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Condition Monitoring of Induction Motor Using FFT Analyzer by Vibration Technique Cause Due to Bearing Fault

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1. INTRODUCTION

All machines with moving parts give rise to sound and vibration. Each machine has a specific vibration signature related to the construction and the state of the machine. If the state of the machine changes the vibration signature will also change. A change in the vibration signature can be used to detect incipient defects before they become critical. This is the basics of many condition monitoring methods. Condition monitoring can save money through increased maintenance efficiency and by reducing the risk of serious accidents by preventing breakdowns. The use of vibration analysis as one of the fundamental tools for condition monitoring has been developed extensively over a period of approximately 35 years. With the parallel developments in electronic equipment, transducers, computers and software nowadays machine supervision is almost completely automated. In the present work the authors present a review of a variety of diagnosis techniques for bearing fault identification with particular regard to vibration analysis. Examples of widely used techniques for bearing are such as Waveform analysis, Time-Frequency analysis, Faster Fourier Transform (FFT), Spectral analysis, Order analysis, Time Synchronous Average, and probability density moments. These vibration based diagnosis techniques has been the most popular monitoring technique because of ease of measurement. Vibration analysis was used former mainly to determine faults and critical operation conditions. Nowadays the demands for condition monitoring and vibration analysis are no more limited trying to minimize the consequences of machine failures, but to utilize existing resources more effectively. [02]

2. LITRETURE SURVEY

1. Saikat Kumar Shome, Uma Datta, S.k.Vadali.

In this paper, vibration analysis has been one of the few important approaches for motor failure detection. However, vibration sensory signals are often corrupted with random noise, processing of which leads to inaccurate results. Thus, there is a necessity of low cost instrumentation with proper filtering capabilities for online vibration measurement which can be permanently fixed to the machine under test (MUT) for continuous monitoring and reliable diagnosis. The present work compares three signal averaging based filtering techniques for the purpose of analysis. The filters have been implemented in Field Programmable Gate Arrays (FPGA) which are characterized by reduced power consumption and high operational speed for real time applications. CM by vibration analysis a technique of growing importance .It is felt that available spectral vibration analysis are not highly reliable in noisy scenario .FPGA is better diagnostic than FFT based vibration analysis. FPGA produced latency problem this is limitation. [1]

2. Mariana Iorgulesc, Robert Beloiu.

In this paper, the vibration and current of an induction motor are analyzed in order to obtain information for the detection of bearing faults. Significant vibration and current spectrum differences between healthy motor and motors with fault bearing are observed. The high frequency spectral analysis of vibration and current provides a method to detect bearing faults. The effectiveness of the diagnosis system is demonstrated through staged motor faults of electrical and mechanical origin.

The technique of evaluating the motor condition by performing a FFT of the induction motor vibration has been verified by the experimental results. In this case electric motor vibration motorizing is very useful to detect bearing fault. So, the plant maintenance can easily and successfully detect mechanical fault that lead to unexpected downtime. A diagnostic procedure using a neural network is described and it is obvious that the development of the neural network and its learning process need a lot of work, but the results are applicable in industry with success. [4]

3. Asaad Musaab Ali Yousif, Adamu Halilu Jabire, Gsimalseed Ali Gsimalseed Gsimalla

In this paper, describes the design and implementation of induction motors breakdown observation based on atmega32 microcontroller. This paper proposes an approach to good motor protection. this has to cover all possible problem areas. It must not be tripped before the motor is put at risk, if the motor is put at risk, the protection device has to operate before any damage occurs, If damage cannot be prevented, the protection device has to operate quickly in order to restrict the extent of the damage as much as possible. Protection and controls the motor from the Phase failure, unbalanced voltage and phase sequence is one of the major functions of most control systems. The experiment showed that the system for protection and controlling induction motor can be used stably and reliably.

The main objective of this system is to protect the motor from phase failure, phase unbalance and phase in sequence which can be achieved using microcontroller atmega8. All the manual operations are replaced by sending signals from the microcontroller to the main contractor. The working of the design can be classified into four phases:-1.phase sequence identification [B]phase failure and phase unbalance identification [C]User Interface Panel [D]Microcontroller processing.[5]

4. Sibu Thomas, Nishi Shahnaj Haider.

In this paper, describes about a spectrum analyzer that how a Spectrum analyzer usually display raw ,unprocessed signal information such as voltage, power, period, wave shape, sidebands, and frequency. Also it discusses its function and requirement of a spectrum analyzer in signal analysis. Also it discusses the types of spectrum analyzer and their various applications in factories and in laboratories.

Frequency limitations: The main limit of the frequency and bandwidth of FFT spectrum analyzers is the analogue to digital converter, ADC that is used to convert the analogue signal into a digital format. While technology is improving this component still places a major limitation on the upper frequency limits or the bandwidth if a down-conversion stage is used. The high level of performance required by the ADC means that this item is a very high cost item. In addition to all the other processing and display circuitry required, this results in the costs rising for these items.[6]

5. Castelli Marcelo, Juan Pablo Fossatti and José Ignacio Terra.

In this paper, the FFT (Fast Fourier Transform) can be used for on-line failure detection of asynchronous motors. In this work a methodology is described for the most likely to happen faults in induction motors: broken rotor bars, bearing damage, short circuits and eccentricity. In industrialized countries, induction motors are responsible for the 40% to 50% of energy consumption. The electric motors in most cases are responsible for the proper functioning of the productive system. In this line, the corrective maintenance of equipment is very expensive since it involves unscheduled downtime and damage to the production process caused by equipment failures. Nowadays, there are many published techniques and allowed commercial tools for the induction motors failure detection.

