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ORIGINAL ARTICLE

CONDITION MONITORING OF DIFFERENTIAL BASED ON FAST FOURIER TRANSFORM

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ABSTRACT: Differential is one of most important part of power transition system, so condition monitoring and fault diagnosis of this part is very important. In this paper an intelligent method for condition monitoring and fault diagnosis of MF-285 tractor differential, that is one of high product tractors in Iran, has been introduced by acoustic analysis. According to this target first acoustic signals were gathered for health and unhealthy states. After that gathered signals transferred from time domain to frequency domain by fast fourier transfer. After that 29 statistical feature were extracted from signals. Extracted feature were used as entrances to classification of artificial neural network. After mentioned stages accuracy of faults classification system obtained 95.16%, this accuracy expresses that introduced method has high power and quality in condition monitoring and fault diagnosis of differential.

KEYWORDS: Condition Monitoring- Differential- Acoustic Analysis- MF-285 Tractor

INTRODUCTION

Due to the importance of monitoring the health of system without stopping, the uses of non-destructive tests are widely improved. Condition monitoring is a conventional method for preventing machineries from failure and breakage. The use of conditional monitoring allows Maintenance to be scheduled or other actions to be taken to avoid the consequences of failure, before it occurs. The condition monitoring and fault detection schemes improve gear transmission systems Reliability and reduce their failure occurrence (Yang and Makis, 2010; Suykens and Vandewalle, 1999). Automation, as another significant stage in industries commonly implemented to reduce the cost of production, quality control and maintenance. Based on these theories several methods are developed to automate the condition monitoring and quality control of systems. The undeniable abilities of artificial intelligence on this way, persuades researches to use different methods of AI in their fields of study. Fuzzy Logic, Neuro-Fuzzy systems, Artificial Neural networks and Support Vector Machine algorithm are the most usual algorithms for implementing artificial Intelligence (Bagheri *et al.,* 2010). Beside these techniques, acoustic signals and signal processing are commonly used for non-destructive tests in fault diagnosis systems.

Rotating machineries are used considerably utilized in the manufacturing of industrial products. Differential as a key rotating motion transmission component plays a critical role in industrial applications (Zhu *et al.,* 2005). Therefore, attracts research interests in condition monitoring and fault diagnosis of this equipment. Importance of gears and bearings in condition monitoring of the machine is undeniable, thus, processing and analysis of acoustic and vibration signals of the differential gears is the common way of extracting reliable representative of the differential condition (Zhan *et al.,* 2006; Rafiee *et al.,* 2010).

Differentials commonly have 4 important roles in vehicles that are: i) power transmission ii) increase torque and decrease rotational speed iii) to provide the ability of twinge to right or left iiii) changing the path of power (90 degree) in some of vehicles.

In this research differential of MF-285 tractor, that is one of high production tractors in Iran, was used as case study for condition monitoring of differential. Also acoustic signals were used for

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fault detection. Gathered signals transferred from time domain to frequency domain by fast fourier transfer. After that statistical feature were extracted from signals. Extracted feature were used as entrances to classification of artificial neural network.

EXPERIMENTAL SETUP

For this work, at first a test bed was built to mount the differential and electromotor on it. The 2KW electromotor was used to drive power to the differential using a coupling power transmission. The input shaft of differential was drove by the electromotor in 1000RPM and its speed was controlled by an inverter. The experiment setup is shown in figure1.

Six classes were classified in this work, namely, healthy differential, tooth worn face of cranwheel gears, tooth worn face of pinion gear, tooth broken of cranwheel gear, tooth broken of pinion gear and worn bearing, That each class considers a type of fault as a most common fault of differential.

Then the Acoustic signals were collected by an microphone that set vertically on the surface of differential. Also the Easy-viber was used as data acquisition with sampling rate of 8192 Hz (Figure 2).

Figure 1: Provided Set for Data Acquisition.

Figure 2: Data Acquisition and Microphone Set.

SIGNAL PROCESSING AND FEATURE EXTRACTION

In recent articles, advanced non-parametric approaches have been considered for signal processing such as wavelets, Fast Fourier Transform (FFT), short time Fourier transform (STFT) (Yang and Makis, 2010; Omid, 2011). Most noise and vibration-acoustic analysis instruments utilize a Fast Fourier Transform (FFT) which is a special case of the generalized Discrete Fourier Transform. It converts the vibration and acoustic signals from time domain representation to its equivalent frequency domain representation. In this study FFT signal processing technique was employed to transfer the acoustic signals from time domain to frequency domain. Figure 3 shows the time signal and Figure 4 shows the FFT signal of one sample of each class that was studied in this research.

