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STEEL – CORD CONVEYOR BELT NDT

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ABSTRACT

Conveyors are prevalent in many sectors of industry, especially in mining. Steel-cord rubber belt is one of the most important parts of a conveyor.
Durability of the belt depends mainly on the steel-cord durability. The steel-cord consists of hundred or more steel wire ropes. When a conveyer belt is in use the ropes can be broken or corroded. Besides, rope splice damage is possible.
The most of steel cord defects are not visible because of their location inside rubber. Magnetic method of NDT is usual to detect the steel rope brakes inside the belts. But the existing magnetic NDT instruments are rather heavy.
The new INTROCON instrument was developed in 2003-2004. A scanner with set of eddy current probes installed at the belt under test surface is significantly lighter than magnetic one and can work at the gap up to (10-20) mm between them and the belt.
The INTROCON was tested at iron and coal pit conveyors. It allows to get, to remember and to display data on steel cord condition in-situ. Using the WINCON soft an operator can get information on rope breaks, corrosion, splice damages and their locations.
The INTROCON has been using in mining industry in Russia with high efficiency since 2004.

Keywords*:* Magnetic testing, Steel rope inspection, Conveyor belt inspection, Steel-cord rubber belt

1. Introduction

Conveyors are common in different industrial sectors like mining, cement industry, dock handling, etc. There are two main types of conveyor belts: steel-rubber and textile-rubber. Steel-rubber belts are prevalent in mining due to their high durability because of conveyors hard working condition: hard load, big length (up to several kilometers) and width (up to 4 meters), hard environment. Durability of the belts is defined mainly by steel cord condition. The steel cord usually consists of hundred or more parallel steel wire ropes located longitudinally inside a belt. The ropes can be corroded or broken. Besides, rope splice damages are possible because of gap appearance between pair of rope spliced. Reason of this is usually bad adhesive bond of rubber to ropes.
It is important to detect steel cord flaws improper time, before the belt break and the conveyor stop. Most of steel cord flaws are invisible due to their location inside rubber. Magnetic flux leakage (MFL) method used to test steel cord non-destructively. There are flaw detectors for steel-rubber conveyor belts based on MFL method, for example [1]. The instrument operates like

the steel rope flaw detector INTROS [2, 3] using magnetization of the rope under test by permanent magnets and detecting magnetic flux leakage at rope break location by Hall generators.
Unfortunately, the MFL steel-rubber belt flaw detectors are rather heavy devices: it takes big mass of magnets to magnetize all steel ropes inside rubber body of the belt. Besides, the existing MFL instruments for the belt testing use inconvenient method of testing data registration.
That is why the INTRON PLUS has developed a new INTROCON instrument based on eddy current method of NDT.

2. INTROCON flaw detector

2.1 Principle of operation and specification

The INTROCON flaw detector for steel cord conveyor belt testing was developed and tested in 2004.
The aim of the development was to create a line of universal devices for NDT of steel-rubber conveyor belts. The devices must meet the next requirements:

- To provide NDT of belts from 0.6 up to 4 m width;
- To defect one broken rope;
- To get testing data independent of belt speed;
- Serviceability (acceptable weight, dimensions and convenient mounting on a conveyor);
- Convenient displaying and recording of test data.

