



CONDITION MONITORING SYSTEM FOR DRIVE UNITS IN BELT CONVEYOR

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Key words: belt conveyors, drive units, diagnostics, monitoring system

Abstract:

A proposal of condition monitoring system for belt conveyors is discussed in the paper. Proposed system consist of layers and modules and has open architecture. Both hardware and software is based on National Instrument products. Physical variables measured in the systems are: acceleration, temperatures, currents and voltages. As an output one may get raw data and diagnostics decision.

1. Introduction

Condition Monitoring of drive units used in conveyor system is one of crucial problem of machinery maintenance in mining industry [9], [10]. Due to total length of conveyor system and its spatial distribution in mine, many subsystems (conveyors) in series, it is reasonable to monitor main transportation ways (i.e. from bucket wheel excavator to power plant). It is proposed here to use an original concept of condition monitoring system. It is result of years of experience and it is dedicated to diagnostics of drive units used in conveyor transportation systems [5], [6], [7], [8]. Based of failure analysis done for drive units used in mining industry [4], it has been concluded that diagnostic system has to detect and diagnose both local and distributed faults in gearboxes and bearings (used in electric motor, gearboxes and pulleys). Local damages in bearings and geared wheels produce weak impulsive signals, which are masked by other sources of vibrations with higher amplitudes. A crucial problem is signal extraction and enhancement [2]. A several advanced techniques have been developed; one of the most efficient is optimal filtering approach (in Wiener sense). Distributed faults may be diagnosed by spectral analysis (for raw data and evenly distributed faults) or envelope analysis (for irregular distribution of the faults). Scheme of procedures with short description will be provided in the paper. In some cases, the condition of rolling element bearings may be described by temperature measurement. In proposed system temperature monitoring for key elements is used. Conveyors operate under time varying operating condition, depending of material stream transported so there is a need to identify operating condition and to include it into diagnostic reasoning process (operating conditions influence vibration signals so values of diagnostic features extracted from the signal will be affected by varying load, too) [1], [6].

Apart from pure diagnostic point of view there are a lot of important technical things during condition monitoring. They have been decomposed into layers and modules. Layers consist of sensors, acquisition cards, transmission layers and application layers (data analysis, decision making, system management, visualization etc). There is a global tendency to minimize hardware part of the system, so all possible problems are solved by computation.

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2. Condition Monitoring System for Belt Conveyors – general information.

As it was said, system consists of layers and modules. Such structure allows to perform auto-diagnostic of the system and makes maintenance of the system easier. System is open; there is possibility to modify it by replacement modules by updated ones. It is important that in the case of failure of part of the system, it may monitor rest of the machine.

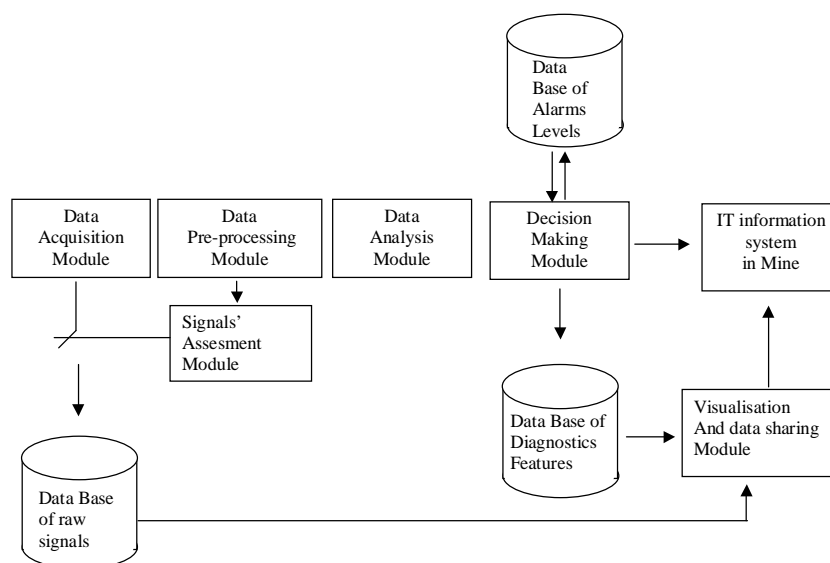


Fig. 1 Main elements of the system

Due to distances between machines and central units, it is proposed to exploit WIFI technology. The system is distributed, sensors and acquisition cards are located on the drive unit and they communicate with central unit via WIFI protocol. The monitoring system is a part of information system in the mine. Decisions, raw data etc are available for user also via Ethernet network (FTP and HTTP server).

