Journal of Advances in Science and Technology
Vol. 12, Issue No. 24, November-2016, ISSN 2230-9659

An Analysis on Motor Current and Vibration Signatures and Its Uses in Fault Detection of Induction Motor

Jasani Chiragkumar Natvarlal[1]* Dr. Yashpal Singh[2]

[1]Research Scholar, OPJS University, Rajasthan

[2]Professor, OPJS University, Rajasthan

Abstract – Motor electrical current signature analysis (MCSA) is sensing an electrical signal con¬taining current components that are direct by-product of unique rotating flux components. Anomalies in operation of the motor modify harmonic content of motor supply current. This paper presents brief introductory review of the method including fundamentals, fault detection techniques and current signatures of various faults.

Induction motors are used worldwide as the "workhorse" in industrial applications. Although, these electromechanical devices are highly reliable, susceptible to many types of faults. 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 this paper I have used both vibration and motor current signature analysis to detect the fault. The various fault discussed in this paper are- Mechanical fault such as bearing damage and Electrical Fault such as unbalanced voltage supply, single phasing. Condition monitoring, signal processing and data analysis are the key parts of the Induction Motor fault detection scheme.

The Motor Current Signature Analysis (MCSA) is considered the most popular fault detection method now a day because it can easily detect the common machine fault such as turn to turn short ckt, cracked /broken rotor bars, bearing deterioration etc. The present paper discusses the fundamentals of Motor Current Signature Analysis (MCSA) plus condition monitoring of the induction motor using MCSA. In addition, this paper presents four case studies of induction motor fault diagnosis. The results show that Motor current signature analysis (MCSA) can effectively detect abnormal operating conditions in induction motor applications.

---------------------------♦-----------------------------

INTRODUCTION

The operators of induction motor drives are under continual pressure to reduce maintenance costs and prevent unscheduled downtimes that result in lost production and financial income. Many operators now use online condition-based maintenance strategies in parallel with conventional planned maintenance schemes. However, it is still the operator who has to make the final decision on whether to remove a motor from service or let it run based on information from condition monitoring systems. This tutorial paper is presented in the recommended style of a tutorial and, to quote the guidelines, the purpose of a tutorial is to teach, not just review. At the discussion of a paper presented by Thomson and Orpin (2002) at the Thirty-First Turbomachinery Symposium, several key questions were asked by the audience, and this tutorial also addresses these points. The question by mechanical engineers/vibration diagnosticians was "but surely the problem of broken rotor bars can be detected via vibration monitoring, would the authors like to comment?"

A crucial point about motor current signature analysis (MCS A) is that it is sensing an electrical signal that contains current components that are a direct by-product of unique rotating flux components caused by faults such as broken rotor bars, airgap eccentricity, and shorted turns in low voltage stator windings, etc. MCSA can detea these problems at an early stage and thus avoid secondary damage and complete failure of the motor, as reported by Kliman and Stein (1990). It is true that broken rotor bars will result in a change to the vibration spectrum,but vibration is traditionally sensed at the bearings. And for each motor there is a different mechanical stiffness between the electromagnetic forces caused by broken bars and the position where the vibration is sensed. This adds an additional complexity when attempts are made to quantify the severity of the problem via vibration analysis.

Electromagnetic forces are proportional to the flux density squared waveform in an induction motor. Hence, the vibration from unique electromagnetic forces from broken ban;, etc., is a second order effect compared to current components directly induced from the specific rotating flux waves. In many cases the fault severity (e.g., number of broken rotor bars) has to be serious before it can be detected by vibration analysis, and even then the prediction of fault severity is another order of magnitude more difficult.

This is not the case with MCSA as has been proven via numerous industrial case histories. With respect to detecting airgap eccentricity problems, a similar reasoning applies as explained above and as reported by Thomson and Barbour, (1998) and Thomson, et al. (1999). With respect to detecting shorted turns in low voltage stator windings then Thomson (2001) has shown that MCSA can detea the fault before a phase-to-phase or phase-to-earth failure. It is therefore possible with a low voltage (LV) stator winding to have some lead time between shorted turns developing and actual failure. In comparison to a high voltage (HV, e.g., 4160 V and above) induction motor, the time to failure with an interfault will be very short indeed.

