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Detection of Bearing Fault of Induction Motor using Signature Analysis

Pratik W. Choudhary
Asst. Professor
MGI-COET,
Shegaon
c.pratik55@gmail.com

Dhiraj Arun Tikar
Asst. Professor
STC,SERT,
Khamgaon.
d.tikar@gmail.com

Digambar R. Bhise
Asst. Professor
STC,SERT,
Khamgaon.
digambar8021@gmail.com

Abstract-The consistency of an induction motor is very much important in industrial, commercial, aerospace and military applications. Bearing play a vital role in the reliability and performance of all motor. Most faults occur in induction type motors are repeatedly connected to the bearing faults.The bearing faults are created in the laboratory by drilling the outer and inner race of ball bearing by using electric discharge machine. FFT is used to transform the time domain to Frequency for effective bearing fault analysis.Matlab software is used for fault analysis.

Keywords- *Induction motor, Bearing Faults, FFT, Fault Analysis.*

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I. INTRODUCTION

Electrical machines are extensively used and core of most engineering system. Induction motor has been used in all kinds of industries. An induction motor 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.Most of the faults occur in 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%).As we have seen that most frequent fault that are occurring in three phase induction motor are bearing fault. Hence we go for the bearing fault detection in three phase induction motor.

Randy R. Schoen et.al.[08] 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 vibration and current frequencies. The test results clearly illustrate that the stator current signature can be used to identify the presence of a bearing fault.

II. BEARING FAULT

Generally speaking, a bearing is a device that is used to enable rotational or linear movement, while reducing friction and handling stress. Resembling wheels, bearings literally enable devices to roll, which reduces the friction between the surface of the bearing and the surface it's rolling over. It's significantly easier to move, both in a rotary or linear fashion, when friction is reduced this also enhances speed and efficiency. Bearing types are as Ball Bearing, Roller Bearing, Ball Thrust Bearing, Roller Thrust Bearing, and Tapered Roller Bearing.

A continued stress on the bearings causes fatigue failures, usually at the inner or outer races of the bearings. Small pieces break loose from the bearing, called flaking .These failures result in rough running of the bearings that generates detectable vibrations and increased noise levels. This process is helped by other external sources, including contamination, corrosion, improper lubrication, improper installation, and brinelling. The shaft voltages and currents are also sources for bearing failures. High bearing temperature is another reason for bearing failure; the IEEE 841 standard specifies that the stabilized bearing temperature rise at rated load should not exceed 45 degree. The bearing temperature rise can be caused by degradation of the grease or the bearing. The factors that can cause the bearing temperature rise include winding temperature rise, motor operating speed, temperature distribution within motor, etc. Therefore, the bearing temperature measurement can provide useful information about the machine health and bearing health.

Some sources such as contamination, corrosion, improper lubrication, and improper installation reduce the bearing life.

Bearing faults can be categorized into distributed and localized defects are as

- Outer raceway defect
- Inner raceway defect
- Ball defect
- Cage defect

In this paper, condition monitoring and fault detection of induction motors is based on the signal processing techniques. The signal processing techniques have advantages that these are not computationally expensive and these are simple to implement. Therefore, the aim of this paper is to utilize the various signal processing techniques for detection of common faults of induction motor.

The main aim of the research work is to diagnose the bearing fault experimentally with suitable signal processing techniques. It is observed that most of the work available in literature is based on MATLAB programming which may be difficult at online monitoring bearing defects are replicated in the laboratory.

III. METHODS & ANALYSIS

A fast Fourier transform (FFT) is an algorithm to compute the discrete Fourier transform (DFT) and its inverse. There are many different FFT algorithms involving a wide range of mathematics. The DFT is obtained by decomposing a sequence of values into components of different frequencies. This operation is useful in many fields but computing it directly from the definition is often too slow to be practical. An FFT is a way to compute the same result more quickly). This huge improvement made the calculation of the DFT practical; FFTs are of great importance to a wide variety of applications, from digital signal processing and solving partial differential equations to algorithms for quick multiplication of large integers.

An FFT computes the DFT and produces exactly the same result as evaluating the DFT definition directly; the only difference is that an FFT is much faster. (In the presence of round-off error, many FFT algorithms are also much more accurate than evaluating the DFT definition directly, as discussed below.) Let x0, ..., xN-1 be complex numbers. The DFT is defined by the formula

$$Xk = \sum X\,n \times e^{-2\pi kn/N}$$

In symmetrical component analysis, here we have calculated only the negative sequence component because when the fault is occurring on the bearing, eccentricity of the rotor is going to be changed. Due this flux density in the air gap is changed. It leads to the unbalance condition. Negative sequence of current is calculated as follows:-

$$V_{abc} = AV_{012}$$

LABORATORY SET UP AND EXPERIMENTATION

Fig. 1 Laboratory set up

Fig.1 shows the set up used for the experimental purpose. Main fed 2 Hp, 3 phase,50 Hz squirrel cage induction motor made by leading electrical industry has been used for the analysis of bearing faults .The dc Generator set is use for Electrical loading. The Motor comprise of two bearing numbered as a 6205, 6206. The bearings having natural defects caused by the regular operation of motor were used in the experimental study. The motor is fitted with different combination of bearing having inner race & outer race defects. Stator current and phase voltage of the motor for each combination of bearing is then captured in order to compare with the healthy bearing. Different experiments were conducted with different combination of rear side and load side bearing to access the performance of these bearings and its effects on the performance of the motor. Three currents Ia, Ib, Ic and voltage Va were captured using experimental set up shown above

The Tektronix DSO, TPS 2014 B, with 100 MHz bandwidth and adjustable sampling rate of 10 kHz is used to capture the currents. The Tektronix current probes of rating 100 mV/A, input range of 0 to 70 amperes AC RMS, 100 peak and frequency range dc to 100 kHz are used. Approximately, 500 sets of signal were captured on different load conditions and different main supply condition.

