VÝSKUM, VÝROBA A POUŽITIE OCEĽOVÝCH LÁN, DOPRAVNÍKOV A ŤAŽNÝCH ZARIADENÍ
RESEARCH, PRODUCTION AND USE OF STEEL WIRE ROPES, CONVEYERS AND HOISTING MACHINES
ISBN: 978-80-553-2607-8

MONITOROVANIE PODMIENOK OCEĽOVÝCH LÁN: KONCEPT A IMPLEMENTÁCIA

WIRE ROPES CONDITION MONITORING: CONCEPTION AND IMPLEMENTATION

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Kľúčové slová: oceľové lano, MFL, výklad automatických dát, monitorovanie

Key words: wire ropes, MFL, automatic data interpretation, monitoring

Abstrakt:
Nedeštruktívna kontrola oceľových lán sa stáva bežnou aktivitou pre rôzne operácie a na trhu sú k dispozícii príslušné zariadenia. Dôvod rastúceho záujmu tejto kontroly je zvýšenie cien oceľových lán, a to predovšetkým pre laná väčších priemerov. Kľúčová myšlienka pre nedeštruktívnu kontrolu oceľových lán je promptné zariadenie a správna interpretácia údajov. Spoľahlivé zariadenie umožňujúce interpretáciu dát pomocou počítača bez zásahu človeka je záujmom viacerých zákazníkov. Spoločnosť INTRON PLUS vyvinula MFL nástroj INTROS-AUTO, ktoré je nástupcom bežne používaného detektora lán INTROS. Nástroj je navrhnutý pre nedeštruktívnu kontrolu oceľových lán s automatickou interpretáciou dát. Využívajú sa nasledujúce kritéria – počet poškodených lán pozdĺž dĺžky a úbytok kovového priečneho rezu v percentách. Kritéria môžu byť upravené podľa požiadaviek zákazníka. INTROS-AUTO ukladá dáta detailne, ktoré je možné stiahnuť a interpretovať bežným spôsobom. Tento prístroj je vhodný pre kontrolu lana aj s priemerom 135 mm a tiež môže byť použitý pre pravidelné alebo permanentné monitorovanie oceľového lana.

Abstract:
Non-destructive inspection of steel wire ropes becomes quite common for onshore and offshore operations, and relevant equipment is now available on the market. The reason for growing interest to this inspection is increasing in prices for wire ropes, especially for ropes of large diameter. The key issues for wire rope non-destructive inspection are prompt equipment and correct data interpretation. Rugged and reliable equipment capable to make data interpretation with computer without human intervention is of interest of many customers. INTRON PLUS LTD. has developed MFL instrument INTROS-AUTO, that is a successor of widely used wire rope tester INTROS. It is designed for non-destructive inspection of wire ropes with automatic data interpretation. Following criteria are used to discard rope – number of broken wires along lay length and loss of metallic cross section area in percentage. Discard criteria can be adjusted according to agreement with the customer. INTROS-AUTO stores detailed data, which can be downloaded and interpreted in regular manner. The instrument is ready for inspection of ropes as large as 135 mm in diameter and can be used for periodical or permanent wire rope monitoring onshore and offshore.

INTRODUCTION

Ropes produced from carbon steel wires operate on cranes, elevators, mining hoists, cableways, etc. to carry people and freight. The bigger and longer is rope, the more expensive it is. Degradation of ropes happens due to different reasons, e.g. friction between internal wires, external wires and sheave surface, corrosion of wires, bending of the rope over the sheaves, and always leads

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ISBN: 978-80-553-2607-8

to reduction in rope breaking strength. When the breaking strength is less than permissible level, further rope operation becomes dangerous and the rope must be discarded. Rope degradation down to permissible level may last over years, but sometimes degradation accelerates dramatically and, if rope is not under proper supervision, may cause accident and even kill people.

