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Mems Based Motor Fault Detection in Windmill Using Neural Networks

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ABSTRACT- Today wind turbine technology is one of the fastest growing power generation technologies operating in large numbers at harsh and difficult environment sites and it is difficult to monitor each and every windmill separately. There are times when faults occur in motors of windmills are not detected in earlier stage and we come to know about damage when motor gets fully damaged. Here we using wireless monitoring based on MEMS accelerometer sensor which senses the vibrations occurring in the motor and based on the severity of vibrations, sensor sends the data to the controlling unit to take further action. Neural network based work is included to get the accurate and precise vibratory signals to detect fault at a very early stage to avoid full damage to the motor.
Keywords- *Accelerometer, MEMS, Neural network.*

I. I.INTRODUCTION

Condition monitoring and fault diagnosis of induction motors are of great importance in production lines. It can significantly reduce the cost of maintenance and the risk of unexpected failures by allowing the early detection of potentially catastrophic faults. In condition based maintenance, one does not schedule maintenance or machine replacement based on previous records or statistical estimates of machine failure. Rather one relies on the information provided by condition monitoring systems assessing the machine's condition. Thus the key for the success of condition based maintenance is having an accurate means of condition assessment and fault diagnosis. On-line condition monitoring uses measurements taken while a machine is in operating condition. There are around 1.2 billion of electric motors used in the United States, which consume about 57% of the generated electric power. Over 70% of the electrical energy used by manufacturing and 90% in process industries are consumed by motor driven systems. Among these motor systems, squirrel-cage induction motors (SCIM) have a dominant percentage because they are robust, easily installed, controlled, and adaptable for many industrial applications. SCIM find applications in pumps, fans, air compressors, and machine Tools, mixers, and conveyor belts, as well as many other industrial applications. Moreover, induction motors may be supplied directly from a constant frequency sinusoidal power supply or by an a.c. variable frequency drive. Thus condition based maintenance is essential for an induction motor. It is estimated that about 38% of the induction motor failures are caused by stator winding faults, 40% by bearing failures, 10% by rotor faults, and 12% by miscellaneous faults. Bearing faults and stator winding faults contribute a major portion to the induction motor failures. Though rotor faults appear less significant than bearing faults, most of the bearing failures are caused by shaft misalignment, rotor eccentricity, and other rotor related faults. Besides, rotor faults can also result in excess heat, decreased efficiency, reduces insulation life, and iron core damage. So detection of mechanical and electrical faults are equally important in any electrical motor.

II. II.EXISTING SYSTEM

The existing system is based on acoustic emission sensor (Hall Effect sensor).

1-Acoustic emission (AE)

Acoustic emission (AE) is the sound waves produced when a material undergoes stress (internal change), as a result of an external force. AE is a phenomenon occurring in for instance mechanical loading generating sources of elastic waves. This occurrence is the result of a small surface displacement of a material produced due to stress waves generated when the energy in a material or on its surface is released rapidly. The wave generated by the source is of practical interest in methods used to stimulate and capture AE in a controlled fashion, for study and/or use in inspection, quality control, system feedback, process monitoring and others. AE is commonly defined as transient elastic waves within a material, caused by the release of localized stress energy. Hence, an event source is the phenomenon which releases elastic energy into the material, which then propagates as an elastic wave. Acoustic emissions can be detected in frequency ranges under 1 kHz, and have been reported at frequencies up to 100 MHz, but most released energy within 1 kHz to 1 MHz. Rapid stress releasing events generate a spectrum of stress waves starting at 0 Hz, and typically falling off at several MHz .

