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Detection of broken rotor bars of Single phase induction motor by wavelet transform along vibration fault detection

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Abstract - *Induction motor has been a huge part of industrial operation. The failure of induction motor due to any electrical or mechanical faults could take a industry in a loss. So protection of induction motor is an important task. Now a days it is done by online monitoring system is used for incipient faults detection. As incipient fault consist of Rotor broken bars. Detection of rotor broken bars has been an important with a minimum time. This paper presents a methodology to detect a broken rotor bars with a most effective method that is wavelet transform. The wavelet transform shows variable window size for all the frequencies. The vibration sensor is used to detect the vibration of motors which has been developed by any kind of fault mostly related to bearing failure.*

Key Words: Induction motor, Wavelet transform, Vibration sensor, Broken rotor bars, vibration fault.

1. INTRODUCTION

Induction motors are widely used as industrial drives because they are rugged, reliable and economical. Induction motor required minimum maintenance. However like other motors, they eventually deteriorate and fail. The major faults of electrical Machines are classified as

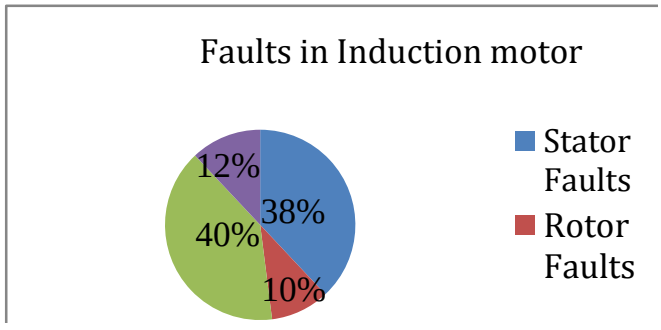

Fig.-1 Classification of faults

The rotor broken bar is an incipient fault. The beginning of this fault is unnoticeable. Therefore online condition monitoring is proposed for fault detection. There are several methods are included in monitoring of rotor bar fault, which involves measurement of vibrations of the machine, Flux in the machine, instantaneous power, instantaneous frequency and current of the machine.

1.1 Rotor Broken Bars

Broken rotor bars hardly ever cause immediate failures, particularly in large multi-pole motors. However, if there are adequate broken rotor bars, the motor may not start as it may not be able to develop enough accelerating torque. The presence of broken rotor bars precipitates decline in other components that can result in time-consuming and costly.

substitution of the rotor core in larger motors is costly; therefore, by detecting broken rotor bars early, such secondary decline can be avoided. The rotor can be repaired at a fraction of the cost of rotor replacement, not to mention averting production revenue losses due to unplanned downtime.

If one of the bar is broken, the healthy bars are affected to carry additional current leading to rotor core damage from persistent eminent temperatures in the surrounding area of the broken bars and current passing through the core from broken to healthy bars.

Fig.-2 Broken Rotor Bar

1.2 Vibration fault

Vibration fault is considered under mechanical faults. Vibration may occurs due to certain reasons like broken rotor bar, mass unbalance, air gap eccentricity, bearing damage, rotor winding failure, and stator winding failure. So by using Vibration Sensor we can detect this vibrations easily.

2. MOTOR CURRENT SIGNAL ANALYSIS

To ensure safe operation of these machines online, fault diagnostics is very important. Reliability of operation can be

increased by timely maintenance. Many tools are present nowadays but still many companies are confronting with surprising failures of system and decreased lifetime of machine. There are many methods of condition monitoring counting thermal monitoring, vibration monitoring, chemical monitoring, but expensive sensors or specialized tools are needed for all these monitoring strategies whereas current monitoring does not need extra sensors. Current monitoring of induction motor is the base of the Motor Current Signature Analysis (MCSA) technique; hence it is not very overpriced. For locating fault frequencies the current spectrum of the machine is used in MCSA. Whenever the fault appears, the frequency spectrum of the current grows into different from healthy motor. The signal processing strategies are utilized for fault detection and condition monitoring of induction machine. Advantages of using the signal processing strategies are that they are economical, and they are easy to implement.

4. WAVELET TRANSFORM

Wavelets are functions that are being used to decompose signals, similar to how to use complex sinusoids in the Fourier transform to decompose signals. The wavelet transform calculate the inner products of the analyzed signal and a family of wavelets. In contrast with sinusoids, wavelets are localized in both the time and frequency domains, so that is why wavelet signal processing is suitable for those signals, whose spectral content changes over time.

$$\Psi_{\alpha,\beta}(t) = \frac{1}{\alpha}\Psi t\left(\frac{t-\beta}{\alpha}\right)$$

Let Suppose that signals x(t) gives the exact value

$$\int_{-\infty}^{\infty} |x(t)|^2 dT < \infty$$

which implies that x(t) decays to zero. The wavelet transform, CWT of (α, β) of a time signal x(t) can be defined as

$$cwt(\alpha,\beta) = \frac{1}{\sqrt{\alpha}}\int_{-\infty}^{\infty} x(t)\,\Psi * \left(\frac{t-\beta}{\alpha}\right)$$

where, Ψ(t) is an analyzing wavelet and Ψ(t) is complex conjugate of Ψ(t).