Eddy current (EC) method was selected as the base of operational principle. Coil of the EC transducer induces eddy currents in steel cord ropes. The currents depend on rope condition: integrity and cross section area particularly. Sensing coil of the transducer gets a signal like a voltage pulse when break of the rope enters into the transducer's sensing area.
The transducer covers 10-12 ropes if they are distanced (17-20) mm each other. Several transducers (depending on the belt under test width) are united in a module. So, 4 transducers combine into the module for testing belt 800 mm width. The modules can be united in a set (scanner) which can include from one to three modules depending on the belt width. Output of each transducer is connected with an electronic unit. Electronic unit supplies the exciting coils of the transducers by alternating current, collects analog data from the transducers and gets pulses from distance counter. There are 8 input channels for not more then 8 transducers. The data are transformed into digital form, processed by microprocessor, stored and displayed on LED display. After downloading of the data to a computer they can be processed by the special software WINCON to analyze the test result and to print the final test report. The transducer works in one of two modes: local fault (LF), like rope break, and loss of metallic area (LMA), like rope corrosion. It is necessary to pass the belt through the scanner twice, if one wants to get the LF and LMA data both.
The portable electronic unit is connected with a scanner by a cable (Fig. 1). All the scanners are compatible with the electronic unit. Mass of the unit is 620 g and dimensions are (85×35×17) mm.
There is the line of scanners for different size (width) of the belt. Thus the Scanner 800 is intended for testing belt from 600 mm to 800 mm width. Its mass is not more than 10 kg and dimensions are (1300×200×70) mm. The scanners for width of belt more than 800 mm queue width the 200 mm step: Scanner 1000, Scanner 1200,…, Scanner 3000. Dimensions of Scanner 3000 are (3500×200×70) mm and mass is 32 kg. Scanners for belt width more than 3000 mm are produced optionally.

Fig. 1: INTROCON flaw detector on a conveyor.

Specification of the INTROCON flaw detector is shown below.

▪ Width of the belt under test, mm	600-400
▪ Thickness of the belt, mm	10-50
▪ Limit of rope break detecting	break of one rope
▪ Testing speed, m\s	0-4
▪ Working time up to full discharge of batteries, hour	6

2.2 Belt testing procedure

When belt is under test the scanner of INTROCON is placed at one side of the belt. Some possible places of the scanner location are shown in Fig. 2. A gap between the scanner and the belt is (10-20) mm depending on the cord rope diameter.

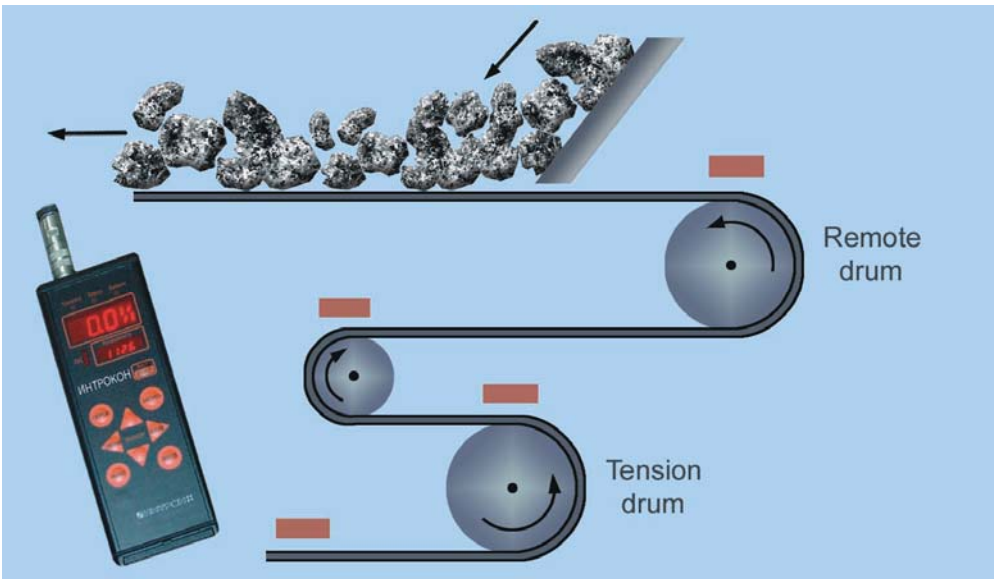

Fig. 2: Scheme of the scanner location on a conveyor.

There are two operation modes of the instrument: on-line mode and data collecting and storing mode.
Using the on-line mode, testing data are displayed on the two symbol displays of the electronic unit and on the five levels LF signal indicator as like as real time signal traces on display of a computer connected. The first display shows current LMA value in percent of standard value of all ropes cross section area or current value of LF signal as like as some other data on cord condition.
The second display used to indicate current distance of the belt test point from a refer point ("zero point").
The second mode means the data are collected and stored in the electronic unit. After test finish they are downloaded to a computer to be processed and displayed under the software WINCON control. The final test report usually is printed as a test result.

