ASSESSMENT OF TRACK ROPES BY NON-DESTRUCTIVE METHOD: A CASE STUDY

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ABSTRACT

The most widely used method to study the condition of aerial ropes is the magnetic non-destructive method. Localized and distributed flaws in aerial ropes are detected in this method. An attempt has been made in this paper to highlight the findings in case of track ropes in the longest aerial ropeway in India.
Keywords: non-destructive method, flaws.

INTRODUCTION

Reliability and safety of many industrial and entertaining equipment involve transportation which in turn depends on technical condition of ropes. For this reason, ropes are usually subjected to proper inspection during its lifetime. The track ropes are designed, manufactured or used solely for supporting carriers on an aerial ropeway. Cabins for passengers travel on wheels upon track ropes in zig-back i.e. to and fro ropeway system. The full locked coil ropes and half locked coil ropes are used as track ropes. For this, carriages/cabins traveling on track ropes give a very smooth ride. The flexibility of track rope is much less than the stranded ropes. The track ropes are made in a single length between the anchored end and the end connected to the rope tensioning system. Helicoidal ropes with round outer wires are not recommended for track ropes [1]. The section of track ropes shall be entirely made of metal including the internal central core. Full locked coil ropes consist of layers of 'Z' shaped wires over a round wire. The characteristic advantages of this construction are high modulus, high axial stiffness, and extensive corrosion protection. The high fill factor, combined with the smooth external surface of the rope imparts high resistance to specific pressure which supports the use of clamps over the rope.

EVALUATION PROCESS

Safe use of ropes connotes different methods of inspection: destructive inspection and nondestructive testing with visual and instrumental inspection. Destructive inspection can only bring the information about tested part of rope. Moreover, the tested part of the rope is not representative due to different kinds of wear which leads to shortening of ropelife. Moreover, destructive tests are not possible where spare lengths are not available for such tests [2]. Visual inspection is the most conventional inspection method for wire ropes [3]. Experts observe the outer surface of rope and assess the rope condition empirically. Practically, it is quite impossible to review thoroughly a lubricated rope and a rope-length of few hundred meters. Rope degradation level and surface defects (like broken wires) are not detected adequately by visual inspection. Hidden internal damage is also not identified in visual method.

Magnetic non-destructive evaluation is regularly done for assessment of rope condition. Instrument MD 120B Wirerope Defectograph used for non-destructive testing of steel wire ropes generally uses the *"DC Magnetic Method"* (also known as Permanent Magnetic Method) [4, 7] for magnetization of the rope with permanent magnets and detection of the changes of magnetic field around the rope and total magnetic flux. Various types of sensors have been applied. Depending on the design of the magnetic concentrators and type, number and location of sensing devices, different signals are made available. Inductive coils and/or Hall generators are popularly used as sensing devices. However generally, due to its application, sensors can be divided into two types: (1) Local Fault (LF) type and (2) Loss of Metallic cross-sectional Area (LMA) type.

Broken wire or corrosion pit creates radial magnetic flux leakage and LF sensor detects it as the rope passes trough the sensor. LF sensor is placed coaxially around the rope, centrally between magnetic poles of the magnetizing circuit. Its signal is rather qualitative than quantitative. However, this signal provides information about presence of local fault and also to an extent information about its magnitude.

LMA sensor measures total axial magnetic flux in the rope as an absolute magnitude or variations in a steady magnitude of the magnetic field. This signal is proportional to the volume of steel or the change in steel cross-sectional area. It provides information about loss of steel due to missing wire, continuous corrosion or abrasion. LMA sensors are located in various places, almost within magnetizing circuit or in its close proximity.

CASE STUDY

Two track ropes (for Car 1 and Car 2), each of 44 mm nominal dia., full locked coil construction of a bi-cable passenger cable car system have been considered for nondestructive evaluation using MD 120B Magnetic Defectograph for monitoring their suitability in the installation [4]. The total length of each rope scanned is approximately 3800 meters. Cross-section of the full locked coil rope is shown in Fig. 1.

