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Study and Implementation of Fault Diagnosis in Induction Motor Using MCSA

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Abstract— *To analysis performs of induction motor needs or requires condition monitoring. Condition monitoring of the induction motor typically used to detect the difference between healthy motors and unhealthy motor Condition monitoring of the induction motor relies on the detection of difference between healthy and faulty motors. The Motor Current Signature Analysis (MCSA) is the most reliable method as it does not require any sensors for its functioning. The major faults in induction motor like broken rotor bar, eccentricity, stator unbalance and stator coil short circuit faults can be diagnosed by using the MCSA method. The testing of the proposed system is done with the help of virtual fault simulator that generates the spectrum of various faults. After testing with the virtual simulator, system could be modified for online testing and analysis.*

Keywords— *Induction motor, faults detection, MCSA, FFT.*

I. Introduction

The Induction motors play an important role in industry for the rotating machine practice because of their hardiness low costs and quasi-absence of maintenance. Nevertheless, it arrives that this machine presents an electric or mechanical. The faults of these machines are varied. However the most frequent are (Benbouzid (2000), Razik (2002) and Trajin et al. (2008)(2): opening or shorting of one or more of a stator phase winding, broken rotor bar or cracked rotor end rings, static or dynamic air-gap irregularities, and bearing failures. In order to avoid such problems, these faults have to be detected to prevent a major failure from occurring. It is well known that a motor failure may yield an unexpected interruption at the industrial plant, with consequences in costs, product quality, and safety. Researcher were conducted many during the past twenty years, there has been a substantial amount of fundamental research into the creation of condition monitoring and diagnostic techniques for IM drives.

Different detection approaches proposed in the literature, those based on the Extended Park’s Vector Approach (EPVA), which allows the detection of inter-turn short circuits in the stator winding(Acosta et al. (2004))(3). The EPVA is appropriate for the stator windings monitoring. Çalis and Çakir (2007(4)) used the 2.*s.fs*spectral component in the stator current zero crossing times (ZCT) spectrum as an index of rotor bar faults. However, the major deficiency for this fault indicator, for low slip IM operating at no load condition it may then be difficult to read its value. In Casimir et al. (2006) (5), the authors studied the diagnosis of IM by pattern recognition method. This method consists in extracting features from the combination of the stator currents and voltages. Some of these features could be irrelevant or redundant. Therefore, the Sequential Backward Selection (SBS) algorithm is applied to the complete set of features to select the most relevant. Then they used the k-Nearest Neighbors (kNN) rules to monitor the IM functioning states. It will be working based on reject options in order to avoid automatic classifications and diagnosis errors. Didier et al. (2007) (5) employed the Fourier Transform of the stator current and they analyzed its phase. It is shown that the basically calculated phase gives good results when the motor operates near its optimal load. When applying load at low level, the result obtained are not robust enough for the detection of an incipient rotor fault. In Li and Mechefske (2004), the authors used the vibration monitoring methodology to detect faults occurring in IM. When performing Vibration monitoring it need to store the large amount of data. Vibration is often measured with multiple sensors mounted on different parts of the machine. The examination of data can be tedious and sensitive to errors. Also, fault related machine vibration is usually corrupted with structural machine vibration and noise from interfering machinery. To overcome these problems Poyhonen et al. (2003) (2) used the Independent Component Analysis (ICA) to compress measurements from several channels into a smaller amount of channel combinations and to provide a robust and reliable fault diagnostics routine for a cage IM. This paper is focused on the Motor Current Signature Analysis (MCSA) approach. This technique utilizes results of spectral analysis of the stator current (precisely, the supply current) of an IM to spot an existing or incipient failure of the motor or the drive system. It is claimed that MCSA monitoring is the most reliable method of assessing the overall health of a rotor system (Thomson (2001)). Unlike the greater part of techniques, MCSA can provide the same indications without requiring access to the motor. This paper focuses on simulation and emulation of major faults of induction motor and techniques to analyze them. A fault simulator was developed and analyzed for the purpose of testing the condition monitoring system. The results of this simulator were discussed and scope of proposal is added.