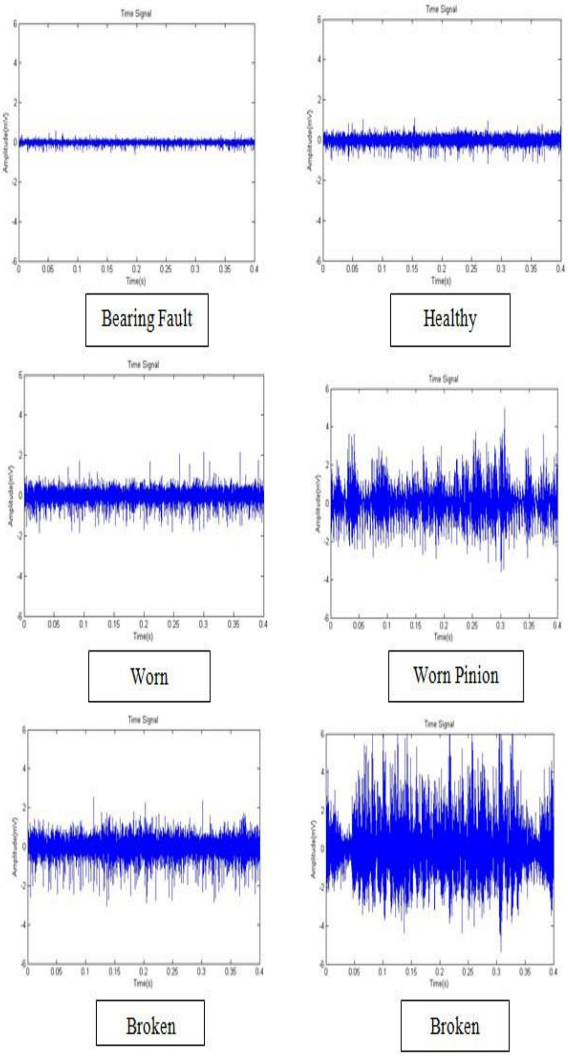

Figure 3: Signals of differential in time domain.

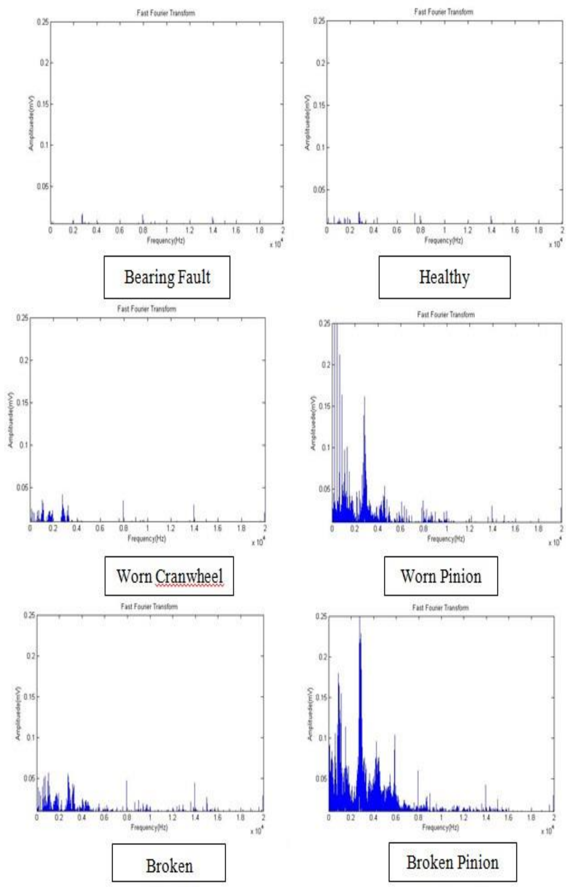

Figure 4: Signals of differential in frequency domain.

Every signal was analyzed with FFT signal processor by MATLAB software and after 29 statistical parameters of frequency domain signals was extracted such as average, maximum, minimum, range, standard deviation and etc. Between 29 extracted features only 6 features selected as superior features by IDE (Improved Distance Evaluation) technique, so set of data decrease about 80%. The selected features were employed to feed the SVM (Support Vector Machine) classifier for fault detection and classification (Vapnik, 1995; Chiang *et al.*, 2004). Support vector machine (SVM) has become an increasingly popular technique for machine learning activities including classification, regression, and outlier detection. Detailed reviews on SVM are available elsewhere (Jordaan, 2002; Fletcher, 1987). The idea of using SVM for separating two classes is to find support vectors (i.e. representative training data points) to define the bounding planes, in which the margin between the both planes is maximized.

SIMULATION RESULTS

In present research six classes was defined for classification. And 342 samples were gathered that divided in 3 parts: i) 250 samples for training SVM classifier ii) 30 samples for validation SVM classifier iii) 62 samples for testing SVM classifier.
The performance of SVM for training and test data was 96.66% and 95.16%, respectively. This accuracy shows the ability and quality of presented system for fault diagnosis and classification of differential.

CONCLUSIONS

This paper considers an intelligent system for fault detection and classification of MF285 tractor`s differential, based on acoustic signals, FFT signal processor and SVM classifier. The accuracy of train and test data was 96.66% and 95.16% that great than 85% so acceptable. The results show that the SVM is appropriate classifier for differential fault diagnosis. Also the results showed the ability of this procedure in differential condition monitoring.

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