The main objective of this work has been to determine a monitoring and diagnosis methodology for asynchronous motors which can be applied at the industrial level. The proposed system is able to ascertain the exact value of the harmonic in study regardless of the sampling time. This methodology gives encouraging results. In this way, the study of the growth tendencies of failures is easier. Also a practical slip estimation method for these motors has been introduced. This method requires minimum sensitization and the no need to remove the motor while doing the tests.[7]

6. Neelam Mehala, Ratna Dahiya.

In this paper, presents an experimental study to diagnose the bearing fault with help of Park’s vector approach. The experiment is conducted on 0.5 hp three phase induction motor. The bearing faults are replicated in the laboratory by drilling the outer and inner race of ball bearing with help of electric discharge machining. The Lab VIEW software is used in the experiment to acquire the signal. The acquired signal is analyzed with Park vector approach. The current Park’s vector presentation is generated by programming in Lab VIEW.

The practical results show that Park’s Vector approach is an effective technique to diagnose the bearing fault at early stage. The bearing fault can be clearly observed by comparing the shape of current pattern of faulty and healthy motor. Based on this approach, different patterns may be obtained for different faults. In further works the above described method may be extended also to diagnose the other faults of induction motor.[8]

7. Anant G. Kulkarni, Dr. Manoj Jha, Dr. M. F. Qureshi.

In this paper, Simulation of fault diagnosis of induction motor based on spectral analysis of stator current signal using Fast Fourier Transform (FFT) is proposed in this paper. System of current recognition is based on a study of the frequency spectrum of stator using FFT current signal. Turn-Turn short in one phase winding, break in stator winding, unbalance in input voltage, and open phase fault of induction motor is studied and result obtained with the help of FFT. The results confirm that the system can be useful for detecting damage and protect the engines. The failure identification techniques applied for condition monitoring of the motor is studied. The modelling of three-phase induction motor in three phase reference frame using MATLAB 7 version software and designing an intelligent system for condition monitoring of the induction motor is proposed.[9]

8. Neelam Mehala

This paper investigates the feasibility of detecting the bearing failure using the spectrum of single phase of the stator current of an induction motor. The signal processing technique (Fast Fourier Transform) is used to detect the bearing faults of motor. Experimental results show that the characteristic frequencies could not see in the power spectrum if outer race fault and inner race fault is small in size. As severity of fault increases, the characteristic frequencies become visible. It is clear from the experimental results that FFT based spectral analysis may be adequate to indicate the presence of bearing faults of induction motors. This may be achieved at relatively low cost, eliminating need for expensive spectrum analyzers.[10]

3. CONDITION MONITORING OF INDUCTION MOTOR

Condition monitoring is the process of monitoring a parameter of condition in machinery (Vibration, temperature, acceleration, amplitude etc.), in order to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. The use of conditional monitoring allows maintenance to best scheduled or other actions to be taken to prevent failure and avoid its consequences. Condition monitoring has a unique benefit in that conditions that would shorten normal life span can be addressed before they develop into a major failure. Condition monitoring techniques are normally used on rotating equipment and other machinery (pumps, electric motors, internal combustion engines, presses)[8]

3.1 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.

3.2 Condition monitoring technology

The following list includes the main condition monitoring techniques applied in the industrial and transportation sectors:

- Vibration condition monitoring and diagnostics
- Thermal monitoring
- Torque monitoring
- Noise monitoring
- Electrical monitoring
    1. Current signature analysis
    2. Wavelet analysis

3.2.1 Vibration condition monitoring

Vibration control and vibration diagnostics are different practical problems. For diagnostics, often both the vibration-acceleration and the vibration-velocity are measured in restricted low frequency ranges.

Most vibration measurements usually use sensors of Vibration-acceleration that work based on the piezoelectric effect. For this type of sensors the output electric charge is proportional to the force applied to the sensor. The vibration signal is converted in electric signals. It is necessary to analyze this signal without loosing the diagnostic information. There are very strict requirements for the analyzing instruments. The operations that the vibration analyzing instruments must perform are the following:

1. Measurement of overall vibration level in a standard frequency range and using the units required by these standards.

2. Spectral analysis of the vibration, by using FFT.

3. Analysis of the oscillation power of separate vibration components extracted preliminary from the vibration signal. The analysis of the spectrum of random high frequency vibration signal is usually used.

This technique depends upon locating by spectrum analysis specific harmonic components in the line current produced of unique rotating flux components caused by faults such as broken rotor bars, air-gap eccentricity and shorted turns in stator windings, etc. Note that only one current transducer is required for this method, and it can be in any one of the three phases. The motor current signature analysis method can detect these problems at an early stage and thus avoid secondary damage and complete failure of the motor. Another advantage of this method is that it can be also applied online. Experiments were conducted on defective bearings with scratches on the outer races and bearing balls an cage defects. It has been claimed that all defective measurements were correctly classified as defective However; the detection procedure required extensive training for feature extraction.[8]

4. FAILURES IN INDUCTION MOTOR

4.1 Introduction

The detection of common faults of induction motor with help of signal processing techniques is main focus of this research. A variety of faults can occur within three phase induction motor during the course of normal operation. These faults can lead to a potentially catastrophic failure if undetected.