Induction motors are the most important equipment in industry and their reliable and safe operation is desirable. Motor failures in industries cannot be tolerated because they lead to production losses, time consumption and unnecessary repairing costs. This motivates the concept of condition monitoring. In general, detection and diagnosis of incipient faults is desirable for product quality assurance and improved operational efficiency of induction motors, running off the power supply mains. It is reported that defects in core components such as rotor, stator and bearings relate to 88% of motor faults. There are three basic themes of maintenance: Corrective maintenance, time based maintenance and condition based maintenance. Condition based maintenance inspects the machine at variable time interval and determine the fault on the basis of knowledge of presence or absence of faults. This is the best maintenance approach, since only in this approach unexpected downtime is eliminated and machine is utilized for its full life span thus resulting in economical profit. On line condition monitoring is the process of monitoring and inspecting the condition of machine while it is in normal operating mode. Online condition monitoring detect the changes in the sensory signal which indicate the presence and severity of machine faults and help in deciding the maintenance steps to be taken before breakdown occur. Components of online condition monitoring are sensors, data acquisition, fault detection, fault classification and fault diagnosis.

Induction motors are a critical component of many industrial processes and are frequently integrated in commercially available equipment and industrial processes. Motor-driven equipment often provide core capabilities essential to business success and to safety of equipment and personnel. There are many published techniques and many commercially available tools to monitor induction motors to insure a high degree of reliability uptime. In spite of these tools, many companies are still faced with unexpected system failures and reduced motor lifetime. The studies of induction motor behavior during abnormal conditions and the possibility to diagnose these conditions have been a challenging topic for many electrical machine researchers. The major faults of electrical machines can broadly be classified as the following:

- Stator faults resulting in the opening or shorting of one or more of a stator phase windings,
- Abnormal connection of the stator windings,
- Broken rotor bar or cracked rotor endrings.
- Static and/or dynamic air-gap irregularities,
- Bent shaft (akin to dynamic eccentricity) which can result in a rub between the rotor and stator, causing serious damage to stator core and windings.

In recent years, intensive research effort has been focused on the technique of monitoring and diagnosis of electrical machines and can be summarized as follows,

- Time and frequency domain analysis.
- Time domain analysis of the electromagnetic torque and flux phasor.
- Temperature measurement, infrared recognition, radio frequency (RF) emission monitoring,
- Motor current signature analysis (MCSA)
- Detection by space vector angular fluctuation (SVAF)
- Noise and vibration monitoring,
- Acoustic noise measurements,
- Harmonic analysis of motor torque and speed,
- Model, artificial intelligence and neural network based techniques.

Of all the above techniques, MCSA is the best possible option: it is non-intrusive and uses the stator winding as the search coil; It is not affected by the type of load and other asymmetries.

MOTOR CURRENT SIGNATURE ANALYSIS BASICS

Motor Current Signature Analysis is the technique used to analyze and monitor the trend of dynamic energized systems,.

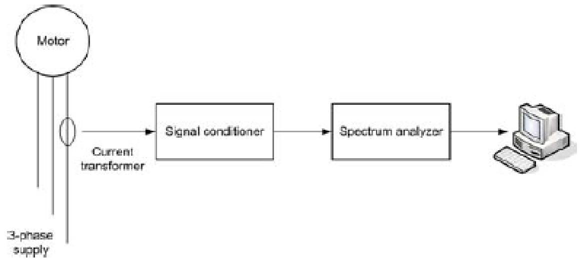

Figure 1 Stator current monitoring system.

MCSA is monitoring stator current (more precisely supply current) of the motor,. Typical stator current monitoring system is illustrated in Figure 1. Single stator current monitoring system is commonly used (monitoring only one of the three phases of the motor supply current). Motor stator windings are used as transducer in MCSA, picking the signals (induced currents) from the rotor (but also revealing information about the state of the stator).

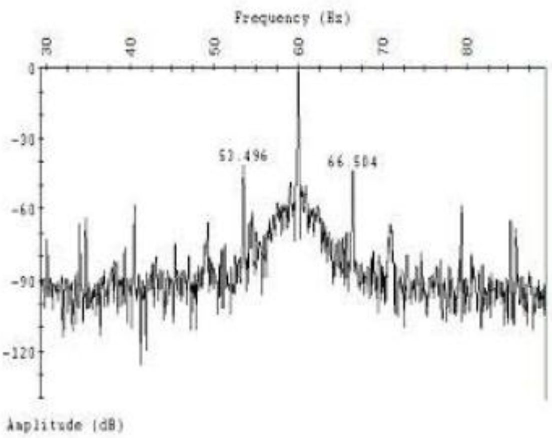

Figure 2 Current spectrum of induction motor.