II. Types of Faults in Induction Motor

Faults in induction motor commonly categorized into two types namely electrical and mechanical faults. Electrical fault are occur due to problems occurring in winding and sometimes it related to rotor problems. Mechanical faults are occurring due to air gap eccentricity, shaft misalignment, and load faults. Faults in induction motor commonly due above faults are bearing faults, Air gap eccentricity, Short turn windings, Rotor faults, unbalanced supply voltage, Load

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torque fluctuation. These faults can analyzed using various techniques such as vibration monitoring , thermal monitoring, acoustic monitoring but problem defining that it will be working using sensors and it restricted to use real time system due cost effective of sensors. To overcome this problem using motor current signature analysis (MCSA) techniques in this we are not using any kind of sensors to diagnosis the faults. Using MCSA it extract the current signature from healthy motor and it using fast Fourier transform. Based on this signature will be extract from unhealthy motor and comparing the result with healthy one. While doing can able to receive motor current spectra are unique for different motor. In 1985, Statistical survey has made by electric power research institute (ERIP) and obtained results as bearing (41%), stator (37%), rotor (10%) and other (12%).

A. *Bearing Fault*

Bearing faults are commonly occurred in electrical machine they are employed to permit rotary motion of the shafts. Bearing faults account for over 40% of all motor failures [1]. A set of balls or rolling elements placed in raceways rotate inside these rings. If continues stress giving to inner and outer race of bearing cause castrophic failure in bearing. These failures result in rough running of the bearings that generates detectable vibrations and increased noise levels. If applying voltage and current to shaft often it will create flux disturbance in rotor eccentricity. High bearing temperature is another reason. Root cause of the bearing fault is thermal stress, electrical stress, mechanical and environmental stress.

B. *Airgap Eccentricity*

In an ideal machine, the rotor is center-aligned in the stator bore, and the rotation center of the rotor is the same as geometric center of the stator bore. An asymmetric air-gap is generated between the stator and rotor when the rotor is displaced from its centered position in the stator bore [3] The effects of air-gap eccentricity produce unique spectral patterns which will be identify by current spectra. To analysis the approach using rotating wave approach whereby the magnetic flux waves in the air-gap are taken as the product of permeance and magnetomotive force (MMF) waves. [5]Unless detected early, the eccentricity progressively damages the motor due to rubbing of the stator and rotor, and consequently damages the winding, stator core and rotor cage. [3]. Due to the fault in air gap eccentricity increasing mechanical vibration, coil movement and rubbing stator and rotor

C. *Short Turn Windings*

Asymmetrical Inter-turn short circuits in stator windings constitute a category of faults that is most common in induction motor. Usually short circuit typically, short circuits in stator windings occur between turns of one phase, or between turns of two phases, or between turns of all phases. Moreover, short circuits between winding conductors and the stator core also occur. Studies in (Thomson (2001) and Bodt et al. (2006)) (3) prove that the stator current is enriched by short turns.

D. *Rotor Fault*

Usually, lower rating machines are manufactured by die casting techniques whereas high ratings machines are manufactured with copper rotor bar. Several related technological problems can rise due to manufacturing of rotors by die casting techniques. It has been found that squirrel cage induction motors show asymmetries in the rotor due to technological difficulties, or melting of bars and end rings. However, failures may also result in rotors because of so many other reasons. There are several main Reasons of rotor faults. During the brazing process in manufacture, non- uniform metallurgical stresses may be built into cage assembly and these can also lead to failure during operation. A rotor bar may be unable to move longitudinally in the slot it occupies, when thermal stresses are imposed. Heavy end ring can result in large centrifugal forces, wh4ich can cause stress. Thus when rotor defect exists it creates in addition of the direct rotor field an inverse field that turns to the speed (-s._s).It is due to the fact that the rotor currents are now direct and inverse following the unbalance of resistances. It is the interaction of this field with the one descended of stator windings that induces an e.m.f. and current in the stator winding at (1-2.*s*).*fs*. This cyclic current variation causes a speed oscillation at twice the slip frequency (2.s.*fs*) and finally, this speed oscillation induces, in the stator current spectrum, an upper component at (1+2.s).*fs* [6].

$$F \text{ Broken Rotor} = (1 \pm 2.K\,.S)\,Fs \quad (1)$$

Where fs-supply frequency,S-slip

E. *Unbalanced Supply Voltage*

Asymmetrical stator faults (caused by stator winding faults Or asymmetrical supply voltages) are also common in induction motor. An asymmetrical stator supply voltage can be caused by the opening of one of the three phases, by the Presence of one-phase-load in the environment near of the Motor, or by the source. The consequences of an unbalanced supply voltage applied to a three phase IM are the reduction of the useful torque and the increase of the losses. Unbalances result in an inverse component that generates high rotor current provoking a very important heating of the rotor and implying an overheating of the motor [6]. The calculation of the unbalance can be approached by the following equation (2) Where fs – supply frequency,

K – 1, 2, 3….