Consequently, a variety of condition monitoring techniques has been developed for the analysis of abnormal condition. Signal processing techniques are also very effective for fault detection. Due to continuous advancement of signal processing techniques and related instruments, online monitoring with signal processing techniques has become very efficient and reliable for electrical machines. The objective of this chapter is top present the classification of single phase induction motor faults and various advanced signal processing techniques.

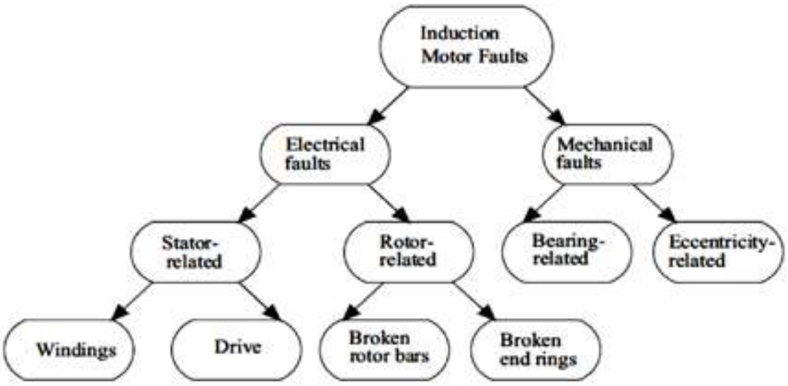

Fig 4.1- classification of failures

4.2 Failures in induction motors

Most failures in induction motors can be classified in two main groups: isolation failures and mechanical failures (Botha, 1997).Isolation failures are commonly characterized by stator coils short-circuits, while mechanical faults are commonly associated to rotor or rotor related damage. The most important mechanical failures are: rotor broken bars and rings, bearings damage, irregular gaps (static and dynamics eccentricities), unbalances, refrigeration troubles, etc.[12]

In general, faults in electrical machines are dominated by failures in bearings and stator coils. Focused on asynchronous motors with squirrel cage rotor failure statistics are the following (Fig. 4.2) (Thomson & Fencer, 2001):[12]

- Bearings fault related: 41%
- Stator faults related: 37%
- Rotor faults related: 10%
- Other problems: 12%

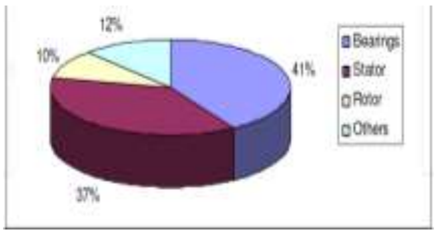

Fig. 4.2- Failures statistics in induction motors

4.3 Faults in induction motors

Short turn winding faults, rotor faults, bearing faults, gear fault and misalignment are common internal faults of induction motor. The common internal faults can be mainly categorized into two groups:

• Mechanical faults

• Electrical faults

4.4 Mechanical faults

Common mechanical faults found in three phase induction motor are discussed below:

i) Air gap eccentricity

ii) Bearing faults

iii) Load faults

4.4.1 Air gap eccentricity

Air gap eccentricity is common rotor fault of induction machines. This fault produces the problems of vibration and noise. In a healthy machine, the rotor is centre-aligned with the stator bore, and the rotor's centre of rotation is the same as the geometric centre of the stator bore. When the rotor is not centre aligned, the unbalanced radial forces (unbalanced magnetic pull or UMP) can cause a stator-to-rotor rub, which can result in damage to the stator and the rotor. There are three types of air gap eccentricity:

- Static eccentricity
- Dynamic eccentricity
- Mixed eccentricity

Static eccentricity is a steady pull in one direction which creates UMP. It is difficult to detect unless special equipment used.

A dynamic eccentricity on the other hand produces a UMP that rotates at the rotational speed of the motor and acts directly on the rotor. This makes the UMP in a dynamic eccentricity easier to detect by vibration or current monitoring. Actually, static and dynamic eccentricities tend to coexist.

Ideal centric conditions can never be assumed. Therefore, an inherent grade of eccentricity is implied for any real machine. The combined static and dynamic eccentricity is called mixed eccentricity.[8]

4.4.2 Bearing faults

Bearings are common elements of electrical machine. They are employed to permit rotary motion of the shafts. In fact, bearings are single largest cause of machine failures. According to some statistical data, bearing fault account for over 41% of all motor failures. Bearing consists of two rings called the inner and the outer rings. A set of balls or rolling elements placed in raceways rotate inside these rings. 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 or sapling. 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. These shaft voltages and currents result from flux disturbances such as rotor eccentricities. High bearing temperature is another reason for bearing failure. Bearing temperature should not exceed certain levels at rated condition. For example, in the petroleum and chemical industry, 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.[8]

A fault in bearing could be imagined as a small hole, a pit or a missing piece of material on the corresponding elements. Under normal operating conditions of balanced load and a good alignment, fatigue failure begins with small fissures, located between the surface of the raceway and rolling elements, which gradually propagate to the surface generating detectable vibrations and increasing noise levels. Continued stress causes fragments of the material to break loose, producing localized fatigue phenomena known as flaking or spilling. Once started, the affected area expands rapidly contamination the lubricant and causing localized overloading over the entire circumference of the raceway. Some sources such as contamination, corrosion, improper lubrication, improper installation or drivelling reduce the bearing life. Contamination and corrosion are the key factors of bearing failure because of the harsh environments present in most industrial settings. The lubricants are contaminated by dirt and other foreign matter that are commonly often present in the environment of industries. Bearing corrosion is produced by the presence of water, acids, deteriorated lubrication and even perspiration from careless handling during installations. Once the chemical reaction has advanced sufficiently, particles are worn-off resulting in the same abrasive action produced by bearing contamination. Under and over-lubrication are also some other causes of bearing failure. In either case, the rolling elements are not allowed to rotate on the designed oil film causing increased levels of heating.

