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Non-destructive testing of mining ropes: technical and economical aspects.

Introduction

Mining industry is one of the main applications for different ropes. Safety of wire ropes is indispensable requirement condition of functioning equipment. For this reason wire ropes must be replaced before they become dangerous, i.e. as soon as they reach retirement criteria. For different reasons ropes sometimes discarded even they did not reach retirement criteria. However premature action leads to extra cost: the replaced rope could be still in use, while new rope and its installation for mining application are costly and time-consuming actions. Timely replacement of rope is possible on basis of knowledge of real rope condition. The rope condition can be detected during examination of rope both visually and by special instrumentation for non-destructive testing (NDT). The owners of the ropes not only look after their safety but also care about expenses concerned with rope use. Use of special instrumentation for rope inspection gives the customer objective information to ensure the safety and to avoid extra expenses for the early rope discard. Thus, knowledge of the rope condition enables the owner to make right decision regarding the rope, which is an advantage as for safety and economical aspects.

Regulation for mining ropes in Russia

Supervision about mining ropes is mandatory in Russia and it is arranged in accordance with Federal mining safety rules. Russia State Safety Rules require for ropes supervision in underground mining industry as well as for other industries. Mining ropes are subjects of periodical destructive and non-destructive testing, both visual and instrumental. Ropes are discarded depending on the quantity of local flaws (LF) and volume of loss of metallic area (LMA). Time interval for testing depends on particular application of the rope and rope construction, quantity of detected LF, volume of LMA measured. For example the more is LMA the more frequent is instrumental inspection. Visual inspection is provided daily for hoisting ropes. However inspector may not provide all-round inspection even at low speed and certainly inspection results are subjective. Hoisting ropes also must be inspected destructively with tearing machine before installation. Repeated testing is to be provided with time interval 3 to 12 months after installation depending of particular rope application. Every time repeated destructive testing requires a section of rope that is cut close to the end of the rope nearby the vessel. Proceeding with destructive testing is quite costly and takes time for the cutting the section as well as for delivery of the rope section to the laboratory for testing. It is also well known that destructive testing provides information about only tested rope section that does not correspond to the whole rope real condition. It may often happen that after certain cycles of periodical cutting-off the rope becomes so short that does not fit requirements anymore. Even if this rope did not reach retirement criteria it has to be discarded due to its insufficient length.

Experience with mining ropes supervision at JSC Norilsk Nickel

Open Joint Stock Company Norilsk Nickel and its subsidiary companies (hereinafter – Norilsk Nickel) – is the leading producer in Russia and one of the leading producers in the world of base and precious metals. Norilsk Nickel is involved in prospecting, exploration, extraction, refining and metallurgical processing of minerals. The Norilsk Nickel trans-polar subsidiary is located nearby the city of Norilsk in the northern part of Siberia. There are about 270 different steel wire ropes of more than 328 km total length that are in service at the company's mine hoists [1]. The ropes are installed at 51 winders of 27 shafts and include haulage, guide, brake and balance ones. There is variety of rope types: round stranded ropes, half-locked coil ropes, locked coil ropes, flat steel wire ropes, steel-rubber flat ropes. The ropes are produced by Russian and foreign manufacturers. Diameters of the ropes lie in the range of 20 to 65 mm, while length (depth of shaft) varies in the range 300-1600 m.

As the supervision about ropes is mandatory, ropes are subject of destructive testing and visual examination at Norilsk Nickel. Visual examination of ropes is carried by 23 people, who spend 25,000 hours annually for this purpose. In the period from 1998 to 2003 the company spent over 10,000,000 rubles (\$345,000) for preparation of rope section for destructive testing and concerned expenses. In the same time the company had to discard 8 ropes with total length 16,250 m and total cost 17,680,000 rubles (\$610,000) due to insufficient length after cutting-off. Total expenses for discarding ropes and replacing them with new ones in 1998-2003 were as much as 29,857,000 rubles (over \$1,029,000).

