Integrating automated wire rope condition monitoring in information environment of industrial facilities

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Summary

Integration of rope monitoring into the comprehensive enterprise information system not only increase safety of industrial facility but also reduce operation costs, so it is important to find out key data parameters and describe procedures that give decisive information about rope condition for technical and administrative staff. A detailed presentation of practical experience in the implementation of Intros-Auto rope monitoring system at different mining and drilling facilities and its integration into appropriate information systems can give a useful example of such a solution. Depending on hoist type and construction different types of magnetic head are applied. MH delivers information to controlling computer unit, which can be connected to external workstation or interact directly with operator smartphone. Resulting information flows into enterprise information system. This paper gives an overview and case study of practical implementation of rope monitoring at high intensity industrial facilities.

Keywords: steel wire ropes, magnetic rope testing, rope monitoring, digital enterprise.

Introduction

Diagnostics of technical condition of wire ropes plays a key role in ensuring the safety of industrial facilities such as mine hoists, factory cranes, aerial rope-ways and drilling rigs. Transition from conventional non-destructive testing to automated quasi-continuous rope monitoring corresponds to a wide trend for the latter's implementation in various industries. It is particularly important for enterprises with intensively used ropes of high importance to the production cycle allowing them to increase the safety of their operations and plan maintenance operations such as cutting and replacement, based to the rope's actual condition. Implementation of such rope monitoring systems is possible when they are integrated with the enterprise's information and management system PIMS.

Conventional wire rope non-destructive testing technique is based on magnetic flux leakage method [1] which can be combined with partial visual inspection. The presence of rope deterioration due to corrosion, abrasion, wire breaks, geometrical distortions may be detected, evaluated, graded to determine safety of the rope's further operation and, ultimately, it's residual lifetime may be forecast. Rope discard criteria is stated in different international standards, such as the ISO 4309:2017 and EN 12927:2019 [2, 3]. The Automated rope monitoring systems, in their majority, also employ the said method of Magnetic Rope Testing (MRT) [4, 5], which will be examined in greater detail in this paper.

The rope monitoring system hardware.

INTROS-AUTO is an automated condition monitoring system (ACMS) based on MRT for different industrial applications: drilling lines on rigs, mining hoists, factory cranes. The system consists of a compact magnetic head (MH), installed on the rope (Fig. 1a), connected to a control and display unit (CDU), placed near an operator's workstation (Fig. 1b). CDU can be then be connected by cable or wireless to external PC or network.

The inspection is done typically once per shift. The MH design can be tailored different applications, for example, for drilling rigs it's design can incorporate stabilisation rollers for high speed travel of the rope, and foresee frequent removal for re-cutting. In contrast the MH for mining hoists (Fig. 1a) and ladle crane are installed permanently on the rope [6], with a reinforced casing for arduous environments. CDU indicates rope condition in a traffic light manner, while additional information is displayed on the LED. Results may also be viewed on a PC in real time. Accuracy of LMA measurement is 2% and sensitivity to wire breaks is about 0.5% of metallic cross-sectional area. Fig. 1b shows installation of two CDU's at the double drum mine hoist.

a b

Figure. 1 Magnetic head (at mine hoist) and 2 control and display units of INTROS-AUTO at the double drum hoist

Integration of rope monitoring into the enterprise information system

For a modern digital enterprise it is important that all manufacturing processes are controlled from one center and all processed data is fed into an appropriate database for further decision making. A rope monitoring system must thus allow local and remote centralised operation (access to control monitoring of all ropes in the hoist – one, two or four, from one console).

Inspection data should be processed automatically and the results loaded into the enterprise's information system. These results should be available for different level of staff: a detailed inspection report for engineers and foremen, and an aggregated report for managers and supervisors. Raw inspection data should be stored in the memory of monitoring system, but be readily available for downloading to verify inspections results by authorized experts. This increases reliability by allowing to fine-tune the system during commissioning and re-calibration (after the rope has been replaced).

Figure 2 depicts a generic information exchange between the monitoring and the enterprise information systems. MH acquires inspection signals from the sensors on the rope, these signals are processed and logged in the CDU; results can then transmitted to the operator console in real-time mode or downloaded later. Inspection result reports can be sent automatically to any appointed persons, for example the chief maintenance officer. If qualified staff wishes to review the inspection results, they call them from the data stored on enterprise servers.

Special software allows to estimate the residual rope lifetime based on inspection results and rope operation conditions. It is also important that accumulated inspection data can be represented in a form of an incremental report accessible from PC, tablet or smartphone, which reflects deterioration of the rope in dynamics to facilitate rope maintenance planing.