2.3 WINCON software

The WINCON software is intended to use it for the INTROCON flaw detector.
The WINCON ability is:

- Downloading the electronic unit stored data to a computer
- The LMA or LF data presentation like diagram traces
- Analyzes of the traces in detail (scaling, zooming, etc., presentation of several transducer traces one under another to evaluate the belt under test condition in full width)
- Data traces comparing for monitoring of belt condition in time
- Trace processing (filtering, cutting-off, etc.)
- Change of calibration and trace distance zero point
- Alarm level setting on traces
- Commentation of test result
- Final test report printing
- Changing of the INTROCON tuning

The WINCON is friendly to operator due to detail and convenient help.

3. The conveyor belt NDT using the INTROCON flaw detector

The INTROCON flaw detector was tested thoroughly in the INTRON PLUS NDT laborotory. It passed sucessfully through field testing at some mining companies in Russia. Now it used to test nondestruetively steel-cord conveyor belts in russian mining industry.
Some examples of conveyors belts NDT are given below.
Fig. 3 presents results of the belt testing at the north Russian enterprise Kovdorsky GOK.
There are two printed records: the LMA 1 and the LF 1 for the first sensor of the scanner. Horizontal axis is the belt under test distance in meter. The LMA is in percent of the standard value of steel ropes under test cross section, the LF value is in mV of a signal. Four pulses on both traces correspond to cord splices and two smaller pulses between 350 and 380 meters correspond to broken ropes. Large-scale scope of this place is presented on Fig. 4. Here are 4 broken ropes because one broken rope produces a pulse of 250 mV magnitude.