Motor current is sensed by a Current Sensor (clamp probe, current transformer) with resistive shunt across its output, and recorded in time domain. Picked current signal is then led to a spectrum analyzer or specialized MCSA instrument. In ideal case motor current should be pure sinusoidal wave. In reality in motor current many harmonics are present. Current spectrum of a typical induction motor is illustrated in Figure 2. Various electrical and mechanical fault conditions present in the motor further modulate motor current signal and contributes to additional sideband harmonics. Faults in motor components produce corresponding anomalies in magnetic field and change the mutual and selfinductance of motor that appear in motor supply current spectrum as sidebands around line (supply, grid) frequency. Based on fault signatures motor faults can be identified and its severity accessed. Frequency range of interest in MCSA is typically 0-5 kHz. This, according to a Nyquist theorem, requires sample rate of at least 10000 samples per second. During the test motor should be run at loading greater then 70%. It should be noted that fault signals detected in motor supply current may also be influenced by operation of neighboring motors and system's environmental noise.

FAULTS THAT CAN BE DETECTED WITH MCSA

The major faults of electrical machines can broadly be classified by the following:

a. Static and/or dynamic air-gap irregularities.

b. Broken rotor bar or cracked rotor end-rings.

c. Stator faults (opening or shorting of one coil or more of a stator phase winding)

d. Abnormal connection of the stator windings.

e. Bent shaft (akin to dynamic eccentricity) which can result in a rub between the rotor and stator, causing serious damage to stator core and windings.

f. Bearing and gearbox failures

The most common faults are bearing faults, stator faults, rotor faults and eccentricity or any combination of these faults. When analyzed statistically, about 40% of the faults correspond to bearing faults, 30-40% to stator faults, 10% to rotors faults, while remaining 10% belong to a variety of other faults. Frequencies induced by each fault depend on the particular characteristic data of the motor (like syn-chronous speed, slip frequency and pole-pass frequency) as well as operating conditions. Main classes of faults that can be detected with MCSA are listed below.

AIR-GAP ECCENTRICITY - Air-gap eccentricity represents a condition when air gap distance between the rotor and the stator is not uniform. Two types of abnormal air-gap eccentricity exist: static and dynamic. In case of static eccentricity the position of minimal radial air gap is fixed, while in case of dynamic eccentricity position of minimal air gap follows turning of the rotor. Normal (concentric) state, static and dynamic eccentricity are illustrated in Figure 3.

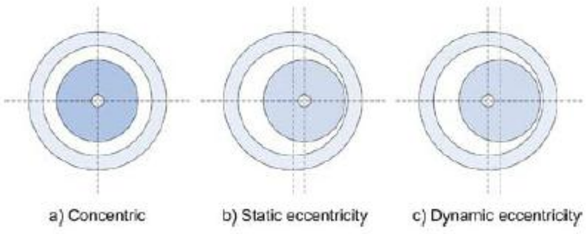

Figure 3 Air gap: a) normal (concentric), b) static eccentricity and c) dynamic eccentricity.

BROKEN ROTOR BARS - Primary causes of broken bars are direct online starting duty cycles (with fivefold the full load bar currents) and pulsating mechanics loads (like reciprocating machinery). They can cause sparking and overheating in a motor. By examining the frequency spectrum of the stator currents, early stages of rotor bar failures can be detected.

BEARINGS DAMAGE - Motor bearings faults are more difficult to detect then rotor cage problems. Four types of bearing misalignments exist, as is described in. Such misalignments are common result of defective bearing installation.

SHORTED TURNS IN STATOR WINDINGS - Most stator failures are related to stator windings. Shorted turns produce excessive heat in stator coil and current imbalance. MCSA exploits the fact that rotating flux waves can induce corresponding components in the stator windings. Motor current components that are influenced only by shorted turns can be detected at frequencies.

LOAD EFFECTS - Electrical motors are converters of electrical energy to a mechanical torque. Load torque may vary with rotor position. These variations cause corresponding variations in the motor current. In that case supply current will contain spectral components related to load torque variability.

