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Condition Monitoring of 3-Φ A.C Induction Motor Using PLC

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Abstract: ***This paper provides about the condition monitoring (CM) techniques for the 3-ϕ induction motor in a precise manner and while selecting proper condition monitoring techniques for specific application this will be useful. CM (Condition Monitoring) is a process of monitoring the operating parameters of machine to know the monitored characteristics and to predict machine health. In industries protection of devices such as motor has become challenging work. Further in this paper, various condition monitoring techniques are given with the specific advantages and disadvantages. For the condition monitoring of alternating motor, the economical and latest method is analyzing the stator current through LabVIEW. An intelligent diagnostic condition monitoring system has been proposed. This system will provide continuous real time tracking of different faults occurring in the system and for automatic decision making estimates the severity of faults.***

Keywords: Automation, Condition Monitoring, 3-ϕ Induction Motor, Programmable Logic Controller, LabVIEW.

1. Introduction

Condition monitoring is a maintenance process for forecasting the requirement of maintenance before any failure occurs, for monitoring the parameters like vibration in the magnetic field, overheating, over current of equipment and for predicting the machine health. Before condition monitoring technique, TBM (time based maintenance) was the technique used for preventive maintenance. In time based maintenance method, maintenance of the equipment was performed on predefined running hours without knowing the any information of current conditions of machine, due to which there is waste of man power, time and money. As maintenance was done offline so it causes many unnecessary shutdowns.

1.1 Induction motors

Electrical machines are extensively used and core of most engineering system. These machines have been used in all kinds of industries. An induction machine is defined as an asynchronous machine that comprises a magnetic circuit which interlinks with two electric circuits, rotating with respect to each other in which power is transferred from one circuit to the other by electromagnetic induction. The rotor winding of induction motor s can be squirrel -cage or wound-rotor type. The squirrel-cage induction motors are preferred because they are cheap, rugged, have no commutators, and are suitable for high-speed applications and is widely used in both low performance and high performance drive applications because of its roughness and versatility.

Electric machines are frequently exposed to non-ideal or even detrimental operating environments. These circumstances include overload, insufficient lubrication, frequent motor starts/stops, inadequate cooling etc. under these conditions; electric motors are subjected to undesirable stresses, which put the motorsunder risk of faults or failures. A 1985 statistical study by the Electric Power Research Institute (EPRI) provides similar results, i.e., bearing (41%), stator (37%), rotor (10%) and other (12%).

1.2 Need for condition monitoring

Condition monitoring is defined as the continuous evaluation of the health of the plant and equipment throughout its service life. It is important to be able to defect faults while they are still developing. This is called incipient failure detection. The incipient detection of motor failures also provides a safe operating environment. It is becoming increasingly important to use comprehensive condition monitoring schemes for continuous assessment of the electrical condition of electrical machines. By using the condition monitoring, it is possible to provide adequate warning of imminent failure. In addition, it is also possible to schedule future preventive maintenance and repair work.

2. Methodology

2.1Existing condition monitoring techniques

Condition monitoring has great significance in the business environment due to following reasons:

- To reduce the cost of maintenance
- To predict the equipment failure
- To improve equipment and component reliability
- To optimize the equipment performance
- To improve the accuracy in failure prediction.

Several methods have evolved over time but the most prominent techniques are thermal monitoring, vibration monitoring, and electrical monitoring, noise monitoring, torque monitoring and flux monitoring.

2.2Proposed method

Electrical monitoring involves Current Park’s vector, zero-sequence and negative-sequence current monitoring, and current signature analysis. This method uses stator current to detect various kind of machine faults. In most applications, the stator current of an induction motor is readily available since it is used to protect machines from destructive over-currents, ground current, etc. Therefore, current monitoring is a sensor-less detection method that can be implemented without any extra hardware.

For a condition monitoring of electric motors, current monitoring technique implementation is not so complex. In all industries, for the measurement of current for control and display purpose CT (current transformer) relays are always installed. CT relay and PT (potential transformer) are always part of electric protection measurement of current for control and on system. Therefore, this technique is cost effective and very useful as it requires no sensors for the measurements. So, this technique can provide economic and implementation benefits. Not only the motor faults but overall motor efficiency, performance, speed and torque information can be extracted from the motor current.