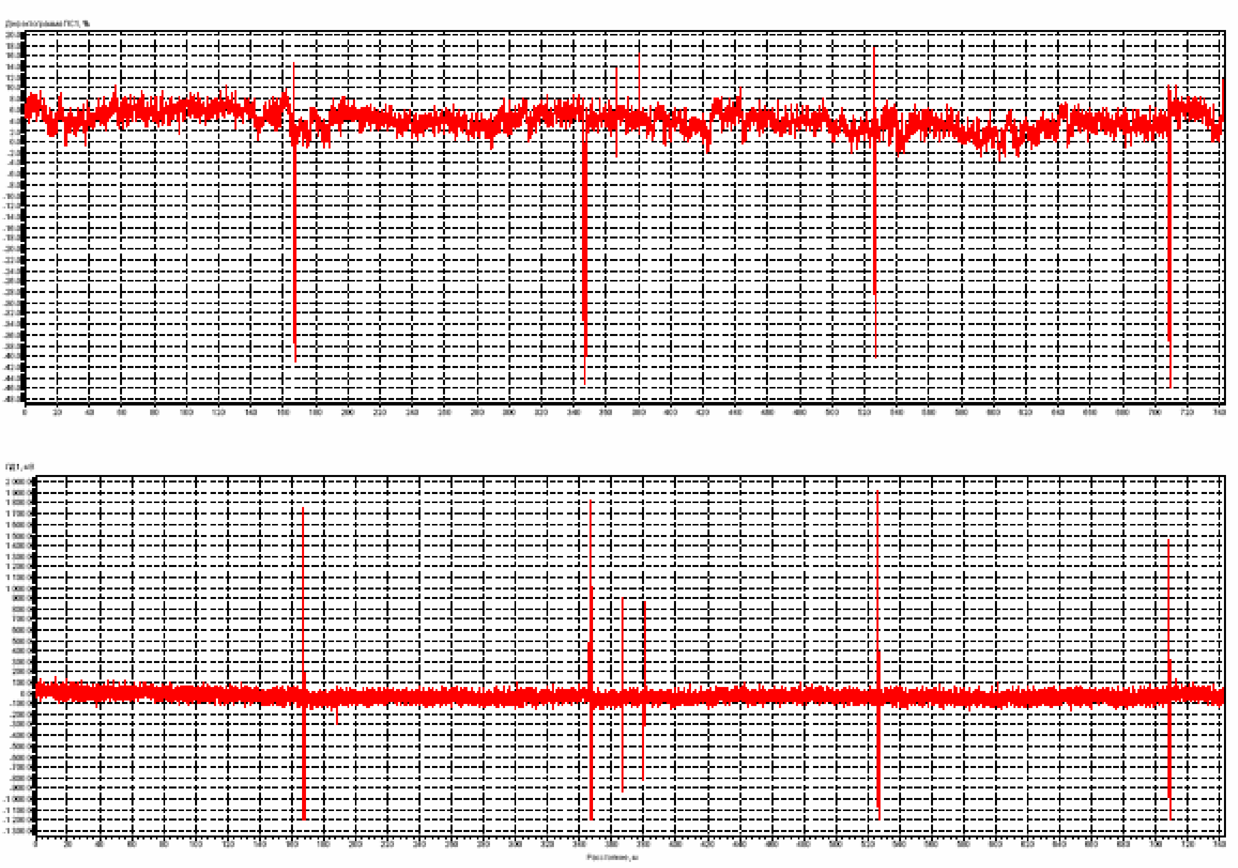

Fig. 3: The LMA (upper) and the LF (lower) traces of the INTROCON record at Kovdorsky GOK.

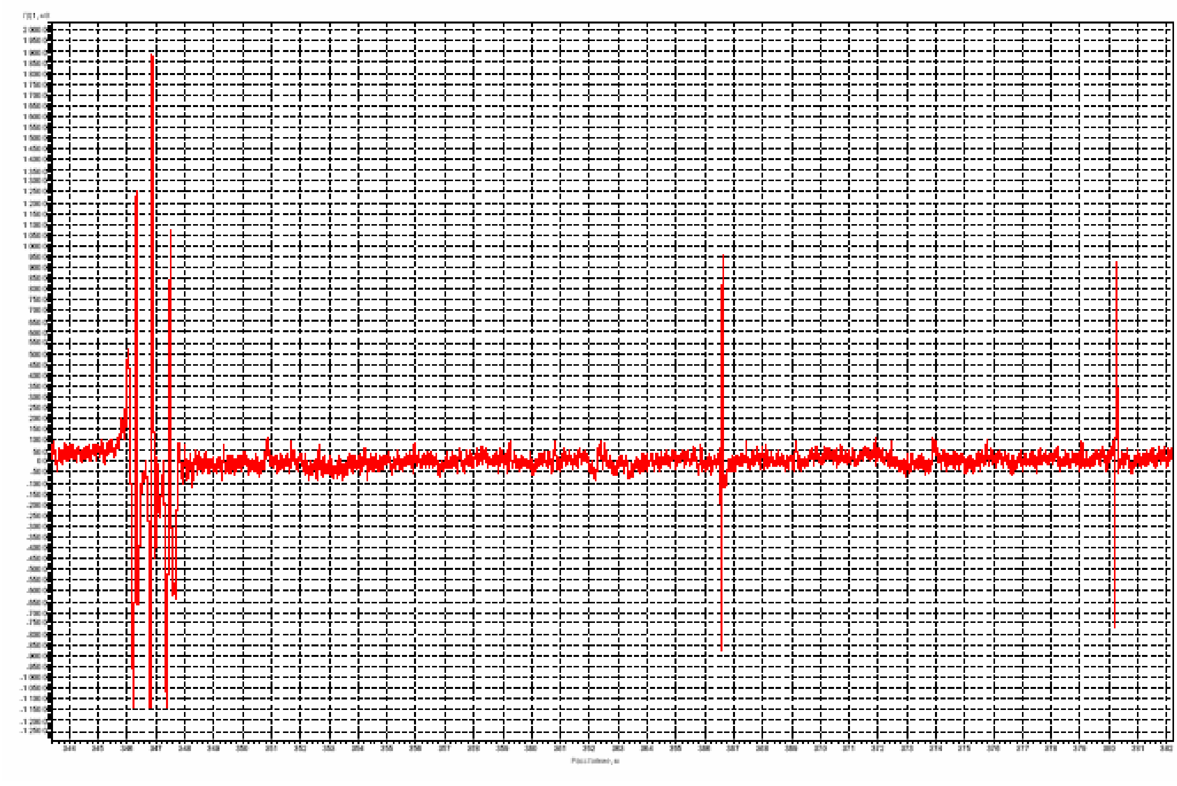

Fig. 4: The large-scale scope of the results of the LF trace Fig. 3 section.