LITERATURE REVIEW

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 and in which power is transferred from one circuit to the other by electromagnetic induction. It is an electromechanical energy conversion device in which the energy converts from electric to mechanical form. The energy
conversion depends upon the existence in nature of phenomena interrelating magnetic and electric fields on the one hand, and mechanical force and motion on the other. The rotor
winding in induction motors can be squirrel-cage type or wound-rotor type. Thus, the induction motors are classified into two groups:

- Squirrel-cage and
- Wound-rotor induction motors.

The squirrel cage induction motor consist of conducting bars embedded in slots in the rotor iron and short circuited at each end by conducting end rings. The rotor bars are usually made
of copper, aluminum, magnesium or alloy placed in slots. Standard squirrel cage rotors have no insulation since bars carry large currents at low voltages. Another type of rotor, called a form-wound rotor, carries a poly phase winding similar to three phase stator winding. The terminals of the rotor winding are connected to three insulated slip rings mounted on the rotor shaft. In a form-wound rotor, slip rings are connected to an external variable resistance
which can limit starting current and associated rotor heating. During start-up, inserting external resistance in the wound-rotor circuit produces a higher starting torque with less starting current than squirrel-cage rotors. This is desirable for motors which must be started often.

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 motors under risk of faults or failures. There is need to improve the reliability of motors due to their significant positions in applications.

According to IEEE Standard 493-1997, the most common faults and their statistical occurrences are listed in Table 1. This table is based on a survey on various motors in industrial applications. According to the table, most faults happen to bearings and windings.
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%). Several contributions deal with these faults.

Types of faults	Number of faults/failures				
	Induction motor	Synchronous motor	Wound rotor motors	DC Motors	All motors
Bearing	152	2	10	2	166
Winding	75	16	6	--	97
Rotors	8	1	4	-	13
Shaft	19	-	--	-	19
Brushes or slip rings	--	6	8	2	16
External device	40	7	1	-	18
Others	10	9	--	2	51

Table 1 Statistics on motor faults/failure modes.

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 detect 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. This can result in minimum down time and optimum maintenance schedules. Condition monitoring and fault diagnosis scheme allows the machine operator to have the necessary spare parts before the machine is stripped down, thereby reducing outage times. Therefore, effective condition

monitoring of electric machines is critical in improving the reliability, safety, and productivity.

Existing condition monitoring techniques - This research is focused on the condition monitoring and fault diagnosis of electric

machines. Fault diagnosis is a determination of a specific fault that has occurred in system. A typical condition monitoring and fault diagnosis process usually consists of four phases as shown in Figure 4. 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.

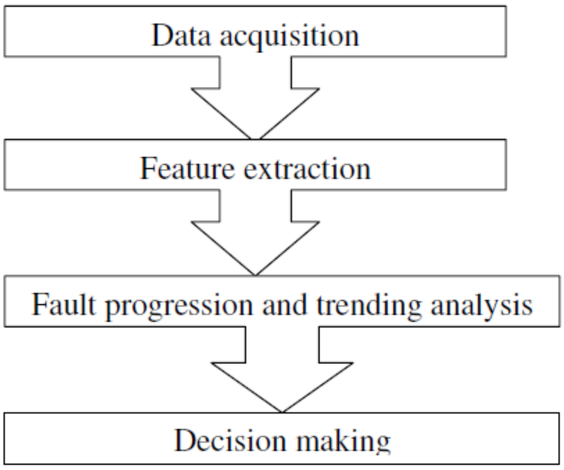

Figure 4: The process for fault diagnosis.

The condition monitoring of electrical and mechanical devices has been in practice for quite some time now. 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.

Vibration monitoring - All electric machines generate noise and vibration, and the analysis of the produced noise and vibration can be used to give information on the condition of the machine. Even

very small amplitude of vibration of machine frame can produce high noise. Noise and vibration in electric machines are caused by forces which are of magnetic, mechanical and aerodynamic origin. The largest sources of vibration and noise in electric machines are the radial forces due to the air gap field. Since the air gap flux density distribution is product of the resultant m.m.f. wave and total permeance wave.

Current signature Analysis - Numerous applications of using MCSA in equipment health monitoring have been published among the nuclear-generation, industrial, defense industries. In most applications, stator current is monitored for diagnosis of different faults of induction motor.