5. DESIGN METHODOLOGY

This system consists of microcontroller along with other peripherals. We have used microcontroller Arduino Uno. Other peripherals included Induction motor, signal conditioning circuit, current transformer, serial communication circuit, USB to serial converter, PC and power supply. We will be monitoring two faults. 1st is broken rotor shaft and the other is vibration of motor. For broken rotor detection, we have to measure current. The current of motor will be monitored through current transformer. Current should be effectively monitored to achieve improved condition monitoring and protection system for induction motor. Signal conditioning circuit will be used to measure current at microcontroller end. Signal conditioning is needed to make the current signal compatible to microcontroller to read. Current will be measured through internal ADC of microcontroller. The current data in the form of digital signal will be transmitted to PC end through serial communication circuit and USB to serial converter. At the PC end, current data will be processed through various blocks wavelet transform of the data will be taken. Also, healthy waveforms will be stored in database. Also, 2nd fault, vibration of the motor will be measured using vibration sensor ADXL335. Output of this sensor is analog. We have used another ADC channel to acquire the signal of vibration sensor. Similar to 1st fault, signal of vibration sensor is also sent to MATLAB and get processed. Wavelet transform of the signals will be calculated and compared with the previously stored healthy waveform.

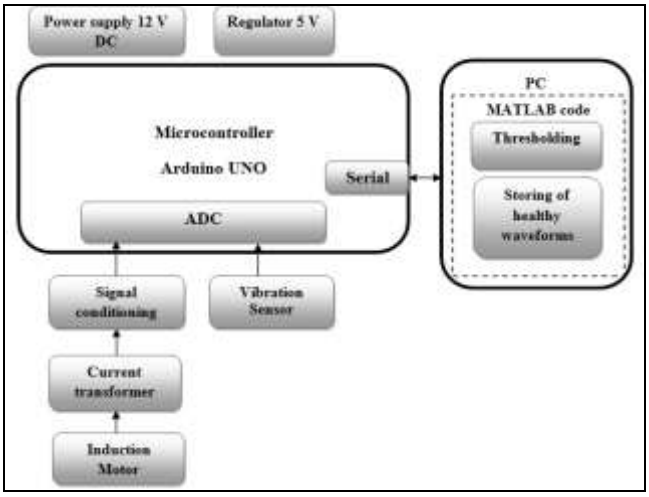

Fig.-3 Block Diagram

6. TEST SET UP

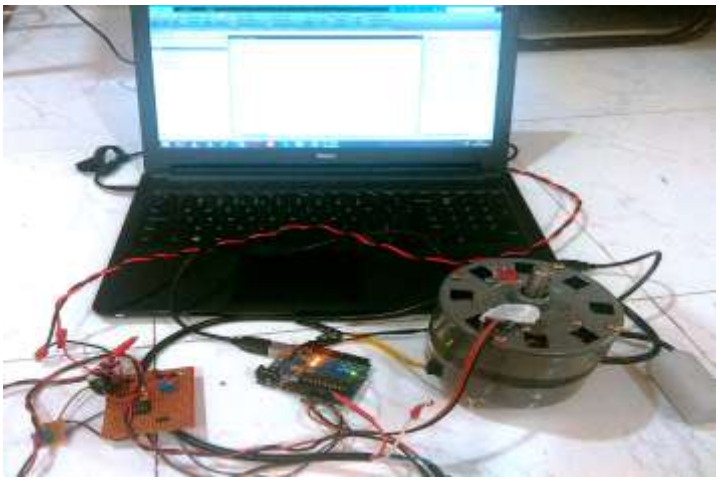

Fig.-4 Test Set up

7. RESULT

It consists of comparison of healthy rotor current with unhealthy current and also healthy vibration of motor with unhealthy vibration of the motor.

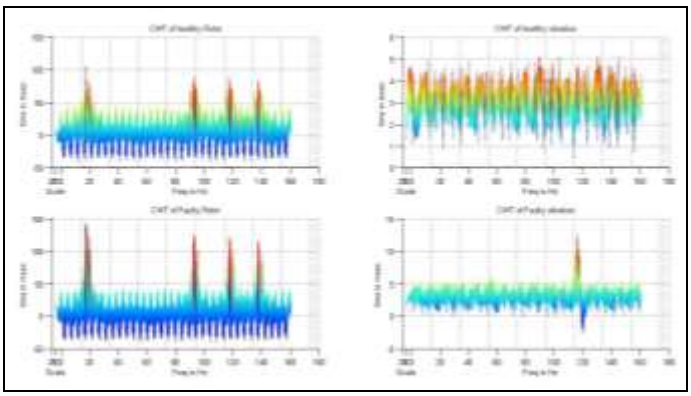

Fig.-3 Comparison of healthy and unhealthy quantities

8. CONCLUSIONS

Detection of an incipient faults at early stage is important for control and protection of Induction motor. The aim of this system is to diagnosis of the rotor failure and to detect vibration of the motor by any means. By using MATLAB with DWT we can achieve detection of broken rotor bars and vibration.

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