Performance Evaluation of Cage and Skip Winder Ropes in a Uranium Mines using Two Nondestructive Testing Instruments

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Abstract

Electromagnetic nondestructive evaluation/testing (NDE/NDT) of wire rope has been in use for over fifty years. The electromagnetic nondestructive test is defined to be any test or measurement method for inspecting or evaluating materials or products which does not adversely affect their serviceability and which use the effects for electromagnetic induction, electromagnetic fields, or varying currents for probing, measuring or inspecting. Regular NDE inspections provide a powerful tool in monitoring the rate of degradation of a rope. The effective technology for these devices depends on the magnetic properties of steel wire rope. An attempt has been made in this paper to evaluate the performance of cage and skip winder ropes in a uranium mines in India.

Keywords: *NDT, electromagnetic, wire rope.*

1. Introduction

Assessment of rope condition either by visual examination or even by drawing a specimen rope length and subjecting it to destructive evaluation seldom speaks about integrity of the entire rope length in the installation. An electromagnetic wire rope inspection is essential for safe operation with maximum safety of winder ropes in addition to visual inspections [1].

Nondestructive testing (**NDT**) is one of the quality control and maintenance inspection methods on mechanical structures. To find the flaws and measure their dimension are the main purposes of NDT. Magnetic nondestructive evaluation method is being used now-a-days to assess the condition of stranded ropes and full locked coil ropes used in mine winders.

2. Instruments used for investigation

MD 120B Wirerope Defectograph developed by scientists of the University of Mining and Metallurgy (AGH) in Krakow, Poland, has been used for scanning of cage and skip winder ropes in uranium mine. This instrument works on the principle of *"Permanent Magnet Method"* [2,3]. It was originally developed for magnetization of the rope with permanent magnets and detection of the changes of magnetic field around the rope and total magnetic flux [3]. Different sensors are shown in the schematic diagram in Fig. 1.

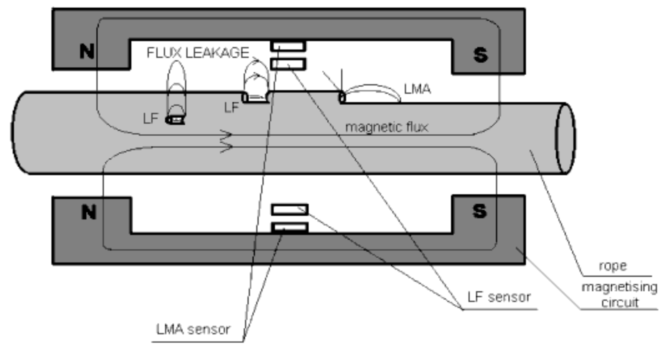

Fig. 1. Location of sensors and the detection of various classes of defects in rope

Local Fault (LF) and Loss of Metallic cross-sectional Area (LMA) sensors have been used for detection of broken wire and change of steel cross-sectional area using magnetic leakage flux variation in radial and axial directions respectively [4,5].

Another instrument INTROS, Russia make Rope Tester has also been used for non-destructive testing of steel wire ropes in aerial ropeways and mine winders. The instrument quantitatively measures the loss of metallic cross sectional area (**LMA**) and detects discontinuities such as broken wires or localized changes in rope structure (localized faults - **LF**). The schematic diagram of INTROS make Rope Tester is shown in Fig. 2.

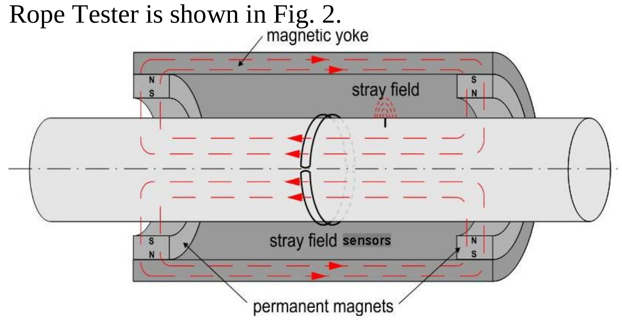

Fig. 2. Schematic diagram of INTROS Rope Tester

LMA is a relative measure of the amount of ferrous material loss from a location along wire rope and is measured through comparing readings in a current point and the reference point on the rope that represents nominal metallic cross-sectional area, as measured with an instrument. LF is a discontinuity in a rope, such as a broken or damaged wire, a corrosion pit on a wire, a groove worn into a wire, or any other mechanical discontinuities that degrades the integrity of the rope, both on surface and inside the rope under test.

Instrument utilizes the magnetic principle of operation. **Magnetic head** of INTROS make rope tester magnetically saturates section of a rope under test. The instrument inspects the rope moving through the magnetic head. Any changes in rope cross-sectional area as well as discontinuities, like broken wires or strands, pits of corrosion etc., causes changes in leakage flux of magnetic field. Magneto-sensitive sensors, which are placed close to the rope midway between the pole pieces of magnetic head, detect the changes of magnetic leakage flux. Signals from sensors supply the **basic unit** where they are processed and displayed [4, 6].

The instrument (either Wirerope Defectograph or Rope Tester) is fitted vertically in a stand (preferably wooden). The winder ropes are allowed to pass through the instrument in either direction in such a way that maximum length of ropes are scanned. The charts (paper) are coming out in case of Wire rope Defectograph and in the case of INTRON Rope Tester, data is stored in the Data Logger unit and the charts can be viewed in computer using Wintros software. The chart in both the cases shows the LMA and LF signals of ropes from the starting point of the readings. The instrument is calibrated before scanning. In case of Defectograph, calibration is carried out keeping the rope inside magnetic heads while Rope Tester is calibrated in air. Readings of different channels are compared with the calibrated data.