Alberto Bellini et. al. (2000) presented the impact of control on faulted induction machine behavior. The diagnostic indexes usually used for open-loop operation are no longer effective. Simulation and experimental results show that the spectrum of the field current

component in a field-oriented controlled machine has suitable features that can lead to an effective diagnostic procedure. Specifically, in the case of stator and rotor faults, the

spectrum components at frequencies 2f and 2sf respectively, are quite independent of control parameters and dependent on the fault extent.

Arkan et al. (2001) presented a non-invasive online method for the detection of stator winding faults in three-phase induction motors from the observation of the negative sequence supply current. A power decomposition technique (PDT) was used to derive positive and

negative sequence components of measured voltages and currents. This study carried out experimental studies, which showed that the negative sequence impedance could vary between 10 % and 50 % during an inter-turn short circuit.

Randy R.Schoen et. al. (2005) addressed the application of motor current signature analysis for the detection of rolling-element bearing damage in induction machines. This study investigates the efficacy of current monitoring for bearing fault detection by correlating the relationship between vibration and current frequencies caused by incipient bearing failures. In this study, the bearing failure modes are reviewed and the characteristic bearing frequencies associated with the physical construction of the bearings are defined. The effects on the stator current spectrum are described and the related frequencies determined. Experimental results which show the vibration and current spectra of an induction machine with different bearing faults are used to verify the relationship between the vibrational and current frequencies. The test results clearly illustrate that the stator current signature can be used to identify the presence of a bearing fault.

Randy R. Schoen (2005) presented a method for on-line detection of incipient induction motor failures which requires no user interpretation of the motor current signature, even in the presence of unknown load and line conditions. A selective frequency filter learns the characteristic frequencies of the induction machine while operating under all normal load conditions. The generated frequency table is reduced to a manageable number through the use of a set of expert system rales based upon the known physical construction of the machine. This list of frequencies forms the neural network clustering algorithm inputs which are compared to the operational characteristics learned from the initial motor performance.

Schoen and Habetler (2006) investigated the effects of a position-varying load torque on the detection of air gap eccentricity. The torque oscillations were found to cause the same harmonics as eccentricity. These harmonics are always much larger than eccentricity-related
fault harmonics. Therefore, it was concluded that it is impossible to separate torque oscillations and eccentricity unless the angular position of the eccentricity fault with respect to the load torque characteristic is known.

Randy R. Schoen and Thomas G. Habetler (2007) presented an analysis of the effects of position-varying loads on the current harmonic spectrum. The load torque-induced harmonics
were shown to be coincidental with rotor fault-induced harmonics when the load varies synchronously with the rotor position. Furthermore, since the effect of the load and fault on a single stator current harmonic component is spatially dependent, the fault induced portion cannot be separated from the load portion. Therefore, any on-line detection scheme which measures the spectrum of a single phase of the stator current must rely on monitoring those spectral components which are not affected by the load torque oscillations.

W. T. Thomson et. al. (2008) presented an appraisal of on-line monitoring techniques to detect air gap eccentricity in three-phase induction motors. On-line current monitoring is proposed as the most applicable method in the industrial environment. The analyses of the
current spectra for different motors are presented in the study. The results verify that the interpretation of the current spectrum proposed in this study was successful in diagnosing air gap eccentricity problems.

Jung et. al. (2008) proposed an online induction motor diagnosis system using MCSA with advanced signal and data processing algorithms. The diagnosis system was composed of the DSP board for high-speed signal processing and advanced signal-and-data-processing algorithm including the PC-user interface. The advanced algorithms were made up of the optimal slip-estimation algorithm, the proper sample selection algorithm, and the frequency auto search algorithm for achieving MCSA efficiently. The optimal slip estimation algorithm suggested the optimal-slip estimator based on the Bayesian method of estimation. In addition, the proper-sample-selection algorithm determined the standard of suitable samples for the MCSA process from the characteristics of a measurement noise and spread spectrum. Finally, the frequency auto search algorithm detected the abnormal harmonic frequency under unspecified harmonic numbers with the tendency of the candidate spectrum magnitudes. To verify the generality of the suggested algorithms, laboratory experiments were performed with 3.7-kW and 30-kW squirrel-cage induction motors. The proposed system was able to ascertain four kinds of motor faults and diagnose the fault status of an induction motor. Experimental results successfully verified the operations of the proposed diagnosis system and algorithms.

