A high-resolution system for automatic diagnosing the condition of the core of conveyor belts with steel cords.

Ryszard BŁAŻEJ
Wroclaw University of Technology, Machinery Systems Division
Pl Teatralny 2, 50-051 Wroclaw, Poland, e-mail: ryszard.blazej@pwr.wroc.pl

Key words: conveyor belt, non-destructive testing (NDT), diagnosis, belt damage, magnetic method of automatic detection

Abstract:

This paper describes a mobile system for the noninvasive diagnosis of the core of conveyor belts with steel cords. The system is based on the 4-channel magnetic head of the EyeQ system which one of the Polish opencast mines bought at the beginning of the 21st century. Because of the restructuring of the mine and the aging of the EyeQ system, measures were taken to improve the latter's resolution and performance. The upgrading consisted mainly in developing a new software for data analysis automation and in replacing the old hardware platform with a new one increasing six-fold system resulution. The system has successfully passed tests in mine conditions and is currently used to assess the condition of belts working in the mine transport system (fig. 1).

Introduction

In opencast mines transport by belt conveyors equipped with steel cord belts constitutes the main system of hauling the output to a power plant or the overlay to dumping grounds. The efficiency and reliability of the whole transport line to a large extent depend on the condition of the system components. The surface and the core of the conveyor belt – the main system component – are exposed to continual damage. Small damage to the bearing covers and the edges does not pose a direct standstill hazard and is considered to be part of the natural wear of the belt. Whereas point damage and linear damage (longitudinal cuts and slits) to the covers and to the core have a decisive effect on the life of the belt and its ability to carry longitudinal and transverse loads [2]. Detailed information about the number and quality of instances of damage to the belt core, supplied by the diagnostic system enables the users to reliably assess the condition of the belt and to take the correct decision about its further fate.

The EyeQ system was upgraded in two stages. In the first stage, the components of the measuring-analyzing system were replaced and in the second stage, an algorithm for the automatic analysis of the data obtained from measurements was developed [3].

Fig.1. System during measurements in opencast mine.

New hardware platform

The principle of operation of the system consists in measuring changes in the magnetic field in the area of damaged conveyor belt core cords. The amplitude of the changes depends on the size and type of damage. The EyeQ system used to offer 4 measuring channels whereby it supplied the user with information from a 60 cm wide belt segment per channel.

The upgrade resulted in a sixfold increase in system resolution, i.e. from 4 to 24 channels, and so a new multichannel data logger had to be employed. For this purpose an 8-slot CompactDAQ chassis (fig. 2) with Ni WLS 9215 modules was used. If one of the channels fails, the cost of replacing the unified four-channel card is not high and the card can be replaced relatively quickly [4]. A module can be replaced by the user without calling service.

Fig. 2. 8-slot Compact DAQ chassis with NI WLS 9215 modules.

All the pieces of equipment making up the measuring system have been placed in a Peli box (fig. 3) resistant to the action of noxious and aggressive agents. The box facilitates transport and protects the system components against damage during transport and measurements. The box is equipped with outer interfaces for quick and safe setup of the measuring system devices.

Fig. 3. View of open measuring system box with visible tablet and wiring and during its operation at belt conveyor.

Description of system functions

The main program window (fig. 4) has been designed having utmost simplicity and clarity of displayed information in mind.

In its top part it shows data on the measurements performed, presenting them in the alphabetical order so as to highlight the most important information about a measurement on a particular belt conveyor. The data can be saved, read in or exported.

The middle part of the window shows a conveyor belt visualization with vertical lines marking the successive belt segments between splices. The system distinguishes 4 alarm thresholds whose limit values are set by the user on the basis of his/her experience and the operational specification of a given belt conveyor.

The colours from green through yellow and orange to red represent damage intensity per 1 running meter of the belt.

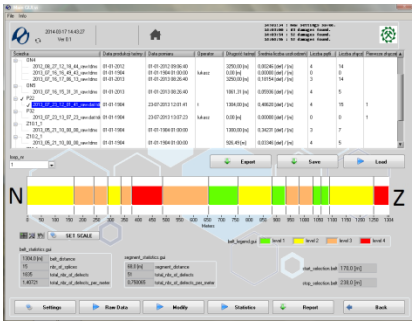

Fig. 4. Main program window with visualization of results after signal analysis.

The bottom part of the window shows brief statistics on the number of damage instances on the entire belt and on its selected segment. Also data about the length of the investigated belt and belt segment and the number of detected splices are shown.

Signal analysis module

The signal analysis module is used:

- during signal acquisition for real time detection of the presence of magnets in order to automatically determine the beginning and end of the belt to be subjected to further analysis, and to determine the number of full loops measured (fig.5);
- after measurement to carry out a post-processing procedure consisting in detecting splices and damage in the successive loops measured.

