ISSN(Online): 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

Fault Detection in Electric Motors Using Vibration Analysis and DSP Processor

Prof. P. C. Latane[1], Punit C. Urolgin[2]

Dept. of Electronics & Telecommunication, Sinhgad Institute of Technology, Lonavala, Savitribai Phule Pune University Pune, India[1]

Dept. of Electronics & Telecommunication, Sinhgad Institute of Technology, Lonavala, Savitribai Phule Pune University Pune, India[2]

ABSTRACT: Electric Motors are used worldwide as the "workhorse "in industrial applications. Although, these electromechanical devices are highly reliable, susceptible to many types of faults. However, the motor can be suffered with undesirable environments, wrong application and overload uses during operation. Hence it may lead the motor to early-stage failure or increase to server problems until the motor's breakdown which it is an important issue to stop all the mechanism processes of line production. In production lines, conditioning monitoring and fault detection of these type of motors has great importance. It can significantly reduce the cost of maintenance and the risk of unexpected failures by allowing the early detection of potentially catastrophic faults.In the proposed work, DSP-based measurement system dedicated to the vibration analysis on rotating machines is designed and realized. Vibration signals are sensed by the piezoelectric sensor and processed to obtain a continuous monitoring of motor status. The method is based on frequency of vibration analysis for detection of faults in motors.

KEYWORDS: Fault Detection, Signal processing, DSP processor, Vibration analysis, Electric motors, Piezoelectric sensor.

I. INTRODUCTION

Electric Motors are widely used devices in industrial applications. It is also known as 'workhorse' in many industries worldwide. Many electric motors such as Induction motors are critical components in many industry based applications. Their reliability is high and also they are very robust machines. However, they lead to different types of faults. Such a failure of electric motors can cause many effects such as plant shut down, raw material wastage, personal injuries and damage. However, such types of faults can be detected in order to prevent the overall failure of machine and unexpected production costs. The basic reason behind the faults is stresses occurred in mechanical and electrical devices. In mechanical devices faults occurs due to changes in loads, overloads which may cause damage to bearing of motors and breakage of rotor bar. In electrical devices faults occurs due to stator winding failure i.e short circuit. It may cause damage to complete motor.Different types of faults which may occur in an electric motors can be classified as follows.

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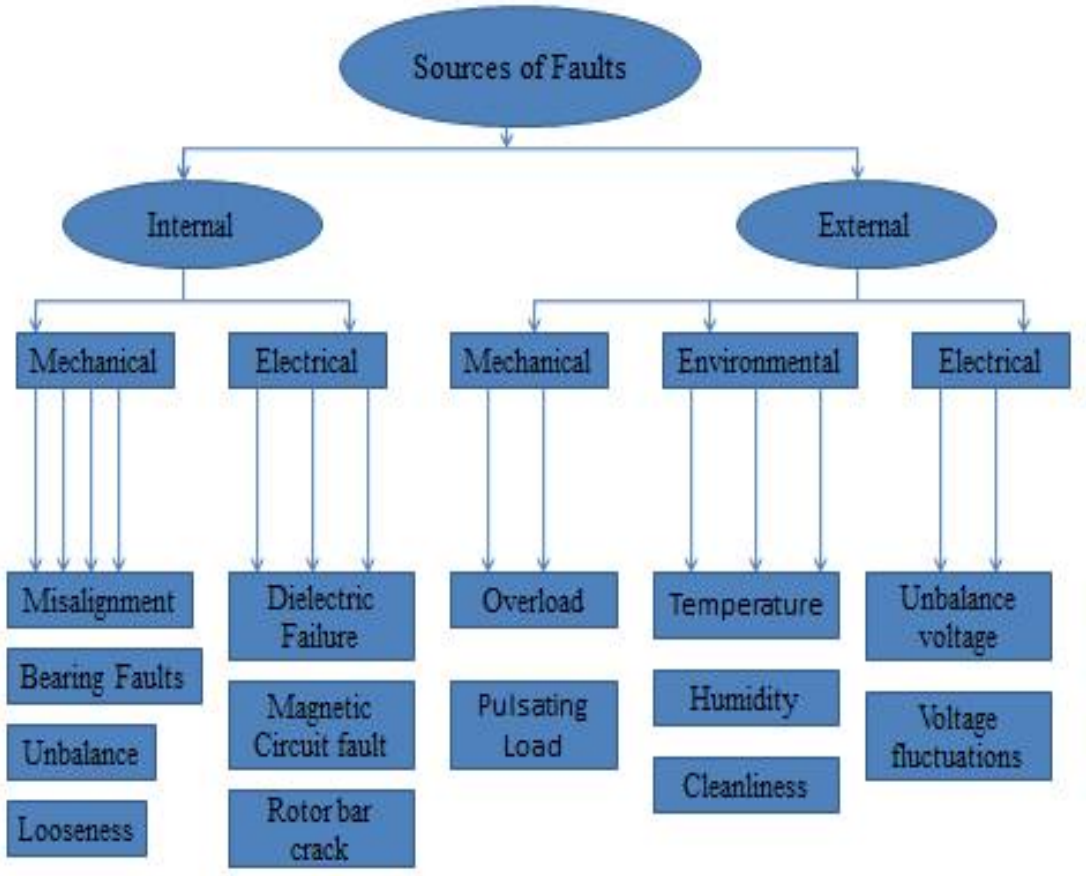