3. Different Faults Effect on Motor Stator Current

3.1Rotor Faults Effect

Broken bars problem associated with rotors can be determined through analysis of motor current spectrum. The magnetic field variations are produced due to broken bars. The frequencies induced in motor current due to broken bars are calculated by

$$f_{drb} = f_e \left[M \left(\frac{1-s}{N_p} \right) \pm s \right]$$

Where,

f_e, is the supply frequency

f_{drb} , is the rotor defect frequency

N_p , is the number of poles

S, is the slip

3.2 Bearing Faults Effect

Misalignment and improper installation of bearings on rotor shaft causes failure of bearing. Due to failure of bearings, there is radial movement between rotor and stator of motor, in turn irregularities are produced in magnetic field and thusfrequency spectrum of stator current is varied due to variations of flux. The frequency of stator current is calculated by

$$f_{es} = \left| f_e \pm M f_{if,of} \right|$$

where:

f_{if} , is the bearing inner race defect frequency

f_{of} , is the bearing outer race defect frequency

3.3 Eccentricity Faults Effect

Eccentricity fault are produced whenever rotor moves in radial direction with respect to stator. In fundamental frequency of current these faults add certain frequency bands. With the help of below equation eccentricity fault frequency can be determined

$$f_{ece} = f_e \left[1 \pm M \left(\frac{1-s}{N_p} \right) \right]$$

Where,

M= 1, 2, 3……

4. LabView Analysis

The acronym for LabVIEW is Laboratory Virtual Instrumentation Engineering Workbench. And it is used in the form of graphical representation for producing flexible and measurable designs, controlling and testing applications with less amount of cost. By using LabVIEW one can interact with the signals of the real world in order to analyse the data for more information which is meaningful, and the result or output can be seen by using web, report and display. Irrespective of experience in programming the user can work easily and fast with lab view.

In Lab VIEW we use G programming where G indicates graphical. And it can also be called as dataflow programming because in order to execute the designed program it will depend on the block diagram structure. If we compare LabVIEW and text programming, LabVIEW is more flexible and user friendly why because here we can develop the program and can be connected with relevant blocks through wiring.The programs in LabVIEW are named as virtual instruments, or VI, due to their appearance and mode of operation of the instruments like oscilloscope and multi- meters. In LABVIEW we are having loops like for, while loops and case structure, sub blocks i.e. sub VI etc.

Research Objectives

Aim of the research is to develop an economical intelligent diagnostic condition monitoring system which should have the following capabilities:

- Detection of motor faults at initial level and show the motor status via human machine interfacing(HMI)
- If fault exceeds preset value automatically shut –down the motor.

5. Experimental Set Up

The test was conducted on 3-φ,4-pole squirrel cage, delta connected A.C induction motor, a programmable logic controller(Siemens), data acquisition module(NI 6221), dual core computer with software LABVIEW 10.0. The block diagram and experimental set up of intelligent condition monitoring system is shown in fig1.

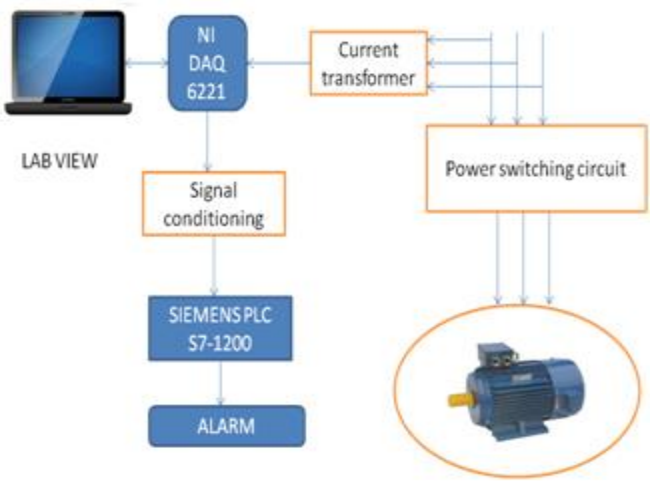

Figure 1: Block diagram of condition monitoring of Induction motor using LabVIEW and PLC

The signal from the motor stator current was acquired through CT(current transformer) and was given to data acquisition module (DAQ). DAQ module converts the analog data to digital data. The code was developed in LABVIEW to give '0'volt at the output of DAQ card in case of healthy motor and '5' volt in case of defected motor. The output of the DAQ card was given to input of programmable logic controller (PLC). The PLC was programmed to generate alarm when the defect occurs in bearing and finally turn off the motor if fault exceeds preset values. LabVIEW diagram of a condition monitoring of induction motor is shown in fig2.

LABVIEW signal processing tool kit was used to obtain the fast Fourier power spectrum. The current spectrum and frequency spectrum of healthy motor and defected motorin LABVIEW is shown in Fig3.By analyzing in frequency domain of both spectrums, the system identifies the largest amplitude peaks to locate the characteristic of defect frequencies.