Chidong Qiu et. al. (2009) developed a multitaper-based detection method for incipient motor faults in order to detect weak fault eigen frequency submerged in noises environment. The tradeoff problem between frequency resolution and variance was studied, and the optimal tradeoff value was chosen to be applied on detecting motor faults. By selecting high energy tapers, the root leakage of eigen frequency was eliminated, and the shape of eigen frequency was changed to be distinguishable. Simulation studies were conducted and results show that multi-taper method has a more steady and antinoise performance compared with other methods. Finally, an experiment was arranged in laboratory, and the bearing faults were
put into the motor. By using the proposed method, it is validated that multi-taper method is effective for detecting the motor incipient faults.

Frosini, and L. Bassi (2011) proposed a new approach to use stator current and efficiency of induction motors as indicators of rolling-bearing faults. This study illustrates the experimental results on four different types of bearing defects: crack in the outer race, hole in the outer race, deformation of the seal, and corrosion. Another novelty introduced by this study is the analysis of the decrease in efficiency of the motor with a double purpose: as alarm of incipient faults and as evaluation of the extent of energy waste resulting from the lasting of the fault condition before the breakdown of the machine.

Faiz et. al. (2013) developed an approach to recognize mixed eccentricity and determine the static and dynamic eccentricities degrees individually at different load levels. In order to evaluate
the impact of load-dependent indices on eccentricity detection and fault-seventy estimation, a systematic relation between each other and eccentricity degree is proposed in this study. Correlation coefficient and mutual information are applied to assess abilities of the obtained
indices for eccentricity detection in terms of their relation to static and dynamic eccentricities, their degrees and dependency on the load of motor. The classification results indicate that the elicited indices estimate the eccentricity type and degree exactly.

METHODOLOGY

Bearing Fault in Induction motor -

Bearing are common elements of Induction Machines. They are employed to permit the rotary motion of the shaft. The bearing mainly consists of two rings called the inner and outer rings. A set of balls or rolling elements placed in raceways rotate inside these rings. A continued stress on the bearings cause fatigue failures, usually at the inner and outer races of the bearings. Small pieces break loose from the bearing, called flaking or spalling. These failures result in rough running of the bearings that generates detectable vibrations and increased noise levels. And this process is helped by other external sources including contamination. Corrosion, brinelling, improper lubrication, improper installation. In some case shaft voltage and current are also sources for bearing failure. High bearing temperature is also another reason for bearing failure.

The different faults that may occur in bearing as follows

- Outer raceway defect
- Inner raceway defect
- Ball defect

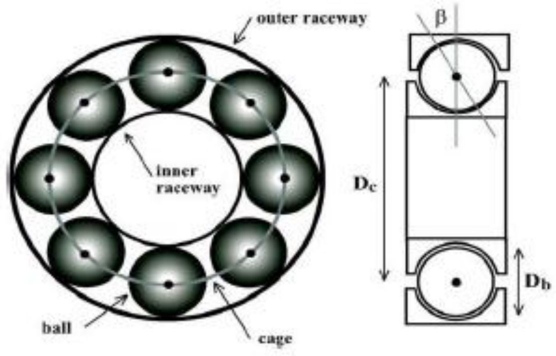

Figure 5: Ball bearing dimensions

Unbalance in supply voltage - A very important aspect of condition monitoring of induction motor is to detect the external faults. Unbalance in supply voltage and single phasing are the two types of external faults of induction motor are considered in my work. Unbalance in supply voltage is created by connecting three single phase transformers in three phases of the supply. Here supply voltage in B phase is reduced to 10% less than the rated voltages in the other two phases to create unbalance. Unbalance voltage is nothing but unequal distribution of incoming voltages or when the phase separation is not 120º. When there are unequal incoming voltages between the three legs of a motor, the motor runs hotter. The reason why an unbalance motor runs hotter is because as the voltage is out of balance so is the winding current. A small voltage unbalance causes a larger current unbalance, which in turns causes the motor.

Single Phasing Fault - For proper working of any three phase induction motor, it must be connected three phase alternating current (Ac) power supply of rated voltage and load. Once these three phase motors are started they will continue to run even if one of the three phase supply lines gets disconnected. The loss of current is described as single phasing. Single phasing is the condition in three phase motors and transformers wherein the supply to one of the phases is cut off. Single Phasing causes negative phase sequence components in the voltage. Single Phasing is cause by the use of single phase protection devices such as fuses and circuits breakers. Three phase loads should be protected by devices which cause the interruption of power to all three phases simultaneously hence a fault occurs. Defective contacts in three phase breakers can also cause single phasing. It can be sometimes cause excessive noise and vibration in motors.