It is convenient to monitor belt condition using the INTROCON with the WINCON software together. Two records of the same belt section registred with half a year apart are presented on Fig. 5.

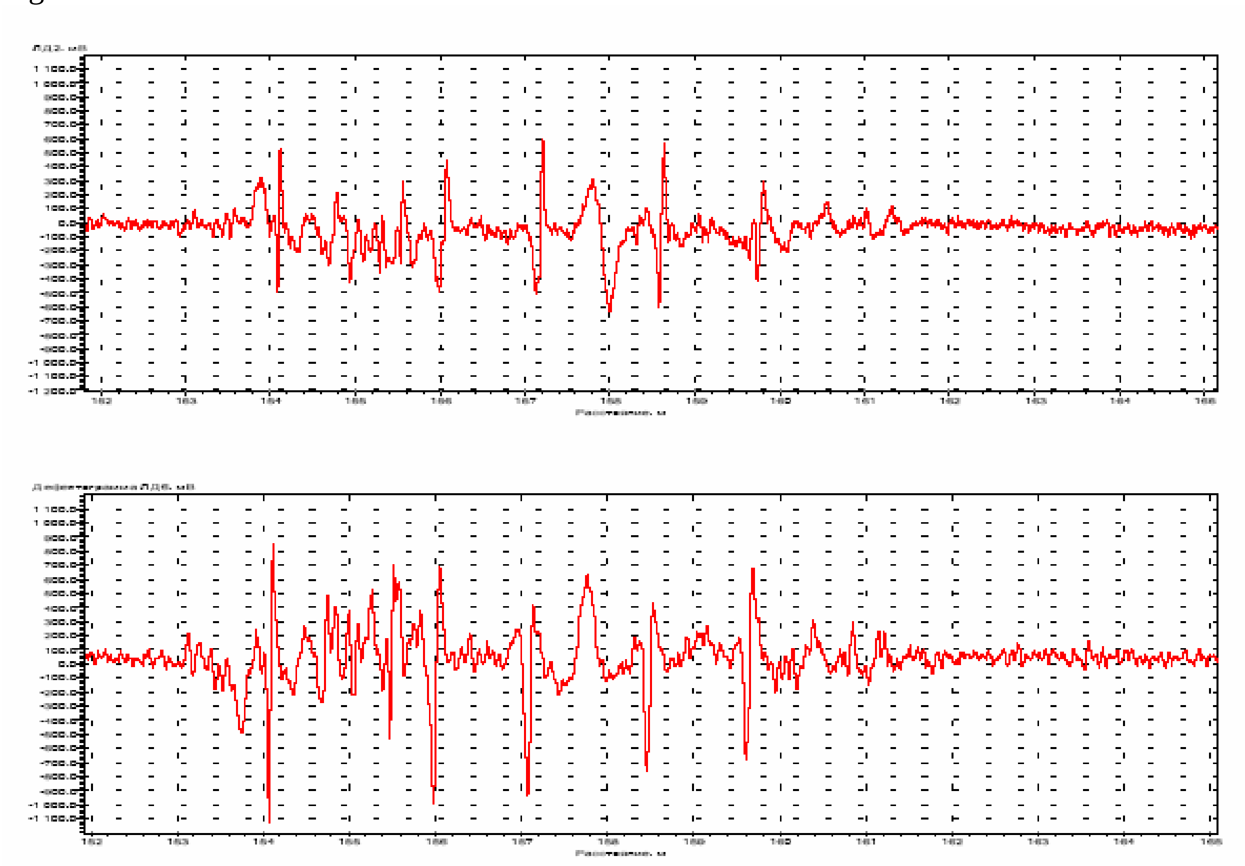

Fig. 5: Two LF records of the same belt section: the lower one is 6 month later.