4.2 Induction Motors Bearing Failures Detection and Diagnosis:

Bearings deterioration is now the main cause of rotor failures. The main factor of bearing faults is dust and corrosion. Induction motors are often operated in hard conditions. That is why foreign materials, water, acid and humidity are the main reasons of bearing deteriorations. Contamination and corrosion frequently accelerate bearing failures because of the harsh environments present in most industrial settings. Dirt and other foreign matter that is commonly present often contaminate the bearing lubrication.

The abrasive nature of this minute particles, whose hardness is vary from relatively soft the diamond like, cause pitting and sanding actions that give way to measurable wear of the balls and raceways. Bearing corrosion is produced by the presence of water, acids, deteriorated lubrication and even perspiration from careless handling during installations. Once, the chemical reaction has advanced sufficiently, particles are worn off resulting in the same abrasive action produced by bearing contamination. Improper lubrication includes both under and over lubrication. In either case, the rolling elements are not allowed to rotate on the designed oil film causing increased levels of heating. The excessive heating causes the grease to break down, which reduces its ability to lubricate the bearing elements and accelerates the failure process.[11]

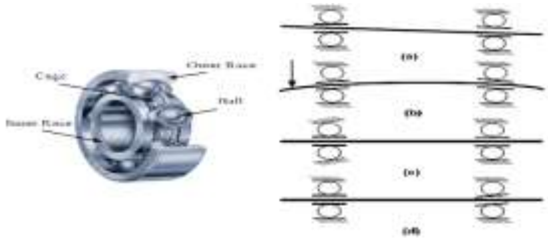

Fig 4.4 bearing failure detection

5. VIBRATION

5.1 What is Vibration?

Vibrations are mechanical oscillations about an equilibrium position. There are cases when vibrations are desirable, such as in certain types of machine tools or production lines. Most of the time, however, the vibration of mechanical systems is undesirable as it wastes energy, reduces efficiency and may be harmful or even dangerous. For example, passenger ride comfort in aircraft or automobiles is greatly affected by the vibrations caused by outside disturbances, such as aero elastic effects or rough road conditions. In other cases, eliminating vibrations may save human lives; a good example is the vibration control of civil engineering structures in an earthquake scenario.

All types of vibration control approaches—passive, semi-active and active— require analyzing the dynamics of vibrating systems. Moreover, all active approaches, such as the model predictive control (MPC) of vibrations considered in this book require simplified mathematical models to function properly. We may acquire such mathematical models based on a first principle analysis, from FEM models and from experimental identification. To introduce the reader into the theoretical basics of vibration dynamics, this chapter gives a basic account of engineering vibration analysis.

There are numerous excellent books available on the topic of analyzing and solving problems of vibration dynamics. This chapter gives only an outline of the usual problems encountered in vibration engineering and sets the ground for the upcoming discussion. For those seeking a more solid ground in vibration mechanics, works concentrating rather on the mechanical view can be very valuable such as the work of de Silva and others. On the other hand, the reader may get a very good grip of engineering vibrations from the books discussing active vibration control such as the work of Inman and others.[13]

5.2 Causes of vibration

There are various sources of vibration in an industrial environment:

(a) Impact processes such as pile driving and blasting.

(b) Rotating or reciprocating machinery such as engines, compressors and motors.

(c) Transportation vehicles such as trucks, trains and aircraft.

(d) Flow of fluids through pipes and without pipes.

(e) Natural calamities such as earthquakes.[14]

5.3 The harmful effects of vibration

There are various harmful effects of vibration:

(a) Excessive wear of bearings.

(b) Formation of cracks in machines, buildings and structure, etc.

(c) Loosening of fasteners in mechanical systems.

(d) Structural and mechanical failures in machines and buildings.

(e) Frequent and costly maintenance of machines.

(f) Electronic malfunctions through failure of solder joints.

(g) Abrasion of insulation around electric conductors, causing soot.

(h) The occupational exposure of humans to vibration leads to pain, discomfort and reduction in working efficiency. [14]

6. EXPERIMENTAL SET UP:

6.1 Components-

1. Induction motor
2. Foundation
3. FFT channel
4. Accelerometer

6.1.1 Specification of components-

6.1.1.1 Induction motor-

Fig 6.1-Induction Motor

• Power range-	0.5HP
• Voltage range-	200-240 volt
• Frequency-	50Hz
• Phase-	single phase AC power
• motorSpeed-	4 pole
• Motor type-	squirrel cage ind. Motor
• Rpm-	1440

6.1.1.2 Foundation

Fig 6.2- Foundation of Induction Motor

- Dimension- 35cm*35cm*5cm
- Material- wood
- Mounting- foot mounting
- Nut & bolt- hexagonal head