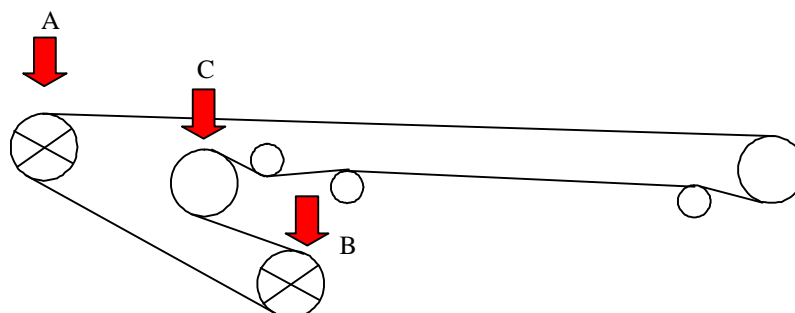


Fig. 2 Scheme of the conveyor with marked (arrows) monitored objects

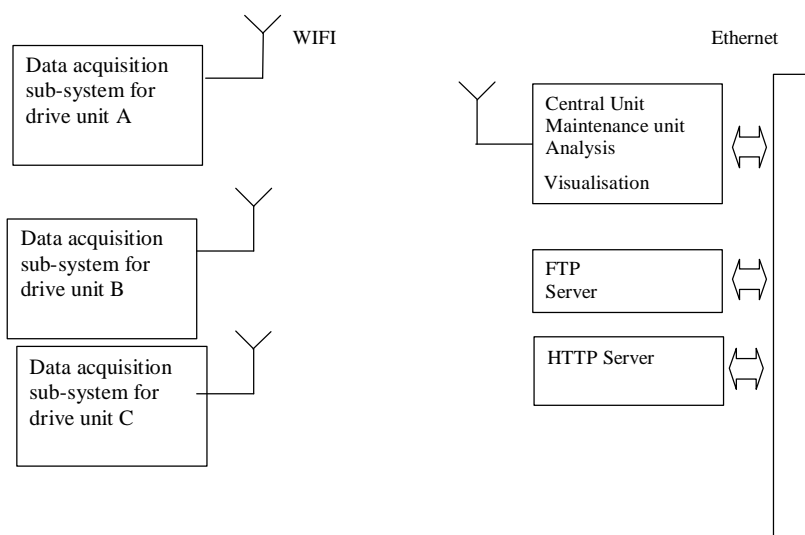


Fig. 3 WI-FI and Ethernet technologies for Condition Monitoring

3. Signal processing and features extraction modules

As mentioned in order to assure efficient condition monitoring (in sense of probability of correct diagnosis) there is a need to measure main (vibration, temperature) and auxiliary signals (current, rotation speed). Auxiliary signals are required for identification of process parameters (operating conditions, i.e. load/speed). Figs. 4 - 6 present schemes of procedures implemented in the for: distributed fault (Fig. 4), localized fault detection (Fig. 5) and operating condition parameterization (Fig. 6). In order to assess the condition of gearboxes a spectral analysis is used, a system detect characteristic components (using a priori knowledge about object) and build vector of features or aggregate them. Combining this information with identified operating conditions (Fig. 6) one may make a decision regarding the gearbox condition. Decision may be done in classical way by simple comparison with threshold; however more reliable reasoning is to do it in multidimensional space as suggested in [6].

