PROSPECTS FOR CONDITION MONITORING FOR ROPES OF MINE HOISTS

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ABSTRACT

Continuous wire rope monitoring is a new emerging application of rope NDT. It allows to increase safety of rope installations, which is especially important at dangerous industrial objects such as drilling rugs, hoists of steel mills, offshore applications, mine hoists, ropeways. Design and implementation of rope monitoring systems should solve problems, which are typical for common rope testing instruments. Firstly monitoring systems should be have rugged designed and be able to work in severe working environment (high and low temperatures, high humidity, dust, vibration, explosive environment) and at the same time require minimum servicing. Secondly it should be automated and give easy to interpret indication, so that it can be applied by general machine operating personnel.
Thirdly it should consider different rope health parameters to ensure the most reliable assessment of rope condition. In many cases it is desired that information from monitoring system could be wireless send to the computer of senior engineer and stored for possible detailed analysis. Problems of the use of common rope testing instruments at the mines, examples of the use of condition monitoring systems, different approaches to condition monitoring, use of the INTROS-AUTO system are discussed.

KEYWORDS

Rope NDT, Condition Monitoring, Mine Hoist, Loss of metallic cross-section area (LMA), Localized faults (LF), Magnetic rope testing (MRT).

INTRODUCTION

Steel wire ropes are in widespread use in many critical industrial installations and machines, where any accident can cause material or even human losses. As an example of such installations one can mention hoisting in mining, calf line of drilling rigs, cranes of steel mills. To avoid this and to estimate condition of the rope non-destructive testing is being used. As the first method of rope condition estimation over decades visual inspection was used, which was nonproductive and enabled to found only external defects and given some indirect qualitative indication to internal damage. However since long time magnetic rope testing (MRT) is been successfully applied to find different kinds of steel rope defects. Both methods are reflected in international technical norms such as ISO 4309 [1]. Standard practice of rope inspection includes both of this methods.

Discarding of ropes is based on quantitative estimation of main defects such as internal and external broken wires, localized groups of broken wires, rate of increase of wire breaks, fracture of strands, reducing rope diameter, internal and external wear, internal and external corrosion, deformation [1]. External and internal wear and corrosion can be sufficiently estimated by MRT with LMA channel (loss of metallic area), external and internal wire breaks can be detected magnetically depending on their size and disturbances, caused by wear and corrosion of the rope. Localized groups of broken wires can be also detected magnetically, but hardly estimated quantitative. In such cases reliability of conclusion about rope condition depends appreciably on experience of the expert and thoroughness of visual inspection.

There are many rope applications with remote location, such as oil and gas drilling rigs or offshore platforms and vessels, which are hardly accessible for external NDT experts but do not have there own specialists. On the other hand many modern hoist systems are used very intensively, so that rope in some cases can deteriorate very quickly. Automatic rope condition monitoring systems offer a reasonable solution for such rope application.

DIFFERENT APPROACHES TO CONDITION MONITORING FOR ROPES OF MINE HOISTS

Non-destructive instrumental testing of mine hoist ropes is now mandatory in many countries. Modern dual channel MRT equipment has proved itself very well in a range of applications, and several attempts were made in incorporating them into a monitoring system. Development and modernization of the mining industry requires a reduction in rope testing time, eliminating (reducing) the influence of the human factor, increasing the usability of equipment.

In 2014 Luoyang BECOT Friction Material of China. built a jig for the simultaneous installation of up to four "INTROS" testers, on rope hoists at a mine in Luoyang, (Figure 1). The jig is located at the zero mark of the shaft near the driving drum. Information on the status of the ropes is registered in the and is available for analysis on a personal computer using the Wintros software

Figure 1. Monitoring system for two rope hoists

In 2013 Donetskgormash of Ukraine comissioned INTRON PLUS to develop and install a system for the simultaneous testing of main trunk lifting head ropes with a friction pulley. The sytem consists of a jig, suspended on the 22 metre mark in the main trunk building, onto which four INTROS MH24-64M3 magnetic heads are installed (Figure 2). The location was chosen to allow for easy access and simultaneous visual inspection of the ropes. Rope inspection is carried out by the jig’s installation on one side of the skip and then symmetrically on the other.

Figure 2. Monitoring in Ukrainian mine.