6.1.1.3 FFT channel

Fig 6.3 - FFT channel

- Analog to digital converter
- channel

6.1.1.4 Accelerometer

Fig 6.4 – Accelerometer

- Model- 7105A-0050
- Serial no- A135067
- Sensitivity- 101.6 mV/g
- Bias voltage- 10.2 Vdc
- Material- Piezo ceramic

6.2 Set up:

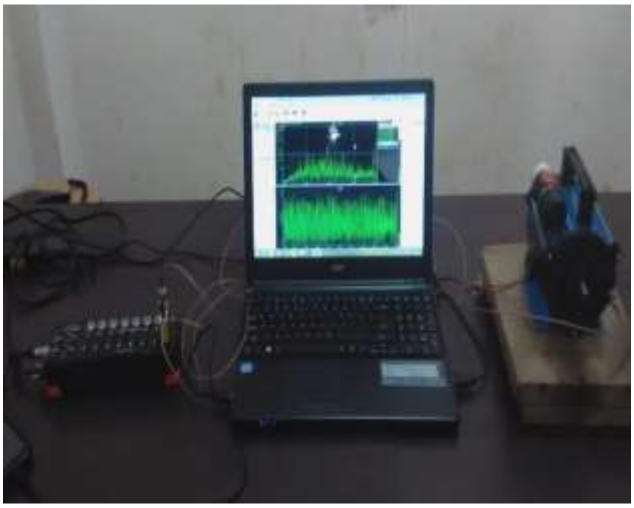

Fig 6.5 - Experimental setup

In order to diagnose the fault of induction motor with high accuracy, a modern laboratory test bench was set up as in figure. It consists of an electrical machine, piezoelectric accelerometer, FFT, computer (PC), Induction motor, wooden foundation.

Ball bearing 6202-Z specifications:

- Number of ball element: 8
- Pitch diameter: 29.75 mm
- Ball diameter: 6.35 mm

6.3 Procedure-

6.3.1 First position-

In first position, the accelerometer is placed on casing on the upper most side of shaft.

6.3.1.1 Healthy motor-

Take induction motor which does not have any fault. The accelerometer sensor placed on casing. One precaution is taken while placing of sensor there is no air gap present in between sensor and position. The surface of motor is cleaned by cotton cloth.

i) The motor is placed on the wooden block on foundation with the help of nut and bolt.

ii) The accelerometer sensor sense the physical vibration of motors which having analogy type signal. This signal is transfer to FFT channel. The channel converts analogy signal into digital signal. This signal pattern is shown on the screen of computer. The pattern shows amplitude (acceleration) vs. frequency. this pattern note as a healthy signature of induction motor

6.3.1.2 Faulty motor-

After that healthy bearing is replaced by faulty bearing and similar procedure taken and this is noted as a faulty signature of induction motor of first position. Note that position of accelerometer same while conducts the experiment and reading are taken.

6.3.2 Second position-

By placing the accelerometer is on the right hand side of shaft. Same procedure is taken for healthy and faulty motor. The pattern of healthy and faulty motor signals is noted down from software.

6.4 System representation using DEWE soft programming:

The purpose of experimental set up is to measure the induction motor stator vibration by using FFT analyzer and to analyse these data determining the fault frequencies on the bearing. The vibrations that flow in the induction motor are sensed by piezoelectric accelerometer. This vibration is supplied to piezoelectric accelerometer. Piezoelectric accelerometer is connected to 8 channel FFT analyzer which sense the vibration and send to personnel computer. The digitalized vibration signal is applied to the low pass current filter to remove the undesirable high frequency components. The 'DEWE Soft programme' converts the sampled signal to the FFT representation. The FFT representation is generated using advanced signal processing module of DEWE Software. DEWE Software for FFT analyzer Approach is shown in figure.

Fig 6.6- Channel FFT set up

In this study, 0.5 hp four pole induction motor was used whose parameters are given in Table. The motor is attached with a piezoelectric accelerometer by means of 8 channels FFT. The nominal current is 1.05 A when star connected to 230 V. The bearing of the induction motor are single row, deep groove ball bearing, and type 6202Z. Each bearing has eight balls. Experiments were conducted on two bearings: one of these is undamaged while one bearing was damaged. One bearing was made fail by drilling the hole in its outer race. Electric Discharge Machine is used to drill the hole in inner and outer race. The damaged bearings were installed on motor one bygone. Figure show the Faulty bearing which were replicated in laboratory.

Fig 6.7- Faulty bearing

7. EXPERIMENTAL OBSERVATIONS AND DISCUSSION:

The FFT approach is a relatively effective technique which has been successfully applied in the steady state diagnosis of bearing faults. The analysis of the signal-phase induction motor can be simplified using the piezoelectric accelerometer. The method is based on the visualization of the motor vibration representation. If this is a perfect constant wave nature the machine can be considered as healthy. If an un-regular wave pattern is observed for this representation, the machine is faulty. From the characteristics of the wave the fault's type can be established.

The induction motor was initially tested with undamaged bearings in healthy motor order to plot FFT pattern. Afterwards, it was tested with the one artificial deteriorated bearing. One bearing is made to fail in experiments by wear out condition i.e., sliding motion present between inner race and outer race. A time window was used for all data acquisition in order to get simple and sufficient detailed pattern. The sample rate was 10000sample/sec. The number of samples was taken 500. The above fig shows the DEWE Software programming for 8 channel FFT approach. The following Fig shows the current pattern for motor with healthy bearing. It could be seen that current pattern for faulty motor is clearly different from vibration pattern of the healthy motor. The shape of the vibrations phase in fig is not of perfect same shape, which indicates bearing fault in the squirrel cage induction machine. This clearly shows the diagnosis capability of the FFT approach .While conducting experiment one important precaution is to be taken that there should no air gap present between piezoelectric accelerometer and motor.