Condition Monitoring System - Condition monitoring means to access the actual condition of motor using the measurements taken while the motor is operating. This is the method for fault diagnosis. In this stage, First of all we create different fault (such as bearing fault, unbalance voltage) due to which symmetry of motor would effect and creates fault characteristics frequency. After that we get that fault frequency by different type of sensors (such as for vibration signal we can use piezoelectric accelerometer, for speed measurement tachometer etc.).

Motor Current Signature Analysis -

This method is used current spectrum to detect the various faults. It is the online analysis of current to detect faults in three phase induction motor. This method analyses the motor signal by using signal processing algorithms such as FFT, STFT, and Wavelet etc. MCSA techniques include parametric, nonparametric, and high-resolution spectrum analysis methods. In the parametric methods, autoregressive (AR) models have been fitted with time series of the signal, and model parameters have been used to compute the frequency spectrum. Furthermore, nonparametric methods are based on Fourier transforms in order to search for periodicities of the signal. And finally a high resolution spectrum method corresponds to an Eigen value analysis of the autocorrelation matrix of the time series signal. One of the classical and widely used nonparametric spectrums method as a MCSA technique is the well-known fast Fourier transform (FFT). The FFT is a simple and computationally efficient algorithm to compute the discrete Fourier transform (DFT) of a discrete-time series function.

In my work I used the FFT technique to analyse the signal.

CONCLUSION

Electrical machinery is the powerhouse of the modern industry. Failures of induction motors cause production downtime and may generate large losses in terms of maintenance and lost revenue. Timely detection of incipient motor faults is hence of great importance. Developing motor faults have its counterparts in waveform and harmonic content of the motor supply current. MCSA can be applied everywhere in industry where induction motors are used enabling non-intrusive on-line (even remote) analysis of motor supply current and detects faults while motor is still operational and without interrupting its service. It can be efficiently applied to detection and the localization for variety of motor faults. As such it is important contribution to tools for condition monitoring of induction motors.

Motor Current Signature Analysis is an electric machinery monitoring technology. It provides a highly sensitive, selective, and cost-effective means for online monitoring of a wide variety of heavy industrial machinery. It has been used as a test method to improve the motor bearing wear assessment for inaccessible motors during plant operation. This technique can be fairly simple, or complicated, depending on the system available for data collection and evaluation. MCSA technology can be used in conjunction with other technologies, such as motor circuit analysis, in order to provide a complete overview of the motor circuit. The result of using MCSA as part of motor diagnostics program is a complete view of motor system health.

REFERENCES

A Singhal and M A. Khandekar (2013). Bearing Fault Detection in Induction Motor Using Motor Current Signature Analysis, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 7, pp. 3258-3264

Alberto Bellini, Fiorenzo Filippetti. Giovanni Franceschini, and Carla Tassoni (2000). “Closed- loop control impact on the diagnosis of induction motors faults”, IEEE Transactions on Industry Applications, Vol. 36, No. 5, pp. 1318-1329.

Arkan M., Perovic D. K. and Unsworth P. (2001). “Online stator fault diagnosis in induction motors”, IEE Proceedings Electric Power Applications, Vol. 148, No. 6, November, pp. 537-547.

Bellini, A., Filippetti, F., Franceschini, G., Tassoni, C., Kliman, G. B. (2001). “Quantitative Evaluation of Induction Motor Broken Bars by Means of Electrical Signature Analysis”, IEEE Trans. Ind. Applicat. Vol. 37, pp. 1248–1255.

Biju K, Jagadanand G (Member, IEEE), Saly George (2010). “Fault detection of induction motor using Energy and Wavelets”, Proc. of Int. Conf. on Control, Communication and Power Engineering.

Chidong Qiu, Yue Tan. Ren Guang (2009). "An online detection method for incipient motor faults based on multitaper spectrum estimates", 9th International Conference on Electronic Measurement & Instruments, ICEMI '09, pp. 460 - 464.

Faiz, J., Ebrahimi, B.M., Akin, B., Toliyat H.A. (2013). “Dynamic analysis of mixed eccentricity signatures at various operating points and scrutiny of related indices for induction motors”. Electric Power Applications, IET, Vol.4 , No. I, pp. 1 – 16.

