were sequenced with 1second period. Sensibility of the sensing device is 0, 08 °C for 30 °C black body.

Measurements were performed on the tearing machine with maximum load 2500 kN (Fig. 1).

3.1. Results of the measurement

3.1.1. The first sample

The first tested sample of lifting accessory form the steel rope had following parameters:

Steel rope	6-stranded, 222 wires
Construction of a rope	6 (1+6+12+18) + v
Lay type and direction of the rope	right lay/contrary
Nominal rope diameter	18 mm
Nominal wire diameter	0.8 mm
Nominal metallic cross-sectional area of the rope	111.6 mm^2
Tensile strength grade of the rope, rope grade	1570 MPa
Nominal rope length mass of the rope	1.03 kg m^{-1}
Calculated minimum aggregate breaking force	175.2 kN

Fig. 2 shows the thermograms scanned during the measurement of the first sample.

The method of two-step thresholding was employed when estimating the temperature at scanned places.