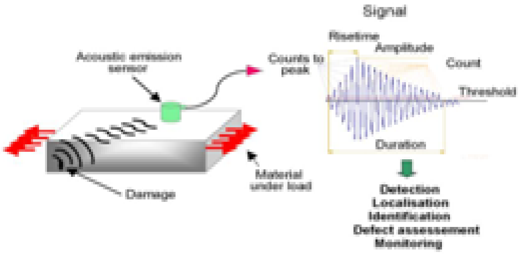

Fig:1 AE sensor working

Acoustic emission (AE) sensors have been used to characterize wear in machine tools, and monitor bearing and gear problems in centrifugal pumps. First developed as a Non- Destructive Testing (NDT) technique to detect cracks in civil structures, these sensors detect acoustic emissions generated by the release of vibration waves in a crystalline lattice due to plastic deformation or crack growth. Measurements are made using piezoelectric transducers with high natural frequencies, 100 kHz to 1 MHz, to capture the ultrasonic AE emissions. An AE sensor is useful as it has the ability to detect subsurface cracks in gear teeth or bearings before appearing on the surface causing further damage. More recently MEMS acoustic sensors have been developed, and one design includes multiple transducers on a single substrate, which each detect acoustic emission energy at different frequencies. This helps distinguish spurious acoustic emissions arising from impact and friction, from those arising from plastic deformation. When compared to typical piezoelectric sensors, the MEMS devices have lower sensitivities and fail to detect some acoustic emissions. In addition, the acoustic emission signal suffers severe attenuation as is crosses various interfaces, such as a gearbox or bearing casings. In one experiment consisting of a pinion gear and an associated bearing, a 44dB attenuation was seen between an AE sensor placed directly on the pinion to one placed on the bearing casing,and in some cases, intermediate loss of the signal was observed.

III. PROPOSED SYSTEM

Wireless communicators were deployed on the turbines to provide a stable and trouble free communication network. The units were installed on the turbines. All the above problems were brushed away by the wireless solution. The maintenance team could now concentrate on maximizing power generation rather than waste time on maintaining the network. In the proposed method, vibration signals are obtained using piezo-electric sensor and motor current signature analysis is performed using Hall Effect sensor. The features of the signal are analyzed using wavelet packet transform. Besides other signal processing techniques, wavelet packet transform is preferred because it has certain advantages. Traditional signal processing techniques like Fourier transform can perform only on stationary signals. Since it is not well suited for non-stationary signals Short time Fourier transform (STFT) is used. STFT uses a constant window function as a base to obtain the frequency spectrum coefficients. The size of the window function cannot be changed which led to the need for wavelet transform. Wavelet transform uses a varying size window function as its base. In wavelet transform low frequency signals are decomposed repeatedly to obtain low frequency information. In wavelet transform the information about high frequency signals are limited. In the proposed method, wavelet packet transform decomposes both low frequency and high frequency information. It can analyze both stationary and non-stationary signals. There are many classifier models to effectively classify the faulty data from the healthy one. They are:

- Analytical model-based methods,
- Artificial Intelligence-based methods.

Analytical model based methods are efficient monitoring systems for providing warning and predicting certain faults in their early stages. Artificial Intelligence based methods are of two categories: Knowledge based models and Data based models. When considering fault diagnostics of induction motor it is difficult to develop an analytical model that describes the performance of a motor under all its operation points. It is difficult for a human expert to distinguish faults from the healthy operation. Though analytical based methods and knowledge based methods are effective classification methods, their performance in induction motors is not good. Moreover conventional methods cannot be applied effectively for vibration signal diagnosis due to their lack of adaptability and the random nature of vibration signal. In such a situation, data based models are used to classify faults in induction motors. Some of the popular data based models are neural networks, fuzzy systems and Support vector machine. Neural networks and fuzzy logic are widely used in the field of fault diagnostics. Fuzzy logic provides a systematic framework to process vague and qualitative knowledge. Using fuzzy logic it is possible to classify a fault in terms of its degree of severity. Artificial neural network are modeled with artificial neurons. Each artificial neuron accepts several inputs, applies preset weights to each input and generates a non-linear output based on the result. The neurons are connected in layers between the inputs and outputs. Support Vector Machine, a novel machine learning technique is used in this paper. It is based on statistical learning theory, and is introduced during the early 90's. SVM is opted in this paper since it is shown to have better generalization properties than traditional classifiers. Efficiency of SVM does not depend on the number of features of classified entities. Property is very useful in fault diagnostics, because the number of features to be chosen to be the base of fault classification is thus not limited. Industrial Motor's condition monitoring systems collect data from the main components such as the generator, the gearbox, the main bearing, and the shaft. The purpose of this data gathering is to minimize downtime and maintenance costs while increasing energy availability and the lifetime service of wind turbine components. An ideal condition monitoring system would monitor all the components using a minimum number of sensors. There have been a few literature reviews on Industrial Motor's condition monitoring. This chapter aims to review the most recent advances in condition monitoring and fault diagnostic techniques with a focus on wind turbines and their subsystems related to mechanical fault. This section summarizes the monitoring and diagnostic methods for the major subsystems in Industrial Motor's such as gearbox, bearing, and generator which are the primary focus of this study.