The Wirerope Defectograph has been calibrated each time by 80 sqmm and 20 sqmm rods for Hall Effect channel for comparison of metallic cross sectional area. For calculation of relative loss in cross-sectional area, steel cross-sectional area for locked coil rope has been assumed about 85% of the full (nominal) cross-sectional area. This nondestructive evaluation on two track ropes has been carried out over nearly three years at regular intervals. The Defectograph with its magnetic head 2-sh suitable for wire ropes of diameter varying from 20 to 60 mm, has been used for the investigation. Average rope speed during investigation of track ropes has been 1.0 m/sec. The internal and external (inner and outer) inductive sensor coils have registered the defects characterized by stepwise changes in rope cross-section implying broken wires i.e. localized flaws and the Hall effect sensor has registered the relative variation in loss in metallic cross-sectional area due to distributed flaws like wear, corrosion in longer length and abrasion [5-7].

The magnetic head of the Defectograph is fitted with separate stand type special arrangement with pulleys on the track rope over the cabin in such a way that as the cabin moves, the instrument passes along with the cabin with the track rope rolling inside the magnetic head. In contrast to scanning process of other ropes (e.g. haulage and winder ropes) where ropes are allowed to pass through the instrument, here the instrument (flaw detector) moves along the rope during testing. The track rope is being scanned through the instrument with the special arrangement for movement of instrument along the rope. The magnetic head placed over the cabin with special arrangement is opened before passing over the tower and closed after the passing. The track ropes are subjected to wear mostly on the towers by cabin passage over them [8]. Usually, the rope is tested only between the towers where two-side access to the rope is possible. It is generally advised to displace the rope along periodically. Due to the displacement after certain period, inspection of rope portion, located on the tower earlier, is carried out.

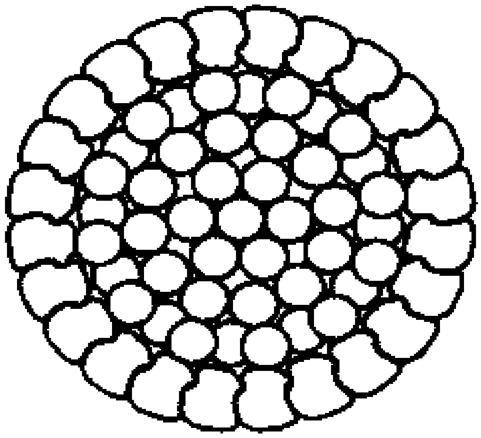

Fig. 1. Cross-section of a locked coil rope

OBSERVATIONS

The first nondestructive investigation has been carried out on these two track ropes after nearly 5 (five) years and not within one year of installation. Comparative study of the two ropes has been carried out. Table – 1 lists the observations for the two cases.

Table – 1. Observations for the track ropes for Car 1 and Car 2.

	Track rope for car 1		Track rope for car 2	
Time (months) at installation	No. of flaws	Relative loss in cross-sectional area	No. of flaws	Relative loss in cross-sectional area
59 months	4	Negligible	0	Negligible
93 months	5	Negligible	5	1.5-1.9%
111 months	7	0.6-0.8%	6	1.5-1.9%
129 months	11	1.7% (maximum)	12	2.5% (maximum)
162 months	17	2.3% (maximum)	20	2.9% (maximum)

Important findings from the above observations are:

1) Relative loss in metallic cross-sectional area in track rope 2 is more than that of rope 1.
2) Number of flaws noticed in rope 2 is more than that of rope 1. The flaws as revealed in both the track ropes during investigations are due to deformation of wires at places scattered over considerable rope length.
3) During the first 9 (nine) years, the relative loss in cross-sectional area in track rope 1 was negligible.
4) Presence of corrosion has also been noticed in both the track ropes.
5) Both the track ropes are more than 13 years in the installation and they are working satisfactorily.

CONCLUSION

The main faults of the ropes are broken wires and disturbances of rope structure because of rather significant bending load on towers and pulleys.

Application of non-destructive evaluation procedures makes it possible to improve the reliability of detecting broken wires over the available rope length for evaluation. This non-destructive investigation on track ropes does not include the aspect of *fatigue* which may develop in rope in course of time.

The reliability of electromagnetic inspection has made it a universally accepted method for the inspection of wire ropes in mining, in aerial ropeway installations etc. [9].

It is advisable to compare readings with a ***signature*** trace taken when the rope was new or first installed and then subsequent traces, to assess more accurately any degradation which has developed in the rope at the time of evaluation [10].

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