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Condition monitoring of Self aligning carrying idler (SAI) in belt-conveyor system using statistical features and decision tree algorithm

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ABSTRACT

Self aligning carrying idler (SAI) is a key component of belt-conveyor has two main functions: power transmission, controlling the belt sway and change the direction of conveyor belt. As the SAI is found to be critical in heavy duty conveyor systems, it becomes an essential activity to monitor its smooth functioning. To ensure this, condition monitoring of SAI needs to be carried out which basically forms a classification problem. Self aligning carrying idler consists of the following components such as bearing, shaft, labyrinth seal and outer roller. The SAI was analyzed with the following cases such as SAI running at good condition (Good), SAI with bearing fault (BF), SAI with shaft fault (SF), SAI with labyrinth fault (LF) and SAI with outer roller fault (RF). From the experimental setup, the vibration signals were acquired for different conditions of SAI. Some useful features were extracted using statistical measures. The features were classified by decision tree algorithms. The classification results are presented in the conclusion part. The effort is to apply the statistical features and decision tree classifier to SAI and examine whether would it be made online.

1. Introduction

Self aligning carrying Self aligning carrying idler (SAI) is a key component of belt-conveyor system may undergo different types of failures because of startling forces, inadequate lubrication and futile sealing. The components that often fail in Self aligning carrying Self aligning carrying idler (SAI) are: bearing, shaft outer roller. The failure of these components directly affects the performance of the belt conveyor system. Hence, one must have a system to detect the failure in advance and alert the operator in order to avoid heavy damage to the system. The different faults considered for this study are SAI running at good condition (Good), SAI with bearing fault (BF), SAI with shaft fault (SF), SAI with labyrinth fault (LF) and SAI with outer roller fault (RF). In the conventional methods like oil condition and thermal state monitoring methods, the faults are detected after they were developed and reach a state to create a great impact in the system. As an alternate, Fast Fourier Transform (FFT) based methods were used for the applications of this kind. In FFT based methods the signals were analyzed in frequency domain. The main disadvantage in the FFT based methods was that it can work effectively only for the stationary signals (i.e.) the signal for which the characteristic frequency will not change with respect to time. However, as the application considered for the

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study will undergo a rotary motion, it becomes obvious that the characteristic frequency will be slightly shifted over a time. Therefore, one cannot rely on FFT based techniques for the precisive failure which is quite common in SAI. It was observed that the vibration based methods will overcome this problem and hence one can achieve a very good with vibration signals. When the components in a belt conveyor system interact each other, a complex vibration signals were generated. The variation in the signature of the signal was seen in the generated vibration signal.

2. Related work

Zarei et al. [1] proposed a methodology for the prediction and classification of various bearing faults in the bearing using an intelligent filters [1] whereas Yan et al. [2] reviewed with the various types of wavelets for the purpose of classification of rotary machineries. It is reviewed that the acoustics signals have been acquired from the rotary machines and they have been used with the wavelets for the useful derivation of the results [2]. Du et al. [3] used the multifractal features using wavelets for fault discrimination of rotary mechanism. It was proved that the multifractal features of the wavelet leaders were good candidates for the fault diagnosis of rotary mechanism [3]. Muralidharan and Sugumaran [4,5] proposed a novel methodology for selection of wavelets for fault diagnosis application using J48 algorithm. In this paper, wavelet features using different families of wavelets were extracted from the vibration signals and the features were classified using decision tree algorithm. It is proved that the J48 algorithm was one of the best algorithms in combination with the wavelet features. Also, they have attempted to realize the fault diagnosis capability of fuzzy logic and rough sets. Certain rules have been framed with rough sets and classified using fuzzy engine. The result was promising one and the techniques were well appreciated [4,5].

Eltokhy et al. [6] have adopted the statistical feature extraction method for breast cancer diagnosis in method for breast cancer diagnosis in digital mammogram using multiresolution representation, where the ECG signals have been used for diagnosing the breast cancer using statistical features and could achieve more than 95 % of the accuracy [6]. Phinyomark et al. [7] proposed a method where statistical features were used and in addition the feature reduction techniques has been proposed. It helps to increase the performance of the system by reducing the computation time. This work was highly appreciated because, the main drawback with the EMG signal is the consumption of the time. This challenge was overcome by this method [7]. However, there were other algorithms also used for classification, feature selection and feature extraction such as naïve bayes algorithms which is mathematically proved. Muralidharan and Sugumaran [8] made a comparative study between naïve bayes classifier and bayes net classifier for fault diagnosis of monoblock centrifugal pump. The algorithms are based on conditional probability and literature related to applications of these algorithms are only few. The comparative study concludes that the bayes net algorithms perform better than its counterpart. However, bayes net algorithm demands strong domain expertise and hence the diagnosis can only be made by a relatively skilled persons [8]. In spite of availability of several classification algorithms, the performance is based on the computational complexity of the dataset. The computational complexity can be reduced by selecting suitable features rather than using all the attributes and proper selection of the classification algorithms. Jeinsch et al. [9] proposed a robust model-based information system for monitoring and fault detection of large scale belt conveyor systems. In this paper an information system is presented, which is developed to meet the requirements on fault detection and on-line monitoring of large scale belt conveyor systems. The paper discusses the consequences of Self aligning carrying idler failures which has similar impact as that of the conveyor pulley, which subsequently lead to belt damage. To evade such catastrophe the paper suggests Condition Monitoring (CM) methods based on physical variables such as vibration, speed, current, magnetic field and temperature [9].

Sugumaran and Ramachandran [10] presented the effect of number of features in the classification performance of bearing dataset. Two different types of features such as statistical features and histogram features have been taken and analyzed with the same classification algorithm. Finally, it was concluded that seven features were the optimum number of features for the bearing dataset [10]. Sugumaran et al. [11] proposed a methodology to select a suitable machining process for particular machining operation based on certain attributes [11].

Randall and Antoni [12] proposed a methodology to predict the different types of faults in the bearings. The different fault conditions were simulated and the signals have been acquired corresponding to each condition. Finally, the signals were classified with the classification algorithm [12]. Tse et al. [13] used enhanced eigenvector algorithms for detecting different types of faults in machine elements. The vibration signals were used to represent them in the form eigen vectors corresponding to each condition so that the classification is performed. The result showed that the eigenvector representation of the vibration signal was better to use. However, representing the vibration signal in the form of eigenvector demands strong subject knowledge [13]. Urbanek et al. [14] presented that an effective method to perform the fault diagnosis of machinery under various working conditions [14]. Rubini and Meneghetti [15] stated the applications of envelope and wavelet transforms for the fault diagnosis of incipient faults in the bearings [15]. Ho and Randall [16] simulated and presented certain faults in the bearings for the understanding of the various fault diagnosis techniques [16]. In all of the above methods, the computation of features take more time and hence the classification process becomes complicated. Though there were lots of research works have been carried out in the field of fault diagnosis, it is evident that very few literatures reported the enhancement of the algorithms. One can understand that in a span of a decade, it is hard to find an article which discusses that the fault diagnosis of the carrying Self aligning carrying idler which plays a very important role in transmission systems. Hence, this study was taken up to analyze the possible