1- Gearbox and Bearing

Gearbox fault is widely acknowledged as the leading issue for wind turbine drive train condition monitoring among all subsystems. Gear tooth damage and bearing faults are both common in the Industrial Motor's. Bearing failure is the leading factor in turbine gearbox problems. In particular, it was pointed out that the gearbox bearings tend to fail in different rates. Among all bearings in a planetary gearbox, the planet bearings, the intermediate shaft-locating bearings, and the high speed locating bearings tend to fail at the fastest rate, while the planet carrier bearings, hollow shaft bearings, and non-locating bearings are least likely to fail. This study indicates that more detailed stress analysis of the gearbox is needed in order to achieve a better understanding of the failure mechanism and load distribution which would lead to improvement of drive train design and sensor allocation. Vibration measurement and spectrum analysis are typical choices for gearbox monitoring and diagnostics. For instance a neural network based diagnostic framework for gearboxes is developed. The relatively slow speed of the wind turbine sets a limitation in early fault diagnosis using the vibration monitoring method. Therefore, acoustic emission (AE) sensing, which detects the surface stress waves generated by the rubbing action of failed components, has recently been considered a suitable enhancement to the classic vibration based methods for multisensory monitoring scheme for gearbox diagnosis, especially for early detection of pitting, cracking, or other potential faults. A study is done using AE in parallel with vibration, temperature, and rotating speed data for health monitoring. It was shown that monitored periodic statistics of AE data can be used as an indicator of damage presence and damage severity in Industrial Motor's. A setup on finite element (FE) simulation study of stress wave based diagnosis for the rolling element bearing of the wind turbine gearbox. It is noteworthy that FE analysis is a good complementary tool to the experimental based study, with which the physical insight of various levels of faults can be investigated. Notice that AE measurement features very high frequencies compared to other methods, so the cost of data acquisition systems with high sampling rates needs to be considered. Besides, it is noise-rich information from AE measurement. Advanced algorithms are needed to extract useful information. For mechanical faults of the drive train, the electrical analysis was investigated. Diagnosis of gear eccentricity was studied using current and power signals. It is noteworthy that the data were obtained from a wind turbine emulator, incorporating the properties of both natural wind and the turbine rotor aerodynamic behavior. Although the level of turbulence simulated was not described, the demonstrated performance was still promising for practical applications. Torque measurement has also been utilized for drive train fault detection. The rotor faults may cause either a torsional oscillation or a shift in the torque-speed ratio. Also, shaft torque has a potential to be used as an indicator for decoupling the fault-like perturbations due to higher load. However, inline torque sensors are usually expensive and difficult to install. Therefore, using torque measurement for drive train fault diagnosis and condition monitoring is still not practically feasible.

2-Generators

The Industrial generators are also subject to failures in bearing, stator, and rotor among others components. For induction machines, about 40% of failures are related to bearings, 38% to the stator, and 10% to the rotor. The major faults in induction machine stators and rotors include inter-turn faults in the opening or shorting of one or more circuits of a stator or rotor winding, abnormal connection of the stator winding, dynamic eccentricity, broken rotor bars of cracked end-rings for cage rotor, static and/or dynamic air-gap eccentricities, among others. Faults in induction machines may produce some of the following phenomena: unbalances and harmonics in the air-gap flux and phase currents, increased torque oscillation, decreased average torque, increased losses and reduction in efficiency, and excessive heating in the winding.