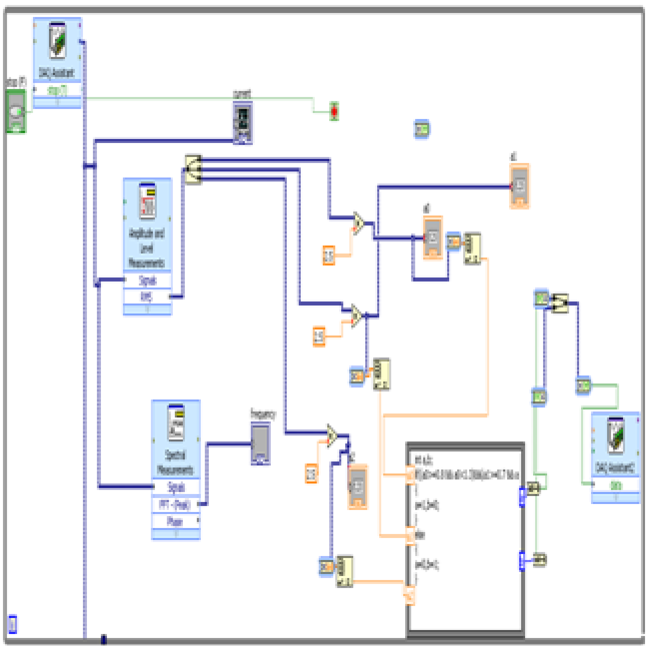

Figure 2: LABVIEW diagram of intelligent diagnostic system.

In this paper PLC is used for activating and deactivating the alarm based on the condition of motor that is whether the motor is healthy or defected. PLC ladder logic diagram is shown below fig (3)

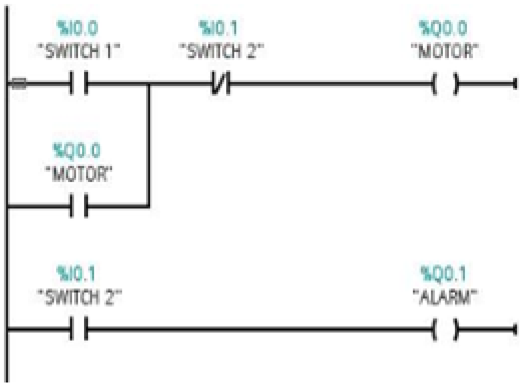

Figure 3: Ladder logic diagram in SIEMENS

6. Results

The current and frequency spectrum waveforms of healthy and defected induction motor are shown in fig3 and fig4.

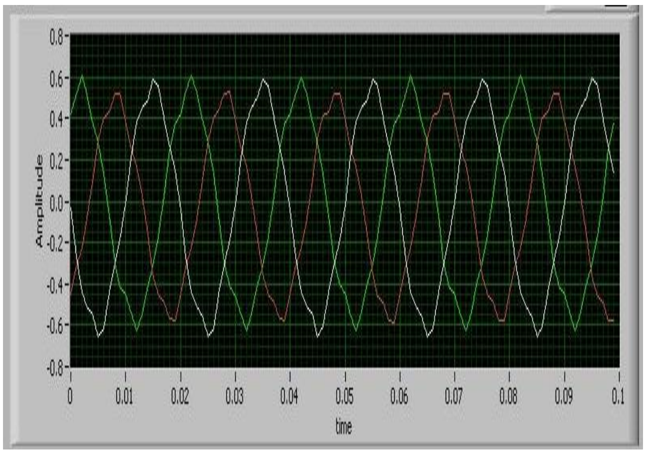

Figure 4: Current spectrum of healthy motor

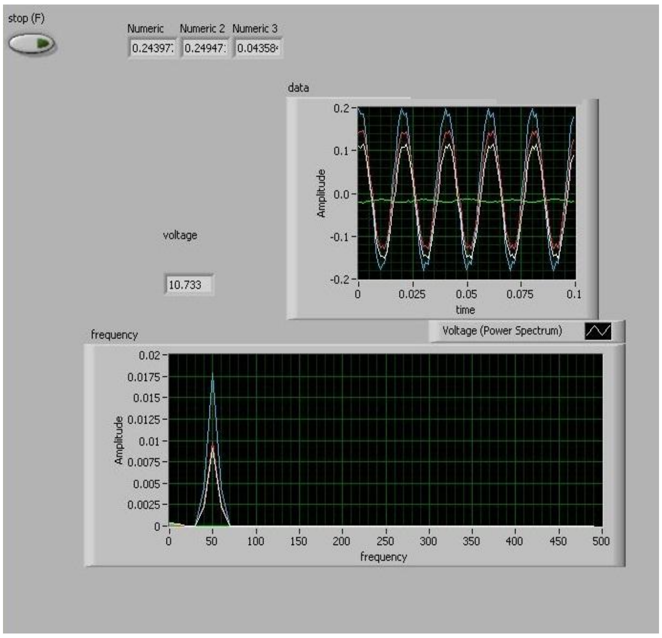

Figure 5: current and frequency spectrum of defected motor

7. Conclusion

In this paper various methods used for condition monitoring of AC motors are compared. Advantages and disadvantages of each technique are presented. Even though the variety of condition monitoring techniques are available but acoustic emission and stator current analysis have proven to be most accurate and suitable techniques. Current analysis technique is however most economical. Also, an intelligent diagnostic CM system for AC motors has been proposed. This technique provides continuous real time tracking of different faults and estimates severity of faults for automatic decision making. It is expected that motor protection system as proposed in this research will be faster, more efficient and user friendly than the other techniques.

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