F. *Load Torque Fluctuation*

The load torque variation induces components in the Current spectrum which coincide with those caused by a fault condition. In an ideal machine where the stator flux linkage is purely sinusoidal, any oscillation in the load torque at a multiple of the rotational speed will produce stator currents at frequencies [6].

III. Motor Current Signature Analysis Technique

Motor Current Signature Analysis (MCSA) is a technique used to determine the operating condition of AC induction motors without interrupting production. Motor current signature analysis is that it is sensing an electrical signal that

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contains current components. MCSA detect the faults at an early stage and avoid the damage and complete failure of the motor. By using MCSA, accurate analysis of fault is possible. An idealized current spectrum is shown in figure 1. Usually a decibel (dB) versus frequency spectrum is used in order to give a wide dynamic range and to detect the exclusive current signature patterns that are characteristic of different faults. [3] Motor Current Signature Analysis (MCSA) is based on current monitoring of induction motor therefore it is not very expensive. The MCSA uses the current spectrum of the machine for locating the fault frequencies. When a fault is present, the frequency spectrum of the line current becomes changed from healthy motor. Motor Current Signature Analysis (MCSA) based methods are used to diagnose the common faults of induction motor such as broken bar fault, short winding fault, bearing fault, and load fault.

IV. SIMULATION RESULT

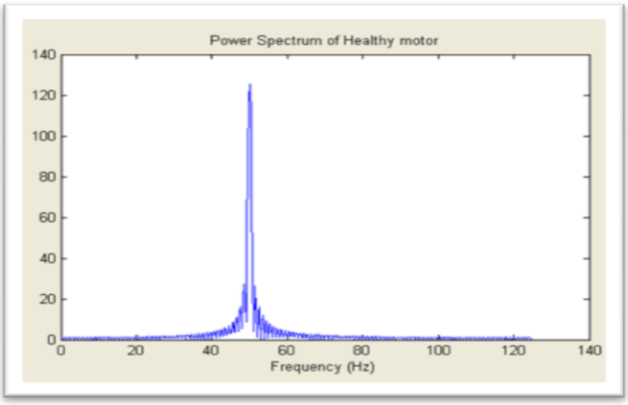

Fig. 1. With and without fault spectrum for air gap.

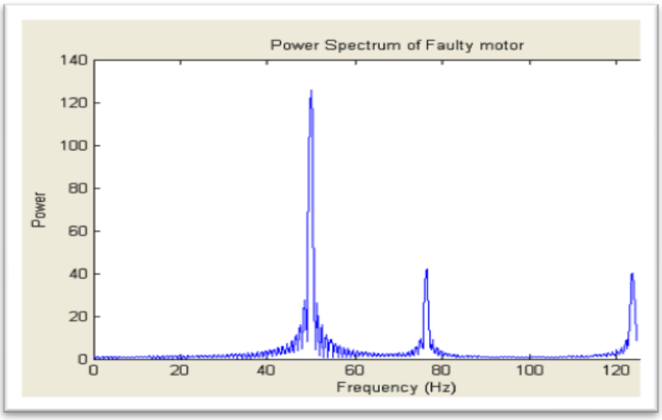

Fig. 2. With and without fault spectrum for short turn.

V. RESULT AND DISCUSSION

Simulator could generate frequency spectrum of the induction motor faults according to the user inputs. These faults are listed in simulator. Also the loading conditions are also given as user inputs in another popup menu. When inputs are set, the push button is pressed to acquire the spectrum of preferred fault. The load conditions are given as input so that the change in spectrum could be appeared. These generated signals could be fed as inputs to the controller through data acquisition cards. Processing of acquired data will be done in the controller to diagnose the fault of induction motor. Fault simulation done using LABVIEW program .The function of the simulator is to read user selection and display the spectrum as per the fault. If the selection of faults is more than one then computation for the display of waveform varies slightly. As it is clear from the literature survey, the spectrum contains the information of the faults found in the induction motors. This is evident from the comparison between the spectrum of faultless and faulty motors. Thus the simulator is found to serve its purpose of fault signal generation. The peaks, which are found at the sides of main input peak, are due to the presence of faults.

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