3- Machine Vibration Analysis

Vibration analysis is a proven and effective technology being used in condition monitoring. For the measurement of vibration, different vibration transducers are applied, according to the frequency range. Vibration measurement is commonly done in the gearbox, turbines, bearings, and shaft. For wind turbine application, the measurement is usually done at critical locations where the load condition is at maximum, for example, wheels and bearings of the gearbox, the main shaft of turbine, and bearings of the generator. Different types of sensors are employed for the measurement of vibration: acceleration sensors, velocity sensors, and displacement sensors. Different vibration frequencies in a rotation machine are directly correlated to the structure, geometry, and speed of the machine. By determining the relation between types of defects and their characteristic frequencies, the causality of problems can be determined, and the remaining useful life of components can be estimated. The history of the equipment, its failure statistic, vibration trend, and degradation pattern are of vital importance in determining the health of the system and its future operating condition. Using vibration analysis, the presence of a failure, or even an upcoming failure, can be detected because of the increase or modification in vibrations of industrial equipment. Since an analysis of vibrations is a powerful tool for the diagnosis of equipment, a number of different techniques have been developed. There are methods that only distinguish failures at a final state of evolution and there are others, more complex, that identify defects at an early phase of development.

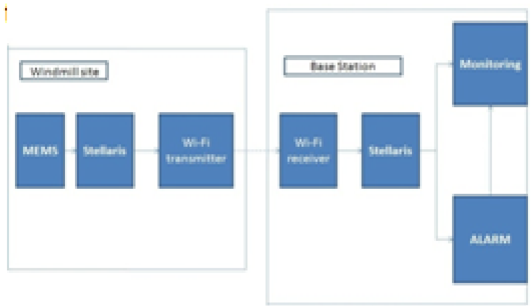

Fig: **Block diagram**

4- Review

To achieve an accurate and reliable condition monitoring system for wind turbines, it is necessary to select measurable parameters as well as to choose suitable signal processing methods. In some examples, electrical sensors installed around the generator are highly recommended as they are non-invasive and easy to implement compared to the mechanical ones. In wind turbines, because of the noisy environment due to the presence of power electronics converters, signal to noise ratio of measured signals is low and the usage of electrical parameters are often more problematic than in a lab environment. Inaccurate signal analysis leads to various false alarms which makes fault detection unreliable. To overcome this drawback, several approaches have been proposed by introducing the vibration measurement and using vibrations as an index for detecting mechanical fault in the system. However, those methods have been applied mostly for drive train failure, bearing faults, and gear tooth damage by using acoustic emission (AE) techniques for detection. Therefore, to enhance the effectiveness and thorough of condition-based predictive maintenance, dissertation proposes a vibration based monitoring system for rotor imbalance conditions. This study presents an excellent health monitoring for Industrial Motor's systems to detect the severity level of mechanical fault conditions. Moreover, a new 3 axis sensor is proposed to monitor the wind turbine output during imbalance conditions.

IV. CONCLUSION

One of the most serious problems in Industrial Motor's is the possibility of mechanical failure, especially for rotating parts of gears and generators. Therefore, a machine health monitoring system is a very important tool in Industrial Motor's. Moreover, wireless sensor technologies make it possible to measure and control the vibrations of the machine during operation. The methods of mechanical fault detection through vibration analysis have been analyzed and assessed based on their ability to detect machine abnormalities. By using an MEMS accelerometer which is low cost, light in weight, compact in size and low in power consumption, a vibration detection method is proposed in this dissertation. Machine vibration analysis in time and frequency domain has been analyzed and a severity detection technique is also established. These are the essential components for an advance health monitoring system. The implementation of mechanical fault monitoring system can be used to estimate the range of severity levels, which makes it possible to detect the abnormalities before failure. It is very useful part of the condition based predictive maintenance. This control technique works well both under the normal and disturbance operation. This enhancement of the vibration suppression capabilities opens up the possibility of improving the performance of the windmill. This will greatly improve the power quality and reduce the downtime when there is wear and tear on the mechanical components, such as shaft, gear box, and rotating parts.

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