Non-destructive inspection of rope is important mean to provide rope safety, it may allow to timely discard rope to prevent accident as well as to extend rope life to avoid unreasonable costs related to its exchange. Visual inspection of rope is obvious, but its capacity is limited due to specific rope design, presence of grease on the rope, and tiresomeness of the inspection procedure; thus, comprehensive inspection of rope with only visual means is not possible. Non-destructive magnetic inspection of ropes enables to collect considerable data for making reasoned decision. Magnetic flux leakage (MFL) equipment with strong magnetization [1] can inspect ropes reliably, and smart software facilitates data interpretation. MFL equipment can measure loss of metallic area (LMA), i.e. relative amount of steel missing from wires due to corrosion and friction, and detect local flows (LF) in form or broken wires, strands, core, pitting corrosion. When LMA value and number of LF reach certain amount, i.e. discard criteria, the customer should discard the rope; knowledge of LMA and LF may also be used for assessing rope remaining breaking strength. Relevant national and international norms and standards [2-5] include requirements for equipment, inspecting personnel, discard criteria, other useful information.

EQUIPMENT FOR MRT

Equipment for MRT, based on MFL principle of operation [6,7,8] has being successfully using for years in different industries, such as oil and gas onshore and offshore, lifting operations, underground and above ground mining, civil engineering, transportation, etc. It is vital to carry MRT with reliable equipment, that has good performance and is available on-site on time, and interpret data by skilled inspector as soon as possible. Rope inspection is usually carried, when the object is out of operation, and inspection procedure may require considerable downtime. Meanwhile the customer pursues to increase production time against inspection time as much as possible. Inspection report may appear after a while, when data are properly interpreted by inspector, but the customer may need to know result of MRT right after the inspection is over to undertake immediate actions if rope is considerably deteriorated. Rope inspector' qualification may suffer from necessary skills unless the inspector is permanently involved in MRT. Thus, customers require a system, which could inspect rope during production run and would process data without human intervention.

WIRE ROPE MONITORING

Monitoring of rope technical condition of different industrial installations is now the big challenge on the market. Usually MRT carried with given time interval, and duration of the interval depends on rope degradation speed – when it is obvious that rope starts intensively degrade, the frequency of inspections should increase. Monitoring of wire rope condition can help customer to make timely actions about continuing or discontinuing rope operation. Generally, two approaches for monitoring procedure are in consideration:

- Periodical monitoring providing with automatic data interpretation; in such case the equipment can be located on the rope on permanent basis or it is mounted on rope prior to MRT and dismounted from the rope right after inspection is over; MRT is carried on timely basis and its frequency is effected by actual rope condition.

- Continuous monitoring with automatic data interpretation; in such case the equipment is located on the rope on permanent basis, continuously get measurements from the rope and forward data to computer or on-board PLC for interpretation and storage. Permanent presence of the equipment on the rope for continuous monitoring requires extra reliability and stability of the equipment, because it continually interacts with rope and is subject for vibration and friction.

ISBN: 978-80-553-2607-8

Intron Plus has developed [9,10] wire rope inspection system INTROS-AUTO (fig. 1), that is successor of the wire rope tester INTROS, and has important features as following:

a) Automatic data interpretation on-line
b) Automatic data post processing
c) High rope speed during inspection
d) High sensitivity to outer and inner LF
e) High LMA measuring accuracy
f) Adjustable alarm and discard criteria
g) Robust design

a) b)

Fig.1. INTROS-AUTO: magnetic head (a); control and display unit (b)