7.1 Position no 1:-

By placing the piezoelectric accelerometer is to upper most position of shaft on casing.

7.1.1 Time-Response Observation:-

1. Table for Average Acceleration

Sr No	Time	good	Faulty
	S	m/s2	m/s2
1	0	0.012737	0.018506
2	2	-0.00331	-0.00934
3	4	-0.00545	-0.004
4	6	0.000766	-0.00014
5	8	-0.00148	0.003917
6	10	0.001211	-0.00591
7	12	0.001763	0.005223
8	14	-0.00912	0.000385
9	16	0.005795	-0.01131
10	18	-0.00372	0.006349
11	20	0.006812	-0.00531
12	22	-0.0077	0.005143
13	24	0.007935	0.001118
14	26	0.002188	0.007985
15	28	-0.00685	-0.00374
16	30	0.004732	0.003328

17	32	-0.00746	-0.00697
18	34	0.006944	0.003104
19	36	0.00741	0.002605
20	38	-0.0092	-0.00412

1. Table for RMS Acceleration-

Sr No	Time S	good m/s2	faulty m/s2
1	0	0.829179	4.574765
2	2	0.827235	4.371129
3	4	0.826993	4.620824
4	6	0.827287	4.416219
5	8	0.833093	4.639552
6	10	0.832715	4.371032
7	12	0.83282	4.543715
8	14	0.835475	4.145731
9	16	0.841893	4.225352
10	18	0.841432	4.080285
11	20	0.840394	4.139463
12	22	0.842224	4.135309
13	24	0.837231	4.156354
14	26	0.836577	4.228223
15	28	0.833043	4.119766
16	30	0.831554	4.180441
17	32	0.839018	3.961032
18	34	0.84307	4.14881
19	36	0.848396	3.881987
20	38	0.820347	4.106289