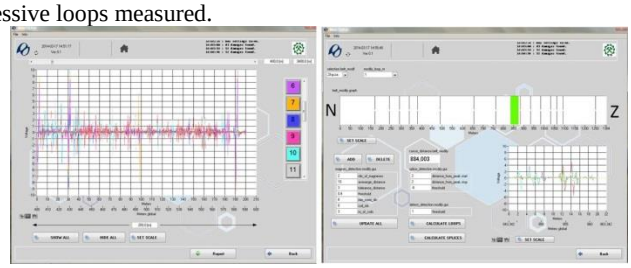

Fig. 5. RAW data analysis and loop and splice detection windows.

Statistical analysis module

Damage (along the cross section) for the 24 measuring channels is presented in two ways: (1) as the number of damage instances (the total number of damage instances for a given channel for the whole belt, for a selected belt segment or its fragment) and (2) as the frequency of damage (the number of damage instances for a given channel, divided by the total number of damage instances, expressed in per cent).

The whole belt or its part, such as a loop, a segment or a segement fragment, is presented as a damage matrix with two (vertical and horizontal) histograms illustrating

damage distribution along the belt width and length. The matrix meshes contain the number of damage instances per a unit area (1 measuring channel/1 running meter of belt) (fig. 6), and the colour representing damage intensity.

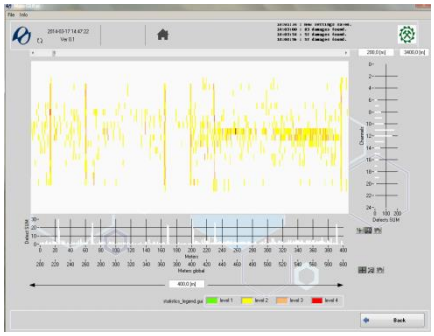

Fig. 6. Statistical analysis window with damage matrix and vertical and horizontal histograms.

Using the length and size selection windows the user chooses the size of the belt fragment to be analyzed. Thanks to this way of presenting the results the user instantaneously gets information on the size of the damage instances and their distribution on the whole loop of the analyzed belt.

Reporting module

The user in a quick and easy way can print out a report on the investigated belt or save it as a pdf file (fig. 7). The content of the report has been consulted with the mine conveyor belt department in order to avoid providing unnecessary information while focusing on supplying the most important data helpful in drawing up plans for belt purchases or belt regeneration and repairs.

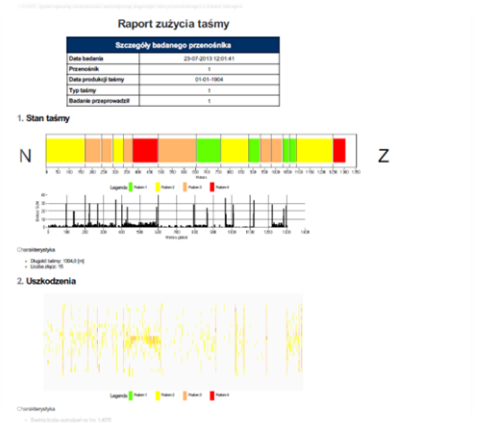

Fig. 7. Report showing belt condition visualization and damage histograms.

Conclusion

Thanks to the new version of the automatic diagnostic system the measuring process and the analysis of the signals after the measurement have been automated. Such functions as the automatic

start, the detection of the number of complete belt conveyor loops, the automatic measurement and automatic detection of damage were not available in the previous version of this measuring system.

The open character of the system, mainly of its software, made it possible to develop automatic procedures for data processing and analysis, reporting, real-time monitoring and statistical analyses.

The software already at the measuring stage enables the user to analyze the condition of the belt on the conveyor and to precisely locate, classify and quantitatively assess belt damage.

The new hardware platform ensures the maintenance-free use of the system and if a failure occurs, it can be quickly removed through the replacement of the unified measuring modules without it being necessary to call specialized service.

This project has been carried out as part of the Applied Research Programme, path A entitled: An intelligent system for the automatic examination and continuous diagnosis of the condition of conveyor belts"

References

[1] Błażej Ryszard, Jurdziak Leszek, Zimroz Radosław: Need for developing in-house diagnostic equipment for automatic assessment of condition of conveyor belts in opencast mines (in Polish). Górnictwo i Geoinżynieria. 2011, R. 35, no. 3/1, pp. 63-71.

[2] Żur T., Hardygóra M. Belt conveyors in mining (in Polish). 1996.

[3] Błażej R, Jurdziak L: Integrated diagnostic device for automatic assessment of conveyor belts condition. In: 22nd World Mining Congress & Expo, 11-16 September, Istanbul-2011. Vol. 3 / ed. Şinasi Eskikaya. Ankara : Aydoğdu Ofset, cop. 2011. pp. 675-680

[4] Błażej Ryszard, Zimroz Radosław, Nowak Robert, Grzyb Krzysztof, Kurp Łukasz: Extension of EyeQ system functionality to cover diagnostics of core of ST belts (in Polish). Transport Przemysłowy i Maszyny Robocze. 2010, no. 3, pp. 24-28.