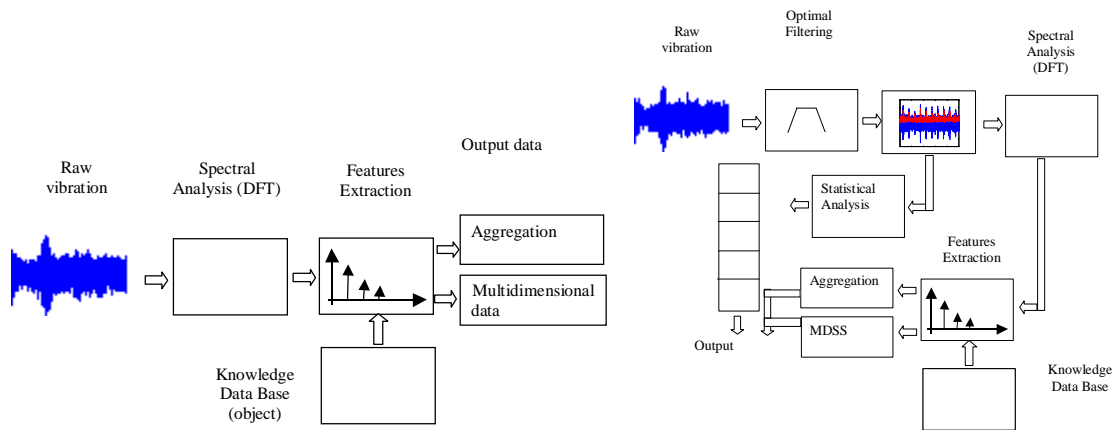


Fig. 4 Distributed fault in gearboxes – preprocessing and feature extraction module

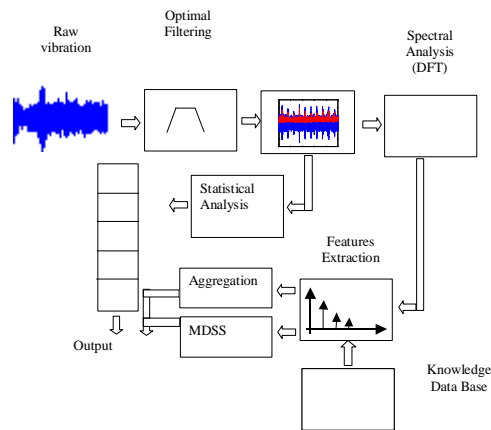


Fig. 5 Localised fault detection module

As it was mentioned above, localised faults are more complicated. Main effort is related to signal extraction. It is propose to use optimal filtering to extract signal of interest (signal containing information about fault). For extracted signal envelope analysis is used and next similarly spectral analysis of envelope may be used to identify faults. A statistical approach may be also used for fault detection.

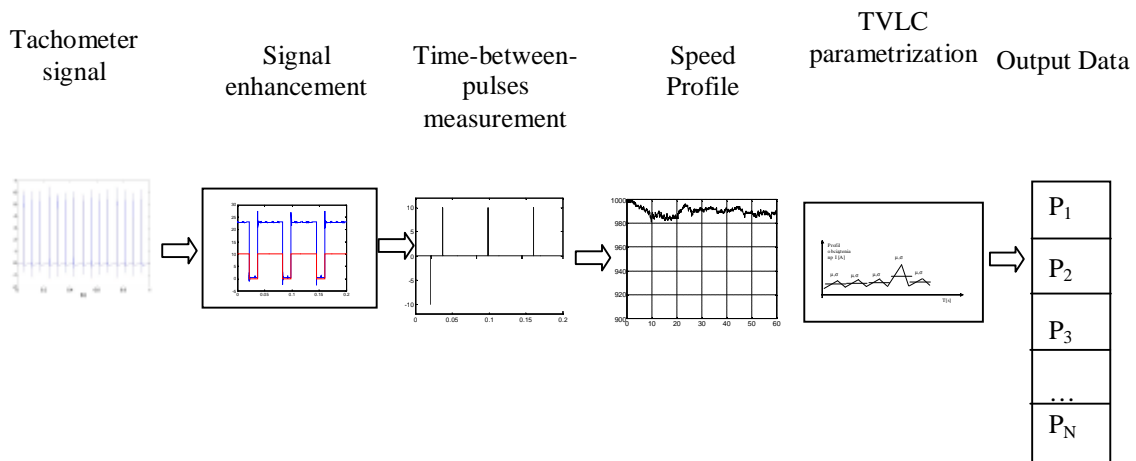


Fig. 6 Nonstationary operating condition parametrisation module

4. National Instrument hardware and software. User Interface

In order to implement all described algorithms and functionality of the system the National Instrument platform has been selected. NI offers standardized components (acquisition) with drivers suitable for measurement of vibration, temperature, voltage etc. The Labview software contains several toolkits (sets of ready-to-use procedures) for basic programming, data acquisition, transmission and sharing or and signal processing and analysis.