Length of connection cable between magnetic head and control and display unit (CDU) is as much as 80 m. Installation of the magnetic head on the rope and dismounting from the rope takes very little time and requires no special skills. Even person, who has no experience with MRT, may easy prepare equipment and carry inspection. CDU is usually permanently located at operator's cab. It is very important, that the instrument can make automatic data interpretation on-line with immediate post processing following end of inspection. During MRT, the instrument automatically interprets data - LMA in percentage, and number of broken inner and outer wires. Value of LMA value and number of outer and inner broken wires per certain distance along the rope, e.g. equal to 30d or 500d (d – rope diameter) compare with allowed level. Data indication of INTROS-AUTO is based on "traffic light" mode: the CDU front panel contains three LEDs of green, yellow and red colors, informing the operator of installation correspondingly about insignificant, considerable and dangerous level of deterioration. Each level is adjustable, i.e. the customer may set considerable level of deterioration, e.g. 70% of discard criteria, and level of discard criteria in accordance to existing norms or with consideration of minimum breaking strength of rope. Yellow LED warns the increase of deterioration; in such case, inspections should be more frequent in order not to miss the moment, when rope condition is critical. Red light alerts critical condition of rope, i.e. it is time to discard the rope. Besides on-line interpretation, INTROS-AUTO makes post processing, i.e. compares data from current inspection with results of previous MRT to access the speed of deterioration. If the speed of deterioration exceeds admissible level, the CDU may alert with red light even LMA and LF value did not reach discard level yet. Post processing lasts only few seconds after the inspection is finished. Those sections of LMA and LF traces, which show revealed defects, are automatically visualized yellow or red for easy finding. All data are stored in the CDU and are available for further downloading

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and manual interpretation at any time if necessary. The CDU has wireless connection to PC, it is possible to implement it into on-board controlling system, and data sent-out via Internet. Intron Plus has tested INTROS-AUTO drilling rope 35 mm in diameter at facility in Czech Republic (fig. 2), and the instrument showed good performance at rope speed up to 6.9 m/s.

Fig. 2. INTROS-AUTO inspects 35 mm rope at drilling rig in Czech Republic.

In 2014 Intron Plus delivered INTROS-AUTO to four drilling Russian companies in Western Siberia, commissioned the equipment and trained local operators of drilling rigs. Arrangements with the customers allowed us regularly receive inspection data from for analysis and consulting the customers. Fig. 3 shows location of magnetic head during inspection of 26 mm drilling rope. The magnetic head was located near the drum, and special fixing slings allowed magnetic head to follow the rope cross motion. CDU was attached to the wall of operator' cabin and long cable connected CDU and magnetic head.

Fig.3. Inspection of 26 mm drilling rig.

The fig. 4-8 show traces, obtained by means of INTROS-AUTO from same drilling rope 26 mm in diameter, when the rope reached certain running time, expressed in ton-kilometers. The traces clearly show increase of LMA value and number of broken wires, i.e. increasing level of rope deterioration. First MRT on 31.10.2014 showed almost absence of defects in the rope. Next sequential inspections with 9-10 days interval revealed continuous increase of LMA value as well as number of broken wires. On 28.11.2014, the instrument showed yellow light, that means approximately 70% of discard criteria. The operator reduced time interval before the next inspection from 10 to 6 days. On-line interpretation of data on 04.12.2014 showed that the rope still might continue operation; however, during post processing the instrument compared data with previous MRT of 28.11.2014 and found excessive speed of deterioration. To prevent the accidence, the operator reeled the rope off to replace deteriorated section from operation. Opening the deteriorated section and its visual examination

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afterwards proved results of MRT by means of INTROS-AUTO. LMA traces on fig. 4-8 at distance 30 to 100 m have special waved form caused by deterioration (friction) due to continuous bending of ropes over the pulley block.

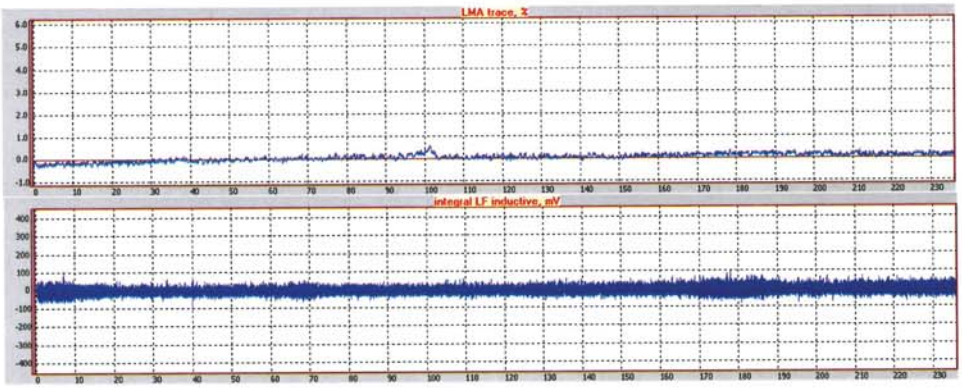

Fig. 4. Traces of 31.10.2014. Rope running 332 t-km. Small LMA value of rope section at distance 100, no broken wires. Green LED is on, i.e. rope may continue operation.