Figure No 01: Types of Fault

Most frequently occurring faults in electric motor are bearing faults (41%) and according to research study followed by stator (37%) and rotor faults (10%).Some researchers have studied and surveyed that 30-40 % faults occurred in the stator or armature faults which is caused due to the shorting of stator phase winding and 5-10% faults occurred in the rotor broken bar and end ring fault. So there is necessity of online conditioning monitoring of motor. This is an important technique used to check health of motor during its operation at early stage. This will result in safety of overall system performance and maintenance. Signal processing is one of the effective procedure and technique used to monitor the motor condition. For this we require DSP processor to analyze, monitor and work according to signal obtained.In the field of rotating machines i.e. motor monitoring analysis of vibration is very effective. In fact, each motor defect produces vibrations with distinctive characteristics that can be measured and compared with reference ones in order to perform the fault detection and diagnosis. Both time domain and frequency domain methods can be used to analyze vibration signals. In the proposed work piezoelectric sensor is placed on the electric motor. It will measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. Faults generated in the electric motors by taking vibration analysis into consideration are sensed by the piezoelectric sensor placed on the motor. The signals generated by the sensor are given to the DSP processor for analyzing and monitoring purpose. DSP is also used for frequency and time domain analysis. The common faults generated are Unbalance, Misalignment, Looseness, Outer ball bearing and gear faults.

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II. METHODOLOGY

A. THEORY BEHIND VIBRATION ANALYSIS

Vibration of electric motors will give some frequency of that machine which will be pre stored in processor. Defects frequency depends on kinematics considerations of particular devices. This frequency can be calculated using geometrical analysis and its rotational speed. Usually, such frequencies lie in low-frequency range (Less than 500 Hz). When certain defect is occurred then there is increase in vibration levels at this frequency can be noticed and so the frequency domain analysis of vibration reading is usually carried out to determine the motor conditions.

B. ARCHITECTURE OF FAULT DETECTION SYSTEM

First step of vibrations measurement of any motor fault is to collect the signals. The sensing element for collecting the signals will be piezoelectric sensor. The sensor gives a frequency of signal that corresponds to the level of vibration. The analog signals given by the sensor are then collected by the Data Acquisition system. The analyzing interface (computer software) is used to perform and use the analysis methods.

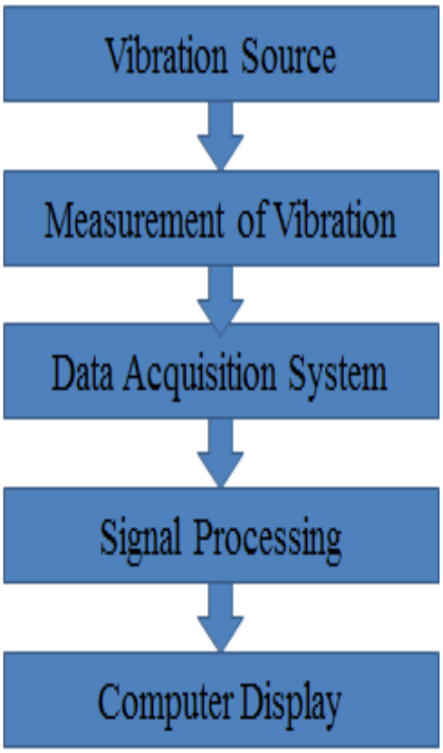

Fig No 02 Architecture of the System

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III.VIBRATION MEASUREMENT

There are many types of vibration measurement techniques such as machine vibration, accelerometers, transducers, including proximity probes etc. The measurement using piezoelectric sensor is most commonly used technique in vibration analysis of any rotating machine. This is achieved by mounting a piezoelectric sensor externally on the electric motor. Piezoelectric sensors are less sensitive to temperature which is important since most machinery fault results in temperature increase. They have been found to be the most reliable, versatile and accurate vibration sensor available.