Another approach was implemented at a mine in South Africa. In Figure 3, it can be easily seen that four measuring heads are permanently mounted on multi rope hoist machine. This approach significantly reduces the rope testing time.

Figure 3. Monitoring in South Africa mine.

IMPLEMENTATION OF MAGNETIC ROPE MONITORING SYSTEM INTROS-AUTO

Rigid requirements for monitoring system are possible to meet only in highly specialized implementations, designed for certain rope application. For example rope monitoring system Intros-Auto has several specific realizations: for hoisting block of drilling rigs, for hot-metal cranes of steel mills. Automatic system for monitoring of drilling rig ropes consists of a compact magnetic head (MH), placed on the rope (Figure 4), connected with a control and display unit (CDU), placed at console of drill tower operator (Figure 5). Monitoring system has explosive proof design, extended temperature range and IP 66 ingress protection, so it can be used in severe environment. The system provides both operation modes: continuous monitoring and periodical automated rope testing. Magnetic head shown at Figure 4 is designed for periodical (every shaft) rope testing. MH is located permanently near the drum in a winch unit, this enables quickly and easy mounting and dismantling of MH at/from the rope, no additional attachments are necessary. Inspection procedure is fully automated, so the operator should switch system on and off and see results at the display. To make indication more understandable it conforms with traffic light principle. If some rope part with valuable deterioration passes through MH, CDU switch on yellow or red LED, depending of rope condition (yellow light corresponds warning condition and red light – critical condition). So far no valuable deterioration is found on the rope, green LED is on. In case the whole accessible length of the rope is checked it is possible to use additional information from comparing successive inspections in order to find out, if the rope begins to deteriorate intensively. At the end of inspection information about found defects is being displayed at CDU to enable an operator to check defects visually, if necessary. The system can store measurements of last several dozens inspection, this results can be send to some external computer via Wi-Fi or a cable. It is also possible to control inspection process from remote computer on-line. The system implements both monitoring modes: continuous and periodical. By demand inspection results can be analyzed by external expert so far measurements have the same representation as common LMA- and LF-traces of general MRT instruments. Speed of the rope during inspection can be from 0.2 to 5 m/s.

Figure 4. MH of INTROS-AUTO at the rope

Figure 5. CDU of INTROS-AUTO at operator console.

Rope condition is being estimated on the base of 3 different criteria – this are: LMA and number of wire breaks over two fixed lengths of the rope (for example, 6D and 30D), which can be combined to meet recommendations of ISO 4309.

APPLICATION OF INTROS-AUTO SYSTEM FOR MONITORING OF DRILLING RIGS ROPES

Since 2014 INTROS-AUTO automatic rope monitoring system was installed for pilot operation at several drilling rigs of some oil and gas companies in Russia. It is used for monitoring of 6- strand and 8-strand steel wire ropes with diameter from 28 mm to 35 mm. Monitoring is executed not continuously but in a periodical manner: the rope is to be checked before every shift, that is twice a day. During inspection the hook goes from the lowest position to the highest position to provide maximal rope length pass through MH. In follows are shown results of system application at some site during two full cycles of rope operation between calf line slip and cut procedures. According to typical operation routine rope service in calf lines is measured in ton-mileage, after some runlife used part of the rope should be slipped and cut out. For the shown example standard runlife amounts 3000 t-km. In our case decision for cutting a rope was made on the base of measured rope deterioration. Figure 6 shows LMA and LF traces of the rope after 30 days operation as it reached running of 4545 t-km, which exceeds cut and slip criteria by approximately 50%: rope has no valuable deterioration. Only several stand-alone wire breaks are to be seen at LF-trace. Figure 7 shows LMA and LF traces as yellow indication come; it was after 36 days of operation and the rope running achieved 5400 t-km. There are to regions with agglomerations of wire breaks: at the distance 90 – 150 m and at the distance 200 – 150 m; maximal number of wire breaks over the length of 30D at the second region is higher, than at the first, and it exceeds warning threshold, that was signalized with yellow light. Wire breaks locates in periodical groups that reflects peculiarity of rope deterioration on sheaves of this hoist.