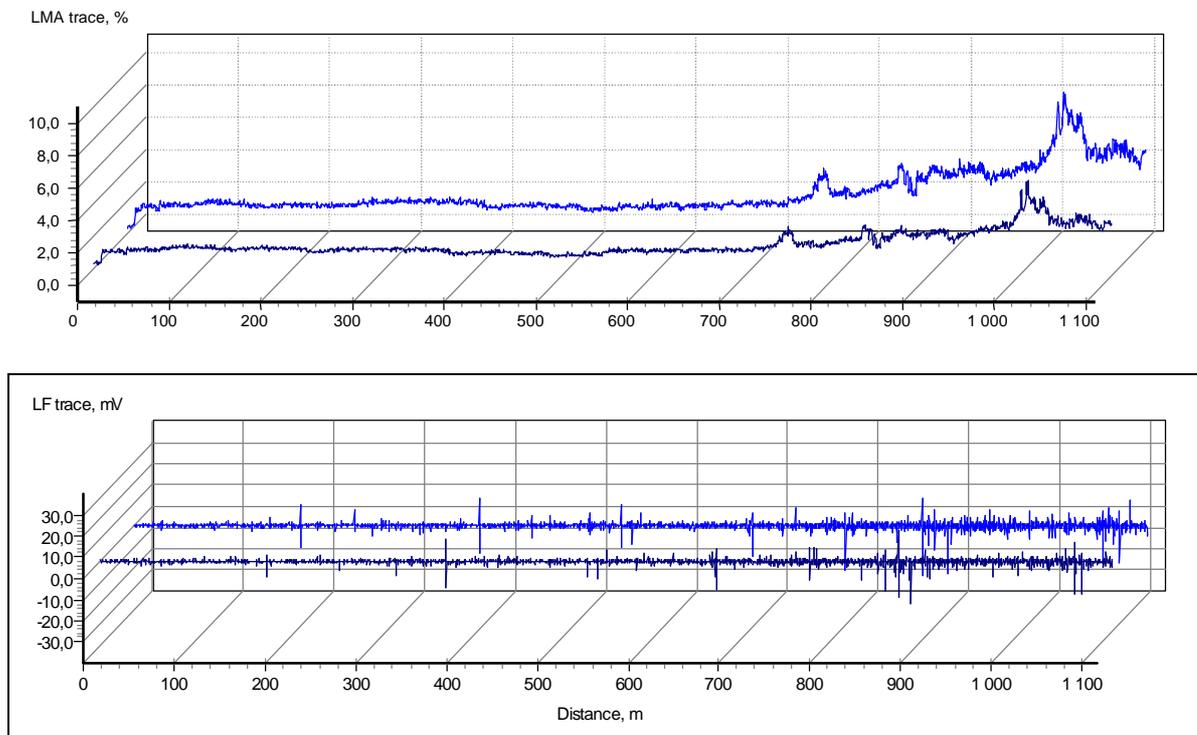


Fig.1. Charts of brake rope obtained by INTROS with 10 weeks time interval

Supervision about ropes at Norilsk Nickel is also carried out with rope testers INTROS manufactured by Intron Plus. Numerous rope testers for inspection round, flat and rubber-flat ropes were delivered to Norilsk Nickel trans-polar subsidiary. Large experience has been collected by personnel in rope inspection by INTROS since 1995. During 1995 – 2003 varieties of ropes with total length about 1800 km have been tested by INTROS. This instrument and applied software WINTROS makes comparison of inspection results easy and fast. Fig. 1 shows the comparison of inspection results obtained in different time periods from the same rope. Brake rope 30,5 mm diameter of cargo/man riding two deck cage of the “Skalistaya” shaft at Norilsk Nickel have been tested with 10 weeks interval. LMA and LF traces obtained from these tests were processed with WINTROS[®] for easier interpretation. The traces show that LMA at the most worn rope section at distance 800-1100 m increased from 6,5% to 8,8% within 10 weeks. There is appreciable corrosion damage of the section too, as it can be seen on the LF traces. Considering above data, an inspector required testing the rope more often and when LMA attained 10%, the rope was discarded. It is important that WINTROS[®] allows inspector to place in the same screen up to 8 charts obtained from the same rope in different time. This option lightens analyzing the progress of rope deterioration.