C. SIGNAL PROCESSING TECHNIQUES IN VIBRATION ANALYSIS

Many signal processing techniques are available for all kinds of rotating machine faults. In the proposed work DSP processor is used. Frequency analysis of vibration of motor elements is fundamental approach in this related work. For fault detection such type of frequency analysis is very useful.

IV. SYSTEM MODEL AND PROPOSED WORK

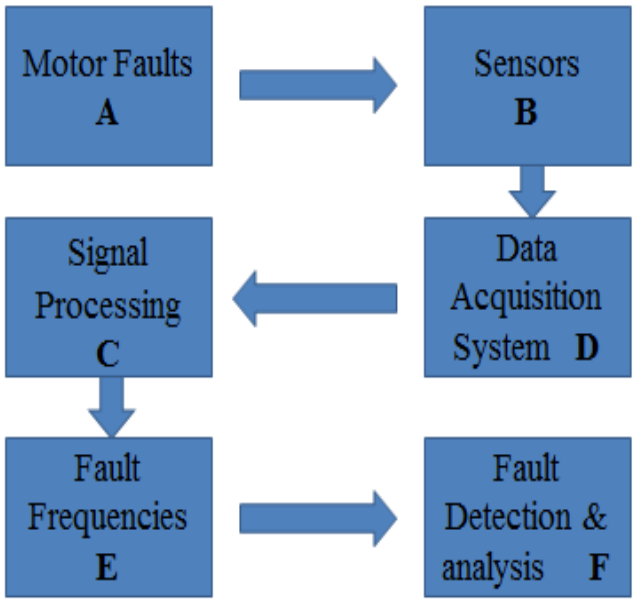

Figure 3: Proposed Model

1. Very first the system will work according to the vibration occurred. So according to vibration analysis the motor faults generated are sensed by the piezoelectric sensor at stage B.
2. In the next stage the frequency signals generated by the sensor are given to the data acquisition system which will record the signals according to the faults generated.
3. At stage C signal processing techniques are used by which it will help the system to detect that which type of frequency has generated which type of fault.

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4. After extracting the different types of frequencies, in the next stage we get the frequencies of different faults by analyzing the sensor signal.
5. In the next stage detection of that faults and analysis is done using pre-stored data technique.
6. At last the frequencies of faults are displayed and it will show which type of fault frequency has generated.