Frosini L. and Bassi E. (2011). “Stator current and motor efficiency as indicators for different types of bearing faults in induction motors”, IEEE Transactions on Industrial Electronics, Vol. 57, No. 1, pp. 244-251.

J. R. Bednarczyk (2012). Induction Motor Theory, PDH Center.

Jung J.H.. Lee J.J., and Kwon B.H. (2008). "Online diagnosis of induction motor using MCSA", IEEE Transactions on Industrial Electronics, Vol. 53. No. 6, pp. 1842-1852.

Kliman. G. B. and Stein, J. (1990). "Induction Motor Fault Detection via Passive Current Monitoring," Proceedings of International Conference (ICEM'90), Massachusetts Institute of Technology, Boston, Massachusetts, pp. 13-17.

Lebaroud, A., Bentounsl, A. (2003). "NDT of Faulty Induction Motor, 11th International Symposium on Applied Electromagnetic", ISEM, pp. 12–14 May, Paris, France.

M. El H. Benbouzid (2000). A Review of Induction Motors Signature Analysis as a Medium for Faults Detection, IEEE Transactions on Industrial Electronics, Vol. 47, No. 5.

Neelam Mehla, Ratna Dahiya. "An Approach of Condition Monitoring of Induction Motor Using MCSA". International Journal of system applications, Engineering and Development.

Norman Mariun, Mohammad Rezazadeh Mehrjou (2011). "An Experimental Study of Induction Motor Current Signature Analysis Techniques for Incipient Broken Rotor Bar Detection", International Conference on Power Engineering, Energy and Electrical Drives, Spain.

R. Schoen, B. K. Lin, T. G. Habetler, Jay H. Schlag, and Samir Farag (2006). "An unsupervised, on-line system for induction motor fault detection using stator current monitoring," IEEE Transactions on Industry Applications, Vol. 31, No. 6. Pp. 1280-1286.

Randy R. Schoen, and Thomas G. Habetler (2007). "Effects of time-varying loads on rotor fault detection in induction machines", IEEE Transactions on Industry Applications, Vol. 31, No. 4, pp. 900-906.

Randy R. Schoen, Brian K. Lin. Thomas G. Habetler. Jay H. Schlag, and Samir Farag (2005). "An unsupervised, on-line system for induction motor fault detection using stator current monitoring. IEEE Transactions on Industry Applications, Vol. 31, No. 6, pp. 1280-1286.

Randy R. Schoen, Thomas G. Habetler, Farrukh Kamran and Robert G. Bartheld (2005). "Motor bearing damage detection using stator current monitoring", IEEE Transactions on Industry Applications, Vol. 31, No 6, pp. 1274-1279.

Thomson, W. T. (1999). "A Review of On-Line Condition Monitoring Techniques for Three-Phase Squinrel-Cage Induction Motors — Past, Present, and Future," IEEE Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives, Gijon, Spain, pp. 3-18 (opening keynote address).

Thomson, W. T. (2001). "On-Line MCSA to Diagnose Shorted Turns in Low Voltage Stator Windings of 3-Phase Induction Motors Prior to Failure," Proceedings of IEEE Conference on Electrical Machines and Drives (IEMDC), Massachusetts Institute of Technology, Boston, Massachusetts.

Thomson, W. T. and Barbour, A. (1998). "On-line Current Monitoring and Application of a Finite Element Method to Predict the Level of Airgap Eccentricity in 3-Phase Induction Motors," IEEE Transactions on Energy Conversion, 13, (4), pp. 347-357 (includes discussion and closure).

Thomson, W. T. and Orpin, P. (2002). "Current and Vibration Monitoring for Fault Diagnosis and Root Cause Analysis of Induction Motor Drives," Proceedings of Thirty-First Turbomachinery Symposium, Turbomachinery Laboratory, Texas A&M University, College Station, Texas, pp. 61-67.

W. T. Thomson. D. Rankin, and D. G. Dorrell (2008). "On-line current monitoring to diagnose air-gap eccentricity in large three-phase induction motors-industrial case histories verify the predictions," IEEE Transactions on Energy Conversion, Vol. 14. No. 4, pp. 1372 1378.

Corresponding Author

Jasani Chiragkumar Natvarlal*

Research Scholar, OPJS University, Rajasthan

E-Mail – chiragjasani@yahoo.com