The INTROCON can be used to test not only flat steel-cord rubber belt but for testing of special shaped belts. Fig. 6 shows the LMA record of S-shaped vertical conveyor Pocketlift.

Fig. 6: The INTROCON scanner positioned on the Pocketlift conveyor belt.

The belt is supplied by rubber pockets for bulk (Fig. 7).

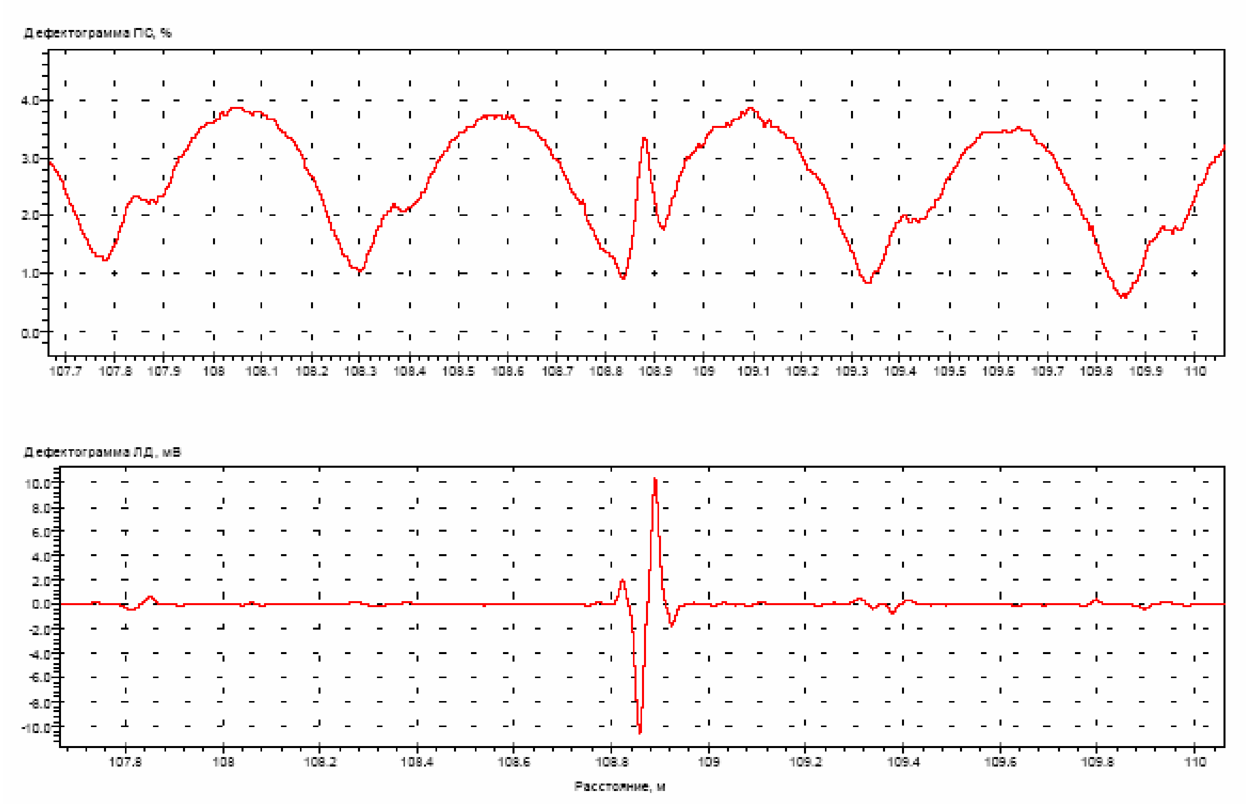

Fig. 7: Records for the Pocketlift conveyor belt.