Russian mining safety rules [2] state maximum duration of rope life depending on their particular application. Beyond maximum duration the rope must be discarded. From the financial point it is reasonable to extend rope life under positive results of rope instrumental inspection, but requirements of the rules are mandatory. Thus many ropes are discarded under maximum life term requirement referred in the rules, even after instrumental inspection showed satisfactory condition of ropes. Considering wide experience and skilled personnel on rope NDT at Norilsk Nickel the Russia Federal Safety Authority in mining industry allowed the company life extension of hoisting ropes at “Oktyabrskaya” shaft provided by instrumental inspection with the INTROS. The extension of only hoisting ropes at only one shaft resulted \$130,000 direct saving. This amount does not include expenses, which could arise for delivery and installation of the new rope.

Having for an object to improve the quality of rope supervision and to reduce material losses the management of Norilsk Nickel has got approval from authorities for experiment aimed the comparison of effectiveness of daily visual check, destructive testing and non-destructive inspection of ropes. The experiment lasted during 6 months. A quantity of different ropes was tested by rope testers INTROS with afterward detail visual evaluation of the ropes. Data of instrumental tests were properly compared with results of visual inspection and testing with tearing machine. It was proved that NDT of ropes with modern dual-functional computerized instruments provides with objective documentary results and gives occasion to extend rope life. Federal mining safety department authorized the Norilsk Nickel with exclusive right to change the procedure of rope inspection in compare with that described in the rules and to concentrate on instrumental NDT.

According to this authorization the ropes can be tested non-destructively by the INTROS more often than earlier:

- monthly for the haulage and guide ropes, if daily number of cycles is more than 100;
- once every two months for all the ropes at auxiliary hoists and for steel balance ropes at multiple-rope hoists.

Earlier the time interval between the instrumental NDT was 12 or 6 months depending of the rope type and application. Mandatory daily whole rope visual inspection was repealed. The visual inspection became obligatory only for the rope sections with abnormalities detected by a rope tester as like as for the sections that are unavailable for instrumental inspection. Fig. 2 illustrates the visual examination of suspected section of hoisting rope followed right after instrumental inspection.

Routine procedures of the destructive rope testing at tearing machines were changed also. The time interval between the destructive testing of rope sections is increased from 6 or 3 months to 12 months for the ropes at the hoists with more than 100 cycles daily and for the ropes

at the hoists with less than 100 cycles daily and for the ropes at the auxiliary hoists – to 24 months. Thus working schedule for hoisting machine has been improved: more time is devoted to production and maintenance instead of daily time-taking visual inspection. Of course visual inspection remained an important addition in shady cases - visual and instrumental inspections supplement each other. Regular use of rope testers INTROS at the company resulted discard of rope not under normative terms referred in the Rules but under rope real technical condition. This enabled better purchasing and stocking of ropes.



Fig.2. Visual examination of suspected part of rope right after instrumental inspection by rope tester INTROS

The company arrived at a conclusion not to make supervision by itself and to commit supervision to an independent authorized contractor. The Talnakhservice, Ltd., as an independent expert company, has been providing the rope NDT and the rope monitoring at all mine hoists of Norilsk Nickel since 2003. The Talnakhservice defines possibility of safe use of the ropes monitored. It utilizes the INTROS instrument practically for all possible kinds of ropes: round, flat and flat steel-rubber. The table below shows equipment that is used by the Talnakhservice Ltd. for NDT of mining ropes at Norilsk Nickel.

Description of the instrument	Quantity
Basic unit INTROS	10
INTROS magnetic head MH 20-40	4
INTROS magnetic head MH 40-64	8
INTROS magnetic head MH 124	2
INTROS magnetic head MH 233	2
INTROS magnetic head MH 233R	4

Intron Plus arranged training course for inspectors from the Talnakhservice in the city of Norilsk. 12 people passed exams and were certified under level 1 and level 2 in accordance with Russia standard practice for magnetic NDT of wire ropes [3]. For some years inspectors accumulated a lot of data about all the ropes in use at Norilsk Nickel. The data bank contains important information about the manufacturer, date of installation and inspections, test reports, etc. Inspectors enable to forecast the rope wear dynamics and this helps to make rope purchase schedule. Purchase volume only for head and balance ropes in March-October 2003 was reduced by 60,000,000 rubles (about \$2,000,000) in compare with the previous years.

Conclusion

Modern rope testers INTROS provide inspectors with reliable information about real technical condition of rope. Rope NDT is effective mean not only to ensure safety of rope but also enable sufficient savings.

References

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