IV. RESULT AND DISCUSSION

In the initial phase of study, we present experimental results obtained from the analysis of electrical current of a test machine equipped with faulty and healthy bearing carrying artificial inner and outer raceway defects. We also conducted tests with industrially used bearings called “real defect” in the following which were replaced due to an unknown fault type problem. Now from the experimentation as explained in the above section we have got different set of readings. With the help of these readings we have plot different waveforms in using Matlab. Pattern of these waveform are as follows

Observation at No Load Condition

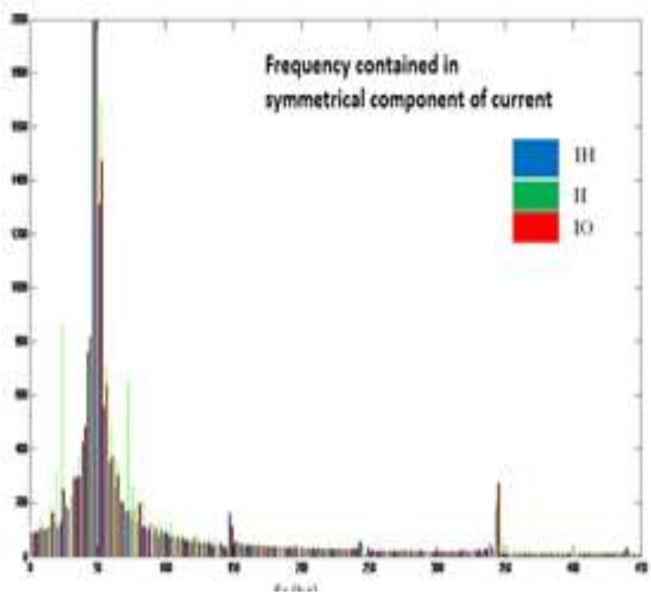

Fig. 2 Bar Graph of Symmetrical Component at No Load

Table1:- Frequency Contend In Symmetrical Component at No Load

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COMPO--NENTS	HEALTHY	INNER RACE WAY	OUTER RACE WAY
3rd	X = 148	X = 148	X = 148
	Y = 163	Y = 10	Y = 14.1
5th	X = 248	X = 248	X = 248
	Y = 140	Y = 15.3	Y = 66.1
7th	X = 348	X = 348	X = 348
	Y = 116	Y = 27.1	Y = 11.7

At no load condition, we have seen that magnitude of different harmonics present in current signal at healthy condition of the bearing is maximum as compare to inner race way & outer race way fault.

Observation at Full Load condition

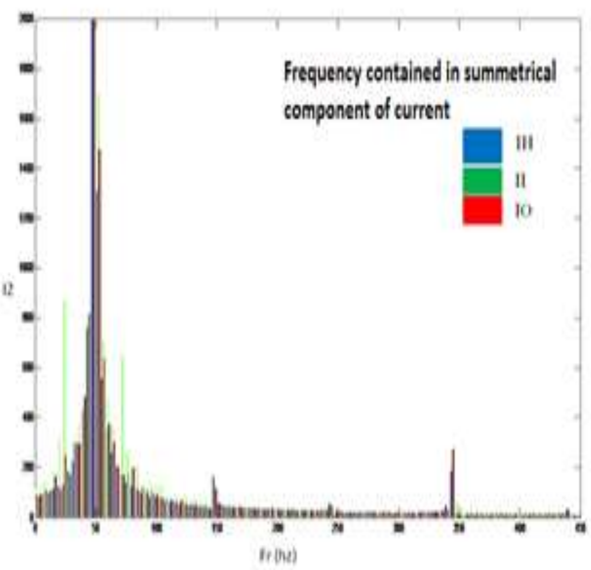

Fig. 3 Bar Graph of Symmetrical Component at Full Load

Table2:- Frequency Contend In Symmetrical Component at Full Load

COMPO-NENT	HEALTHY	INNER RACE WAY	OUTER RACE WAY
3rd	X = 148	X = 148	X = 148
	Y = 140	Y = 26.7	Y = 126
5th	X = 248	X = 248	X = 248
	Y = 98.5	Y = 31.4	Y = 282
7th	X = 348	X = 348	X = 348
	Y = 103	Y = 59.7	Y = 154

At FL also, we have observed that the magnitude different harmonics in case of outer raceway fault is maximum as compare to inner race way fault. So from this observation at different loading condition, we can say that fault is occurring on the outer raceway so finally from symmetrical component we are able to discriminate between faulty and healthy condition of the bearing.

V. CONCLUSION

In this paper work the method based on the signature analysis for the detection and classification is introduced.The method uses stator current of any one phase for analysis purpose in different phases for detection of bearing race defects in induction motor.It is found that the method can exactly discriminate between the healthy and faulty condition of bearing at different load condition.

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