3. Case Study

In-situ study on the Winder ropes (two ropes of Cage winder and two ropes of Skip winder) each of 28 mm dia., full locked coil construction, lay RH & LH, galvanized of multirope friction winder of Narwapahar Mines (UCIL) have been carried out over two years [7]. Two investigations have been carried out with the help of two different nondestructive testing instruments during the period of approximate two years.

Directorate General of Mines Safety (DGMS), Dhanbad, India is the authority for safety in Indian mines and ropes are continued in the mining installations with the approval of DGMS who usually refers this test result and recommendation. There are some international standards on rope discard. They are usually referred case to case basis. Normally, reduction of diameters, concentration of flaws in a lay, abnormal increase in laylength etc. are noticed. These points are compared while analyzing the field results.

Comparative study of the number of flaws, diameter, lay length and relative % loss in metallic cross-sectional area of the cage and skip winder ropes have been shown in Table 1(a-d).

Table – 1(a) Observations for the Cage Winder ropes during first investigation

MD 120B Wirerope Defectograph					
Cage winder	Time (age of rope)	Length scanned	Distance of flaws (in meter)	Average Dia. (mm)	Lay length (mm)
North side rope	8 months	394 m	Nil	27.94	178
South side rope	8 months	394 m	106 m	27.93	181
These two cage ropes have been removed after 2 year 1 month and the new ropes have been installed.					

Table – 1(b) Observations for the Cage Winder ropes during second investigation

Intron Rope Tester					
Cage winder	Time (age of rope)	Length scanned	Distance of flaws (in meter)	Average Dia. (mm)	Lay length (mm)
North side rope	1 month	410 m	Nil	27.82	177
South side rope	1 month	410 m	42 m 239 m 240 m	27.82	176
Present investigation on newly installed Cage Winder ropes has been carried out using INTRON Rope Tester after 1 month of installation. Relative loss in cross-sectional area has been observed as negligible.					

Important findings from the above observations are:

1. The total length of rope scanned by INTRON Rope Tester is more than that using MD 120B Wirerope Defectograph. The lengths available for scanning are about 394 m/410 m for cage ropes and 418 m/434 m for skip ropes.
2. Relative loss in metallic cross-sectional area is negligible compared to a healthy portion of rope as observed by Defectograph whereas in the INTRON Rope Tester, maximum relative loss in cross-sectional area is shown as 1.6 % for North side rope of Skip Winder.
3. Usually, distance of flaws from cage/skip cappel end has been observed for cage/skip winder ropes.

4. Maximum reduction in diameter in cage and skip ropes are 0.64% and 0.29% respectively.
5. The laylengths of cage and skip ropes as observed range from 6.29d and 6.46d where d is the diameter (nominal) of rope in mm.
6. Number of flaws observed in North side skip rope during first observation is 14 (fourteen).

Table – 1(c) Observations for the Skip Winder ropes during first investigation

MD 120B Wirerope Defectograph					
Skip winder	Time (age of rope)	Length scanned	Distance of flaws (in meter)	Average Dia. (mm)	Lay length (mm)
North side rope	1 year 9 months	418 m	88 m 92 m 230 m 233 m 238 m 268 m 269 m 270 m 273 m 275 m 279 m 282 m 284 m 325 m	27.8	182
South side rope	1 year 9 months	418 m	Nil	27.8	181
These two skip ropes have been removed after 2 year 1 month and the new ropes have been installed.					

Table – 1(d) Observations for the Skip Winder ropes during second investigation

Intron Rope Tester					
Skip winder	Time (age of rope)	Length scanned	Distance of flaws (in meter)	Average Dia. (mm)	Lay length (mm)
North side rope	1 year 1 month	434 m	2 m from counter weight cappel end	27.92	177
South side rope	1 year 1 month	434 m	Nil	27.92	180
Present investigation on newly installed Skip Winder ropes has been carried out using INTRON Rope Tester after 1 year and 1 month of installation. Relative loss in cross sectional area has been found as 1.6% for North side skip rope whereas it is negligible for South side skip rope.					

Conclusions

Nondestructive study on winder ropes is carried out to enforce the discard criteria. The study depicts the present condition of ropes only. According to program information bulletin no. P00-11 of Mine Safety and Health Administration [8], US Deptt. of Labour alerts the mining industry of the advisability of conducting electromagnetic testing of wire ropes to determine if unsafe conditions are developing. Section 56/57. 19023 (C) of 30 CFR requires that non-destructive tests be conducted on the active length of each wire in service every 6 months, or, diameter measurements be made at specified locations.
It is necessary to take into account the state of the rope and the conditions under which it works for continuance/ discard of ropes. The rope manufacturers may also get information on their products' lives in real situations so that they can think of any change in the design, construction and recommendation for use in different situations.
Two ends of a winder rope are connected to two different cages/skips on their roofs for the links by cappelling arrangement. The wire rope lengths of about 4 to 8 meters each from both cappel ends are covered/wound with seizing wires preventing outer layer of ropes from coming out. These lengths are not subjected to nondestructive inspection due to instrument's positional disadvantage. It has been experienced through destructive study with the 3 meters sample of ropes from cappel ends that generally there is no broken wire throughout this length from cappel ends. In running ropes, broken wires are observed primarily in sections that move over sheaves, pulleys and winch drums. Localized flaws in the form of broken wires usually concentrate near the points which cross and halt in the pulley whenever the cages stop at boarding-deboarding/loading-unloading stations. Usually, breaks develop in segments of the rope surface that come in direct contact with the sheave [9].

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