7.1.1.2 Graphical representation between good and faulty motor (position 1):-

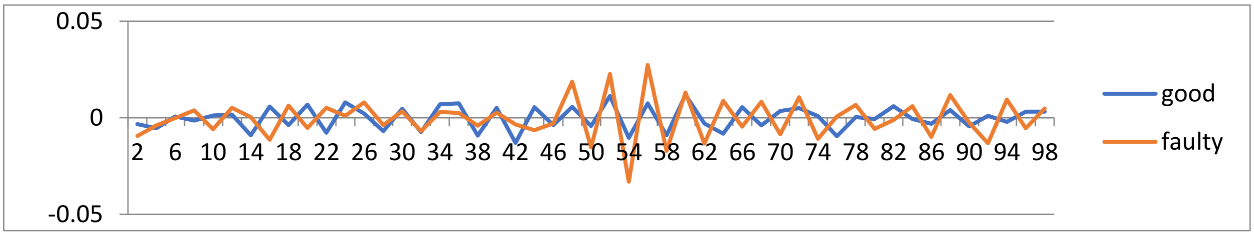

Fig 7.1- Average graph of response vs. time

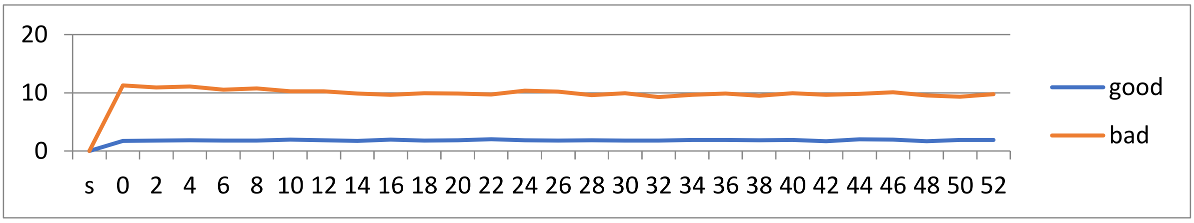

Fig 7.2- RMS graph of response vs. time

7.1.2 Frequency response:-

1. for healthy signal:-

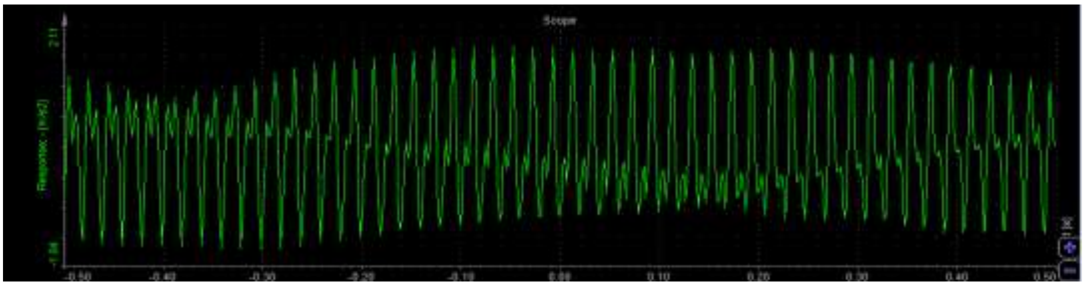

Fig 7.3-Vibration of scope

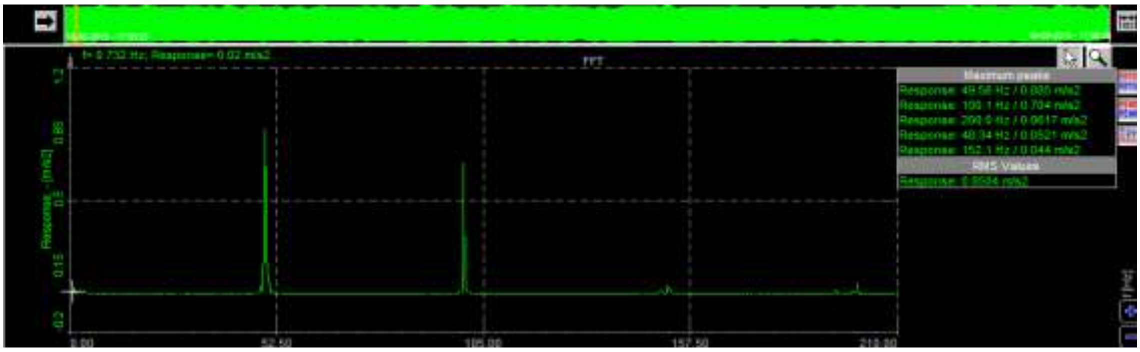

Fig. 7.4-FFT signal of vibration of Induction motor

2. for faulty (Bearing failure):-

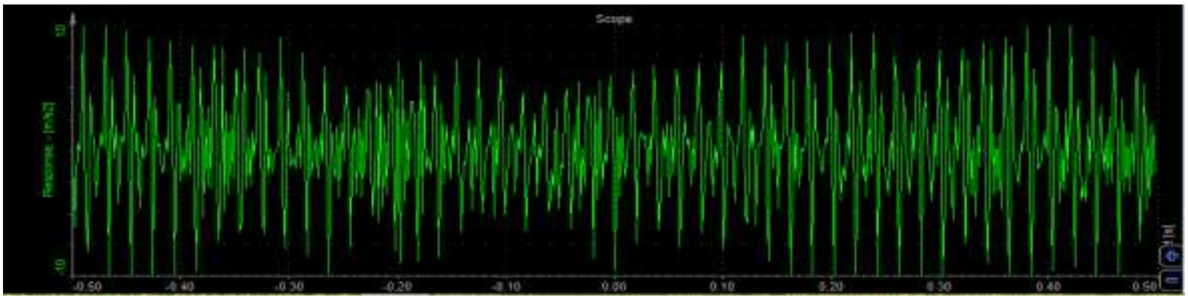

Fig 7.5-Vibration of scope for faulty condition

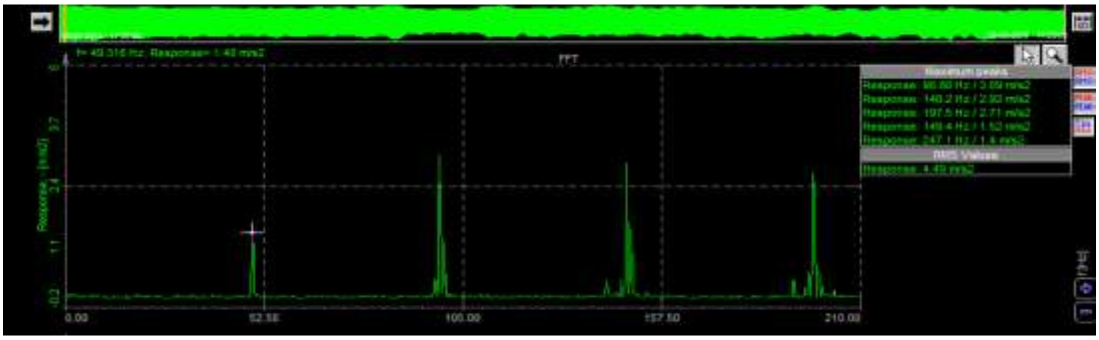

Fig 7.6-FFT signal of vibration of Induction motor for faulty condition

7.2.2 Frequency response:

1. for healthy signal:-

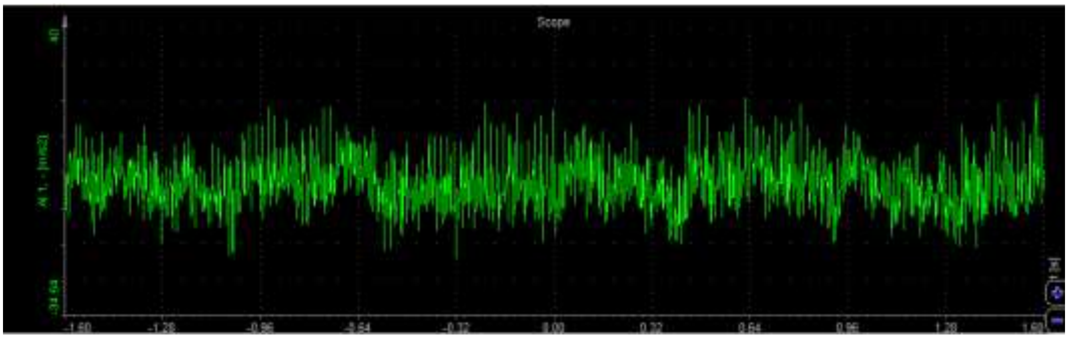

Fig 7.9-Vibration of scope

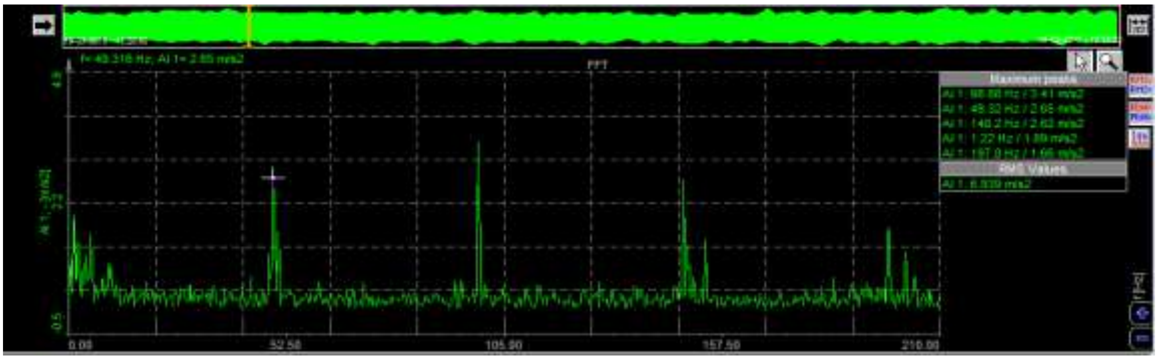

Fig 7.10-FFT signal of vibration of Induction motor

2. for faulty (Bearing failure):-

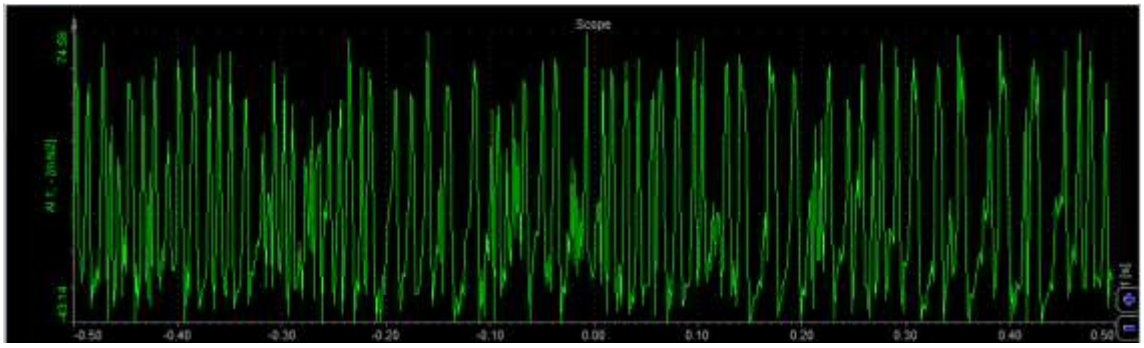

Fig 7.11-Vibration of scope for faulty condition

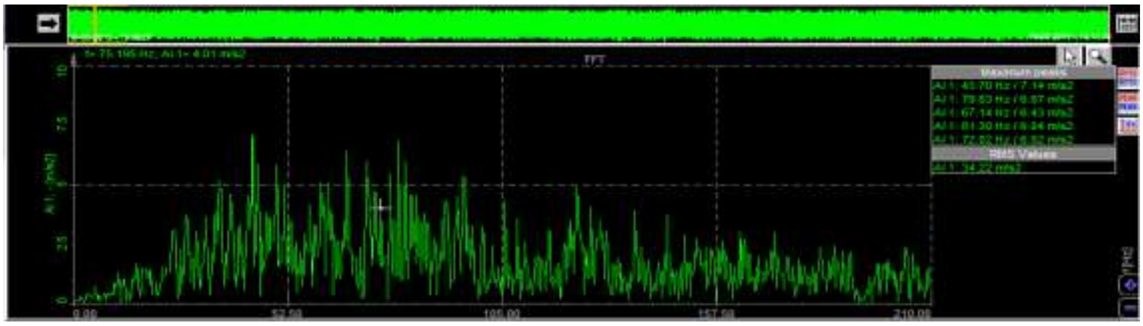

Fig 7.12-FFT signal of vibration of Induction motor for faulty condition

9. CONCLUSION

This project presented FFT analyzer approach for detection of bearing faults of induction motor. The results of experiment showed that FFT approach can be successfully used for diagnosis of bearing failure. The bearing fault can be clearly observed by comparing the shape of current pattern of faulty and healthy motors. The main objective of this work has been to determine a monitoring and diagnosis methodology, for induction motors which can be applied at the industrial level. This methodology gives encouraging results. A significant change in the amplitudes indicated a developing fault. Bearing fault is practically implemented and their effects on motor's current were studied with help of FFT signal conditioning technique. The DEWE software was used to study these effects. In bearing fault, harmonic shows a significant change when fault was present. The signal processing technique (FFT) was applied to detect the bearing fault for motor. Experimental results showed that the characteristic frequencies could not see in the power spectrum if fault is small in size. As severity of fault increases, the characteristic frequencies become visible. FFT shows better result than any other CM techniques like Park's vector method. The major benefit includes the prevention of lost downtime, avoid the major motor repair, or replacement costs.

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