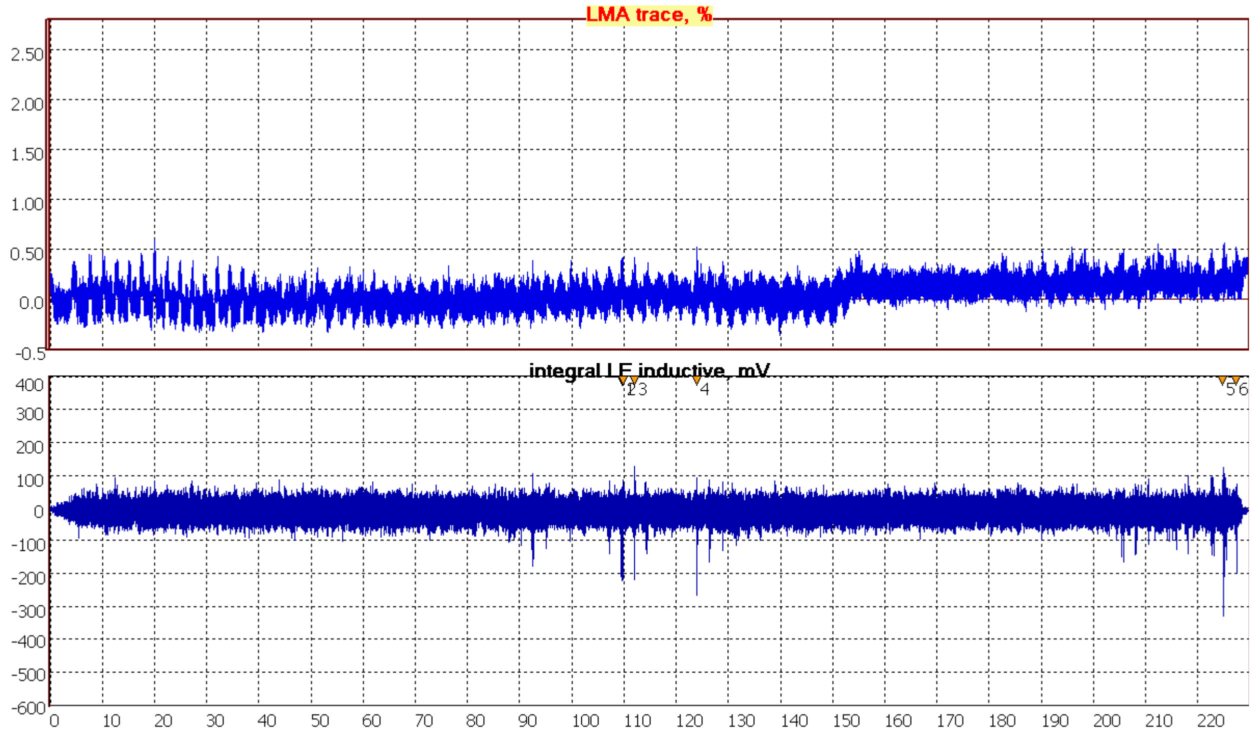

Figure 6. LMA and LF traces for the rope running 4545 t-km.