The trace of Fig. 6 indicates periodical signals corresponding to ferrous details for pocket fitting. A rope break was detected due to the pulse at 108.8 m distance. That is the place of a pocket fitting to the belt.

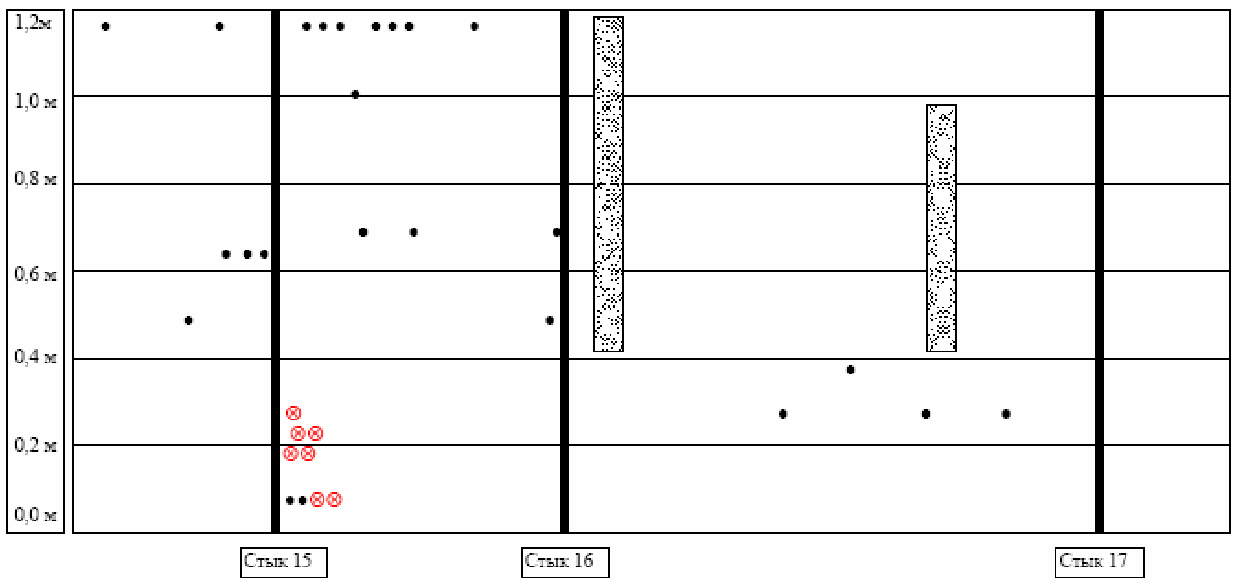

Fig. 8: Final diagram of a belt inspected.

All the LMA and LF traces correspond only to one of the sensors of the scanner. So they indicate condition of the belt cord strip 200 mm width. To get information about full width of the belt the data of all sensors of the scanner must can be united by a final diagram (Fig. 8). The diagram presents the test result of NDT inspection of the conveyor belt at the Estonian shale oil shaft ESTONIA. The belt width is 1.2 m and it is divided into 6 strips (0.2 m width each) on the diagram. It is shown result for the belt section between splices number 14 and 17 (total length of the section is 500 m). The black point indicates a rope break, the red dagger in a circle corresponds to accumulation of inadmissible rope breaks, the shaded rectangle indicates corroded area, the vertical black line corresponds to a splice.

The diagram Fig. 8 indicates that the belt section located close to splice number 15 in strips from 0 to 0.3 m must be repaired or changed.

The final presenting of test results as it is made on diagram like Fig. 8 provides quick finding of belt defective areas to monitor and repair them in proper time.

The limiting state criteria of steel-cord belts are defined in a new normative document: instruction for inspection of the steel-cord conveyor belt condition. The document is submitted now to Russian State Safety Body ROSTECHNADZOR.

Bearing capacity of the belt can be calculated taking into consideration NDT data. The simulator of the belt is developed for the calculation [4].

4. Conclusions

The new eddy current NDT technology of the steel-cord conveyor belt developed lets have an ability to raise safity of conveyor and to decrease lost of money due to unplanned conveyor stop when a belt is out of order.

5. References

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