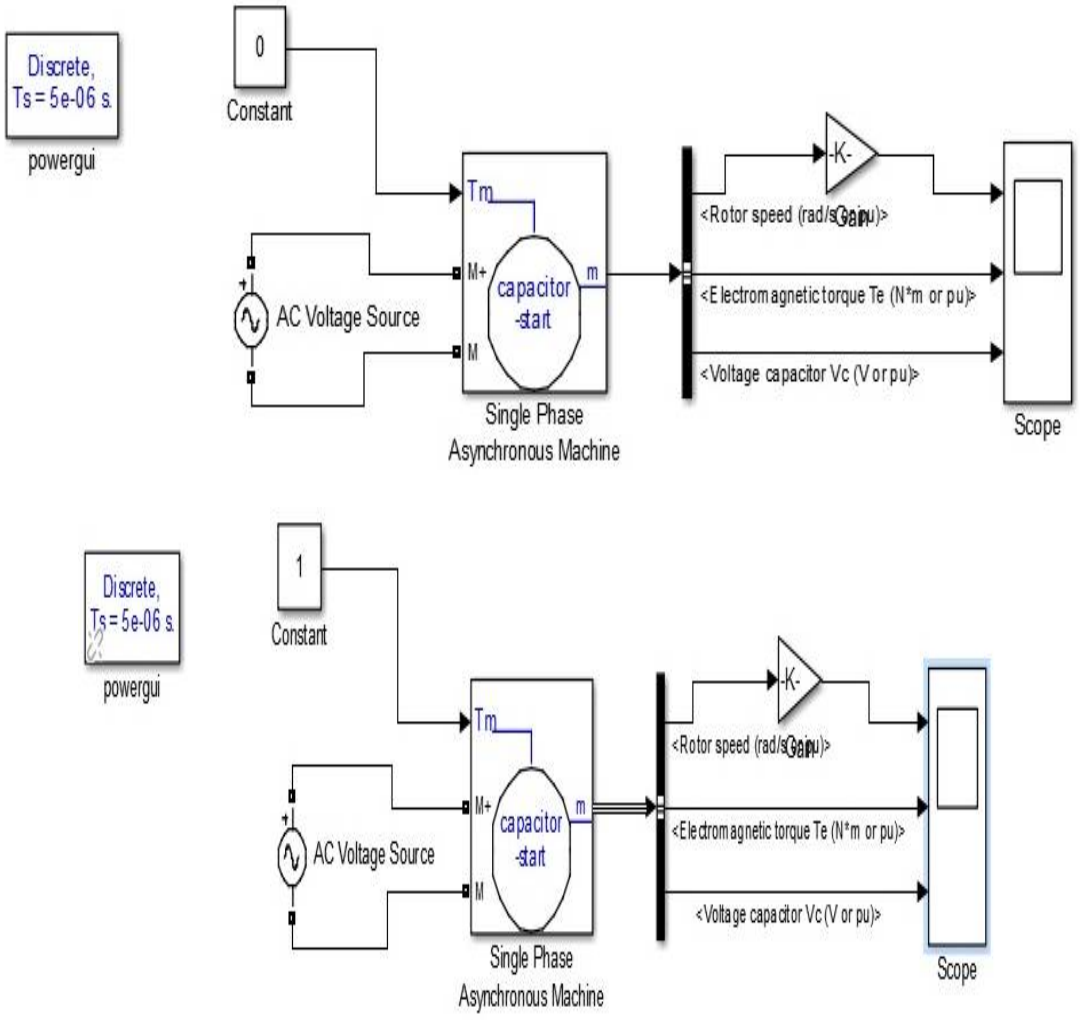
V. RESULTS

From vibration analysis some of the common faults related with the motor will generate due to some of the following parameters.

1. Rotor Speed (rad/sec)
2. Electromagnetic Torque (N*m or pu)
3. Voltage Capacitor or Vc (V or pu)

MATLAB simulation has been carried out to see what happens when these following three parameters related to motor are varied. By taking into consideration above parameters we can see changes that will take place due to vibration of motor.

MATLAB SIMULINK MODEL



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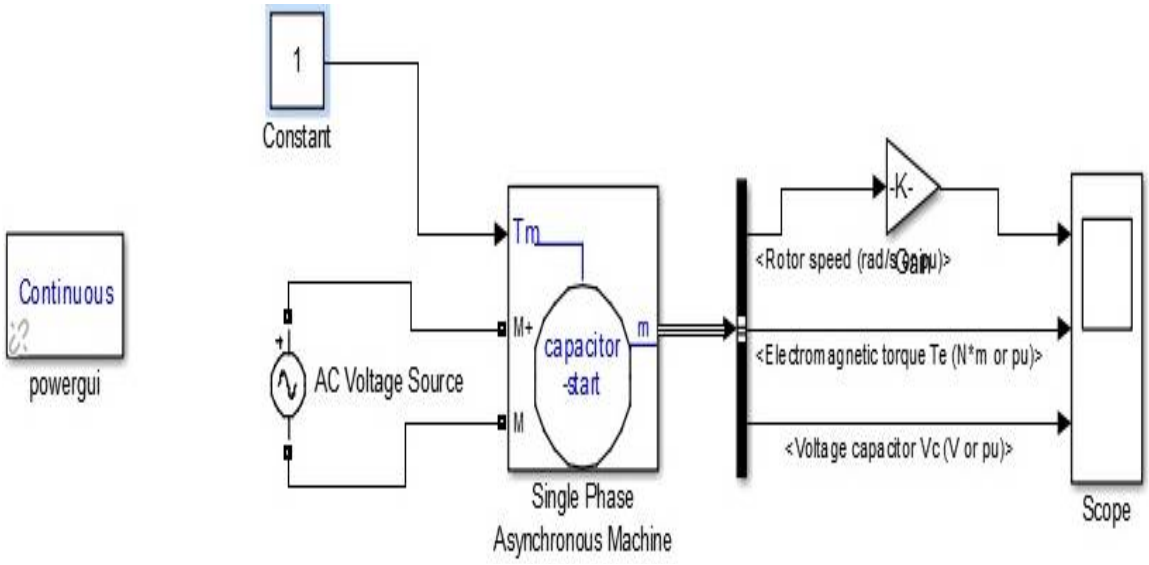
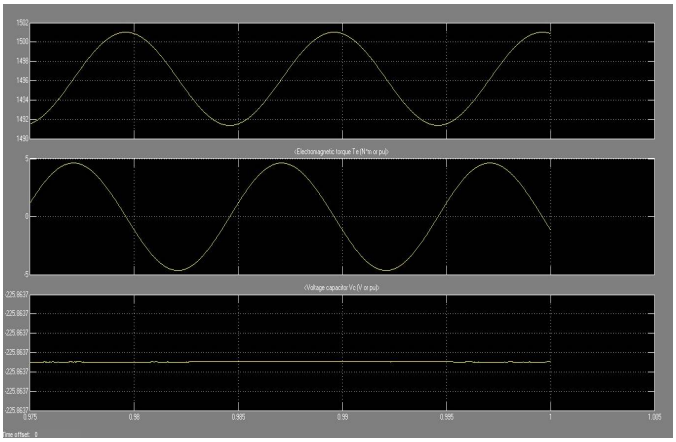
Discrete Powergui with constant 0 and 1 respectively. Constant 0 indicates that motor is in OFF condition and Constant 1 indicates that motor is in ON condition.