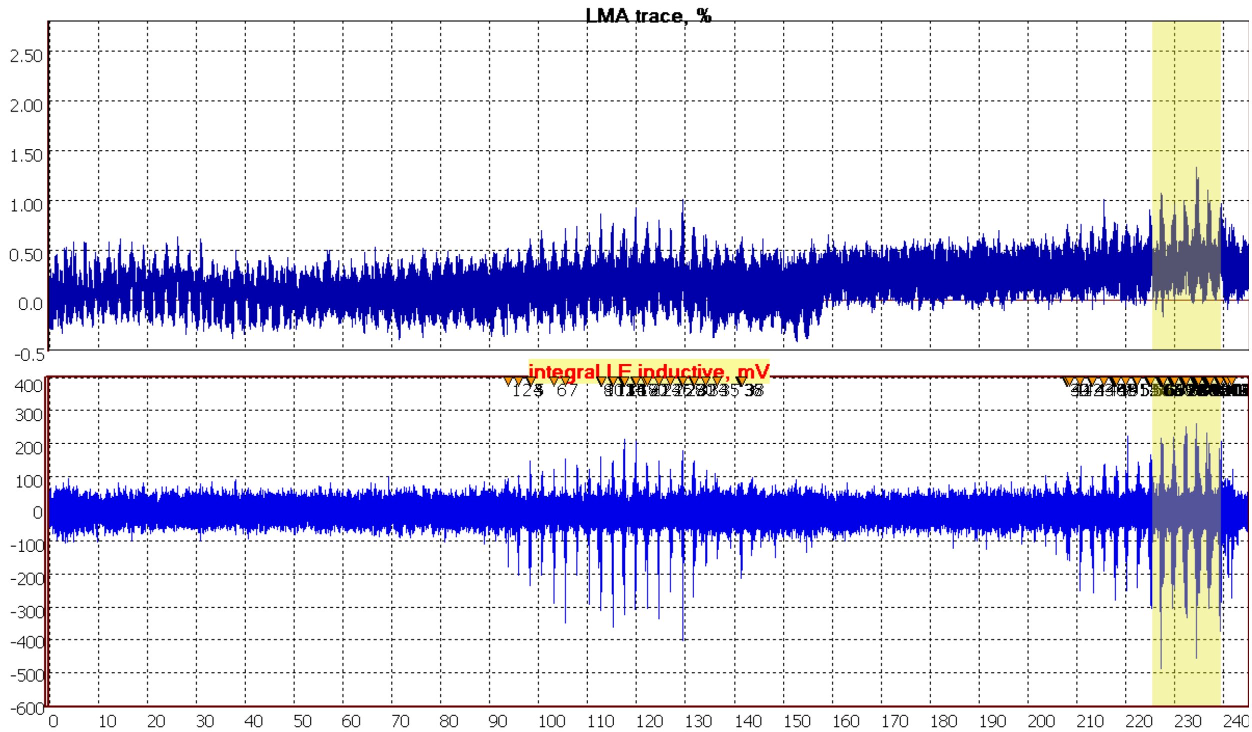

Figure 7. LMA and LF traces for the rope running 5400 t-km.

Figure 8 shows LMA and LF traces as red indication come; it was after 38 days of rope operation, rope got a running of 5900 t-km. Maximal number of wire breaks over 30D length at the distance of 200 – 150 m exceeded rope discard threshold. It should be stressed that it occurred only in 2 days after the yellow indicator – without monitoring it could be dangerous to use this rope. The end rope runlife in this case is nearly two times higher, than prescribed criteria for cut and slip operation, so the rope was used notably longer, that means measurable cost reduction.