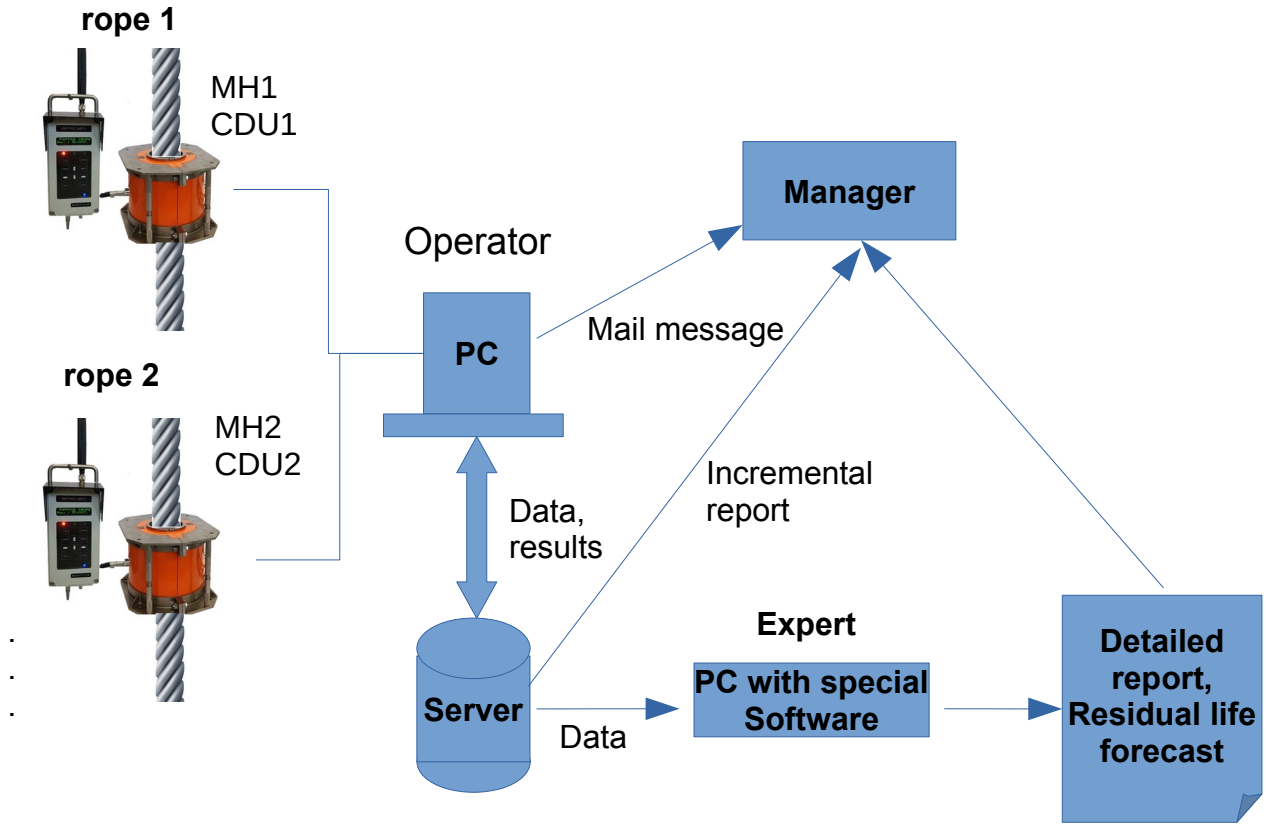

Figure 2. Data flow diagram for rope monitoring system

Drilling rig case study.

Implementing the rope ACMSs on drilling rigs carries an additional challenge that these facilities are usually remotely situated in remote wilderness or open seas. Their manning personnel work in shifts, are subject to regular shuffles, with few holding any qualification in non-destructive testing. In addition, there is no regular time window for installation and maintenance at such facilities. Rope inspection should thus take a minimum of time and not require any special training.

The magnetic head must be positioned such that the most stressed segment of rope, prone to deterioration and be accessible to personnel, will be inspected. Usually this is near the drum. Due to the rope experiencing lateral travel as the drum unwinds, the MH is in constant mechanical contact with the rope (by means of special rollers). To minimise wear, its is removed when data collection

is not required (Figure 3 shows the MH INTROS-AUTO on a calf line). Installation and removal of MH from the rope takes no more than 15 minutes in total, which is acceptable for a daily inspection.

The drilling rig may not have a common local network and a single-unit server, so the monitoring system stores all the necessary data to forward the foreman or supervisor the results of ongoing monitoring and the ability to create an incremental report over a cable or wireless connection.

Rope maintenance on drilling rigs is planned in accordance to the mass-distance (tonne-kilometer, ton-mile etc.) that the rope carries, which can be counted in the rig's controlling system. The INTROS-AUTO can receive this or calculate itself by taking raw data from the tension meter on the hook and an external odometer. Figure 4 shows an incremental inspection report with reference to the current operating time of the rope. This allows to schedule rope maintenance operations and extend the service life by combining current mass-distance rope life and the found damage, should the operating company incorporate such a system into its management chart.

Figure 3. MH INTROS-AUTO at the rope of drilling rig hoist

Report on rope technical condition

Inspected item: Drilling rig NNN

Rope certificate: № 4134856006.

Rope construction: СТО 71915393

Rope lengtht, diameter: 0 м, 64 мм.

		Inspection date and time	Rope run , (tkm)	Length of inspected section, (м)	Found defects			Increment against previous inspection	Assessment of rope condition
					LF, (at the whole rope)	Maximum LF density (for 6D)	LMA, (%)		
1	2	3	4	5	6	7	8	9	10
		21.01.2021 18:36	125	748	5.0	1	1	0.0	Usable
		22.01.2020 18:55	305	769	6.0	2	0	1.0	Usable
		23.01.2020 18:36	562	758	8.0	2	1	2.0	Usable
		24.01.2020 18:36	794	748	12.0	2	1	4.0	Usable
		25.01.2020 18:32	1131	756	18.0	5	1	6.0	Limited-usable

Figure 4. An incremental report of rope testing according to rope run in ton-milage

The INTRO-AUTO system has been implemented on more than 20 drilling rigs of various oilfield service companies and has been successfully used for more than 8 years. It has also been delivered to a range of mining and metalurgy companies. Appraisals have been carried out on many other applications including ropeways, heave compensation systems, skip loaders and many other high value applications, where the ropes can face rapid subjective deterioration patterns.

Conclusion

The best implementation of a wire rope automated condition monitoring system is when it is integrated into the general information environment of the enterprise. This ensures increased safety and accelerates management decision-making process. Full economic benefit will be possible if the reports are integrated into the relevant operating regulations.

References

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