Continuous Powergui with motor in ON condition i.e. constant 1.

Following are the simulation results of all above three models shown.



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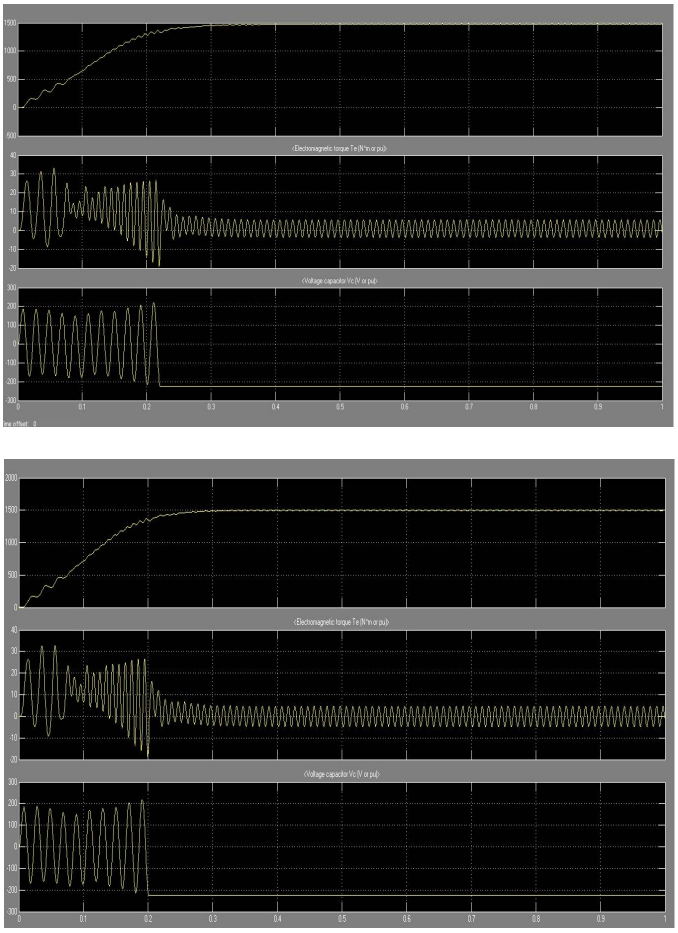

Above results shows three windows respectively with rotor speed , Electromagnetic torque and Voltage capacitor.

VI. CONCLUSIONS ANDFUTUREWORK

The overall system is designed mainly for security purpose. Security of different types of rotating machines is necessary to avoid big problems in Industries and companies. Such a system is designed considering some of the important faults usually generated in motors. Using vibration analysis technique it is very sensitive to monitor and detect the faults in motors. The main aim of this work is to create the field of continuous conditioning monitoring and fault diagnosis in Electric motors operating in variety of operating conditions. For large size motors we require additional work to perform as there is necessity of different signal processing tools to be applied. For such motors, new challenges can be put using current based fault detection. Current monitoring for detection of fault may give additional extra security regarding the motors. This will add a new challenge for future related work.

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