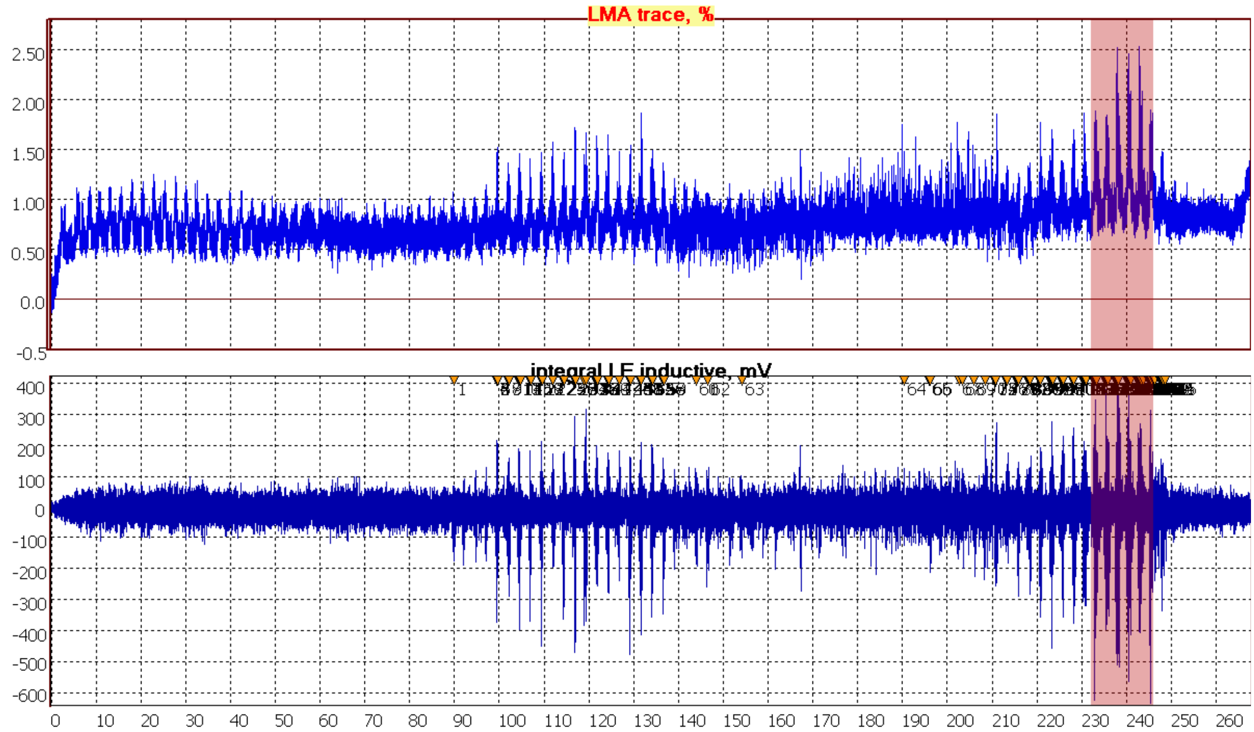

Figure 8. LMA and LF traces for the rope running 5900 t-km.

To check a real condition of the rope the most deteriorated section was cut out and disassembled to count real number of broken wires. Figure 9 shows separate wires of one strand after it was unstranded. Maximal number of wire breaks at the lay length put together 27, that exceeds a discard criteria, which permits breakage of 10% of wires at one lay length (corresponds to 6*d*), in this case – 21 wires. So system indication was correct.

Figure 9. Broken wires of one strand after its unstranding.

CONDITION MONITORING FOR ROPES OF MINE HOISTS

As it was shown in the above example, INTRON PLUS has a positive experience of using the INTROS-AUTO in the monitoring of the calf lines. At present, this experience extends to the development of monitoring systems for mine hoisting ropes. INTRON PLUS is now developing a monitoring system for the head ropes of the main trunk-lifting complex for Uralkaliy and EuroChem-VolgaKaliy on the basis of the INTROS-AUTO monitoring system.

The mine "10 years of independence of the Republic of Kazakhstan" of Donskoy Ore Mining and Processing Plant, TNC Kazchrome JSC (Figure 10) is also interested in development and purchasing of our condition monitoring system.

Figure 10. The mine "10 years of independence of the Republic of Kazakhstan”

The Figure 11 shows an example of the INTROS-AUTO system application for hoist machines. All MHs are connected to the CDUs, which are located in the hoist operator cabin. MH is installed on the sheave wheel platform and securely anchored to stationary structures. MHs are to be installed on ropes during all technological procedures of the mine-hoisting machine operating. The rope offset in the horizontal plane with respect to the axis of the pulley should not exceed 15 mm. This requirement is achievable, since the wobble of the rope in the sheave wheels platform space is nonsignificant. The CDUs is installed in the hoist operator cab and connected to the MH with a cable and another cable is connecting CDU with the encoder of the hoist machine control system. The CDU transfers the recorded data to an external computer or a hoist operator's computer via the WiFi or via an RS 485 cable.

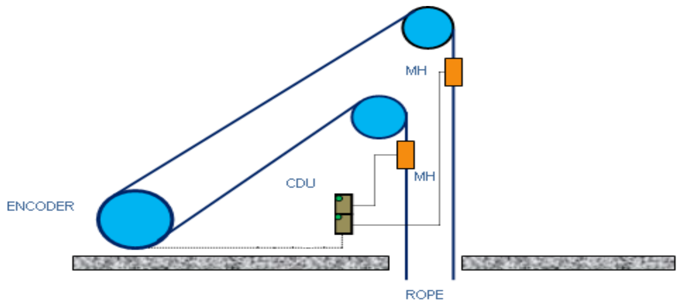

Figure 11. The example of application of the INTROS-AUTO system

During the operation of the conditions monitoring system of mine hoisting installations, highly qualified personnel is not required for carrying out non-destructive testing,, which significantly reduces the charges of the enterprise.

CONCLUSION

The above examples show that whilst use of standard MRT equipment is possible for monitoring purposes,a dedicated automated system allows for more timid operation at much less operating costs.

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