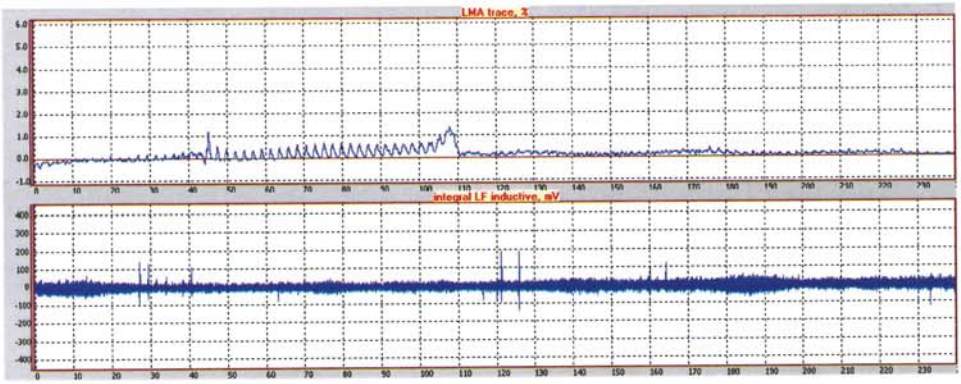

Fig. 5. Traces of 09.11.2014. Rope running 940 t-km. Increase LMA, single broken wires along the rope length. Green LED is on, i.e. rope may continue operation.

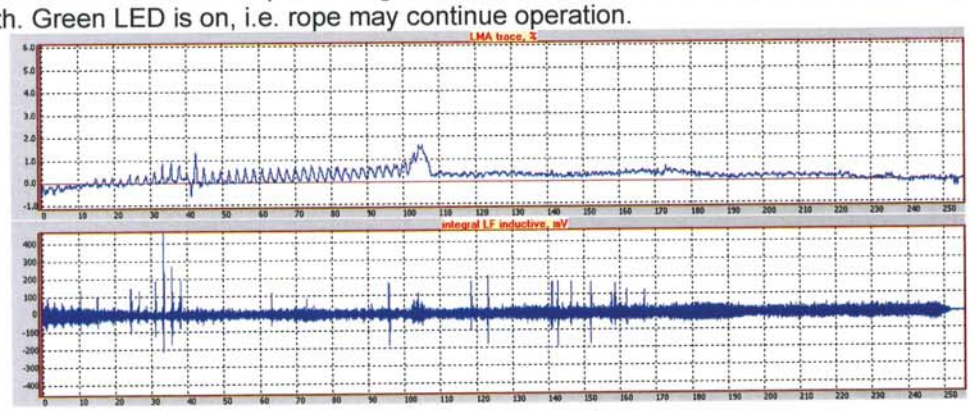

Fig. 6. Traces of 18.11.2014. Rope running 1431 t-km. Increase LMA and number of broken wires along the rope length. Green LED is on, i.e. rope may continue operation.