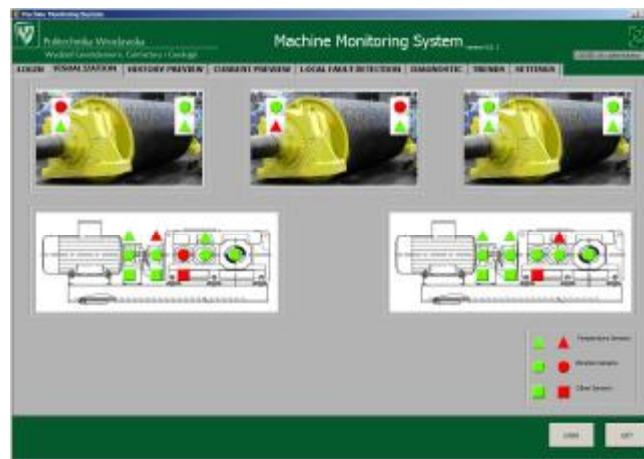


Fig. 7 Tab *VISUALIZATION* with monitoring of sensors installed in the system

Fig. 7 presents general screen of the system, one may monitor colors of indicators that inform if any faults exist in the system. If icon is in red color, system detect a problem and advanced action is required. Fig. 8 and 9 show example of screens for cases of distributed and localized faults in gearboxes.

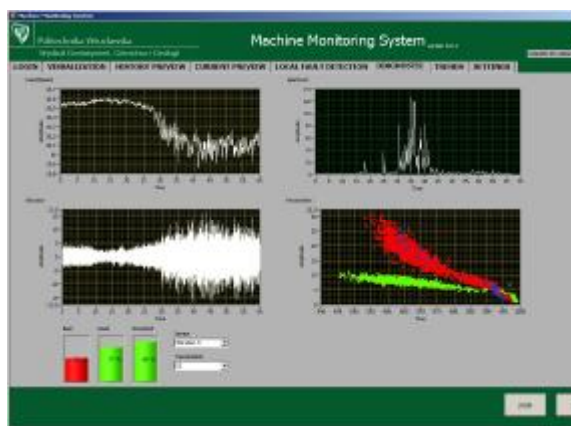


Fig. 8 Tab *DIAGNOSTICS* for detection and assesment of distributed faults In gearboxes under nonstationary load

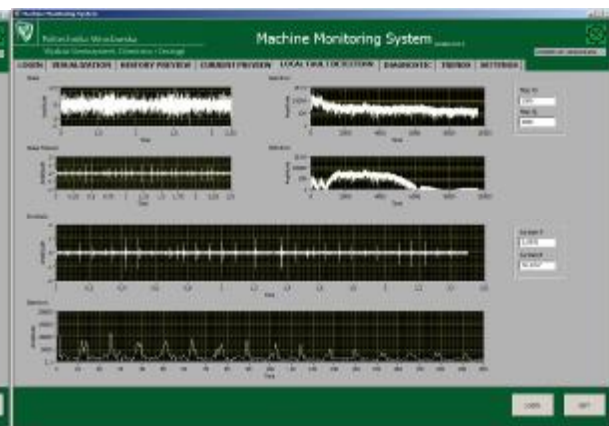


Fig. 9 Tab *LOCAL FAULT DETECTION* for detection and recognition of local damages in gearboxes and bearings

5. Conclusions

A condition monitoring system for drive units used in conveyors has been presented in the paper. The task has been defined as an automatic detection and diagnosis of localized and distributed faults in bearings (electric motor, gearboxes, pulleys) and geared wheels (gearboxes). System is modular, consists of layers and it is dedicated to conveyors systems. As a technological platform National Instrument and Labview software have been selected as the quickest and most efficient environment for monitoring and diagnostic system environment.

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