ISBN: 978-80-553-2607-8

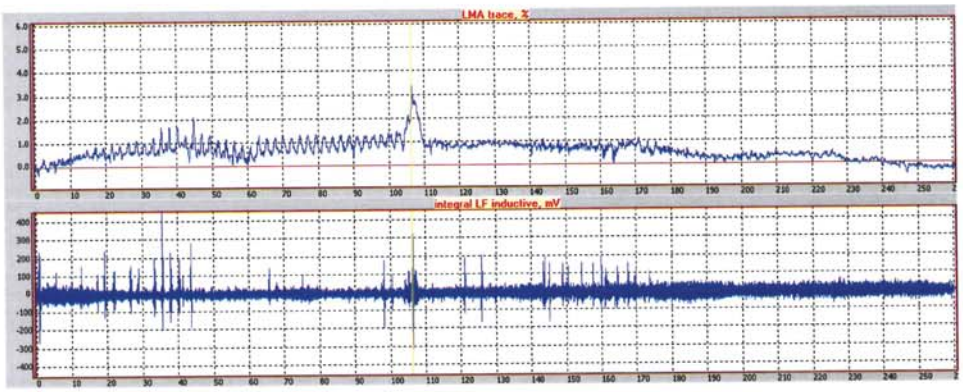

Fig. 7. Traces of 28.11.2014. Rope running 2455 t-km. Rope section at distance 107 m reached 70% of discard criteria. CDU lights yellow. Section of rope with defects automatically visualized yellow. Rope may continue operation.

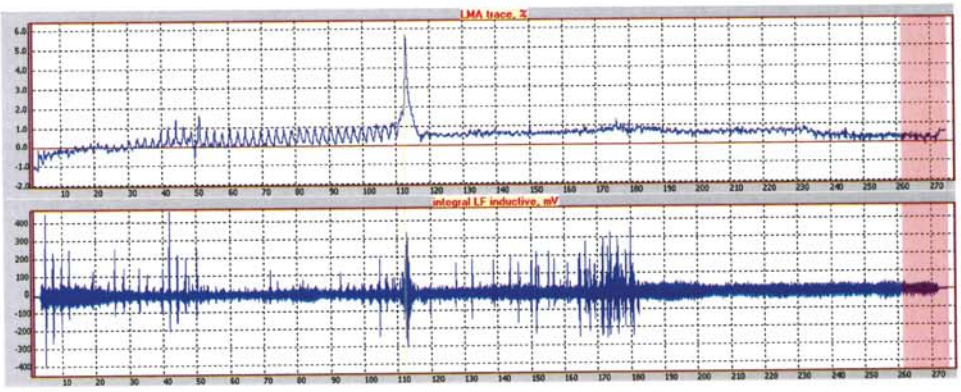

Fig. 8. Traces of 04.12.2014. Rope running 2990 t-km. Post-processing shows high speed of deterioration. The red light is on, alerting necessity to discard of the rope.

Offshore vessel cranes often operate large diameter low rotation ropes, which are very expensive and should remain in service as long as possible, i.e. to be discarded only for reason. Ropes of heave compensation system sometimes deteriorate very fast and supervision on such ropes must be very careful, especially with consideration that these ropes may carry bulky and expensive freight. Continuous rope monitoring in this case may extend safe operation of rope. Intron Plus now is technically capable to produce continuous wire rope monitoring system for ropes up to 135 mm in diameter.

Having large experience with non-destructive inspection of mining ropes, we have recently developed and commissioned wire rope inspection system INTROS at coalmine in Ukraine to inspect four ropes of hoisting machine at once (fig.9). The main advantage of such system is considerable reduction of inspection time, which is very important in order to increase duration of production run. This system is located in direct proximity to the ropes, and its mounting on the ropes takes few minutes.

ISBN: 978-80-553-2607-8

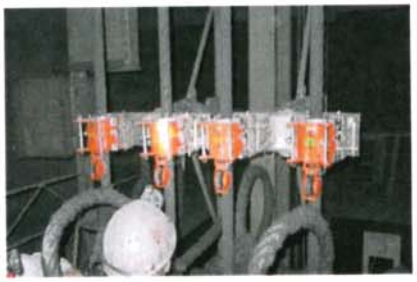

Fig.9. Rope inspection system INTROS to inspect four mining ropes at once.

We have recently started two new projects at potassium mine in Russia to inspect hoisting ropes periodically with automatic data interpretation, and another one is to continuously inspect crane rope at steel mill. The rope at steel mill is subject of essential heating and needs continuous monitoring in order to prevent its break.

CONCLUSION

Intron Plus has developed the first equipment in the world for monitoring wire ropes. This equipment non-destructively inspects ropes and provides the customer with results of automatic data interpretation. Use of this machine makes rope operation safer, and the customer can discard ropes for reason, and thus avoid unreasonable costs. Operation of this equipment on-site proved its reliability and good performance.

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