# A Review on Different Fault Diagnosis Methods of Induction Motor

[1] Vikas Kumar Singh [2]Amandeep Sharma [3]Dr. Lini Mathew
[1]M.Teche Student Department of Instrumentation & Control, Nitttr, Chandigarh, India,
[2]Ph.D Scholar Department of Instrumentation & Control, Nitttr, Chandigarh, India,
[3]HOD Department of Instrumentation & Control, Nitttr , Chandigarh, India.

***Abstract :*** An Induction Motor is the most unobtrusive electrical machine[1] from constructional perspective, in most of the cases. There are different faults in induction motor. Mechanical components that are moving in an induction motor are especially giving issue from bearing shortcomings, internal bearing external bearing, and eccentricity. Bearing issues are the essential driver of motor disappointment. Just about 40-half of all IM disappointment is bearing related. Various variables profoundly affect the genuine existence of bearing. These variables are as per the following. Additionally in electrical issues. Two fundamental classes in faults are i) Stator Faults and ii) Rotor Faults Different signal processing techniques are used for motor fault analysis like Motor Current Signature Analysis (MCSA), FFT Wavelet Analysis, & Support Vector Machine (SVM).

**Index Terms-MCSA (Motor Current Signature Analysis) , (Fast Fourier Transform) FFT ,WAVELET, Discrete Wavelet Transform (DWT) Support Vector Machine ( SVM )**

## I. INTRODUCTION

Induction motors are generally used in a variety of industrial applications and consume a significant portion of energy . Environmental stress and load conditions applied to these motors can cause a reduce the efficiency of the motors leading to repair expenses and financial loss due to unexpected downtime. Therefore, to increase the productivity of the plant and to reduce maintenance costs of these systems, reliable condition monitoring and diagnosis is often desired [1]

## II. Construction of induction motor (IM)

### 2.1 Stator

The stator is comprised of different stampings with openings to convey three stage windings. It is twisted for a particular number of posts [2]. The windings are geometrically isolated 120 degrees isolated. Two sorts of rotors are utilized in Induction motor: Squirrel cage rotor and Wound rotor. No DC field current is required to run the machine. Rotor voltage is incited in the rotor windings instead of being physically associated by wires

### 2.2 Rotor

The rotor is the rotating part of the electromagnetic circuit. Common type of rotor is the squirrel cage rotor[3] rotor consist of a cylindrical laminated core with axially placed parallel slots for carrying the conductors. Each slot have a copper, aluminium, or alloy bar.

### 2.3 Types of faults in IM

There are various faults in induction motor. Mechanical mechanisms that are in motion in an induction motor are particularly giving problem from bearing faults, inner bearing outer bearing, and eccentricity. Bearing problems are the primary reason of motor failure. Almost 40-50% of all motor failure is bearing related. Various factors have a profound effect on the actual life of bearing. These factors are as follows: Similarly in electrical faults. Two main types of stator winding failures are (i) open phase failure and (ii) short circuit of few turns in a phase winding

In machine learning, a mix of classifiers, known as a troupe classifier, regularly beats singular ones. While numerous outfit methodologies exist, it remains, be that as it may, a trouble- some undertaking to discover a appropriate outfit design for a specific dataset. This paper proposes a novel review about different fault diagnosis methods.

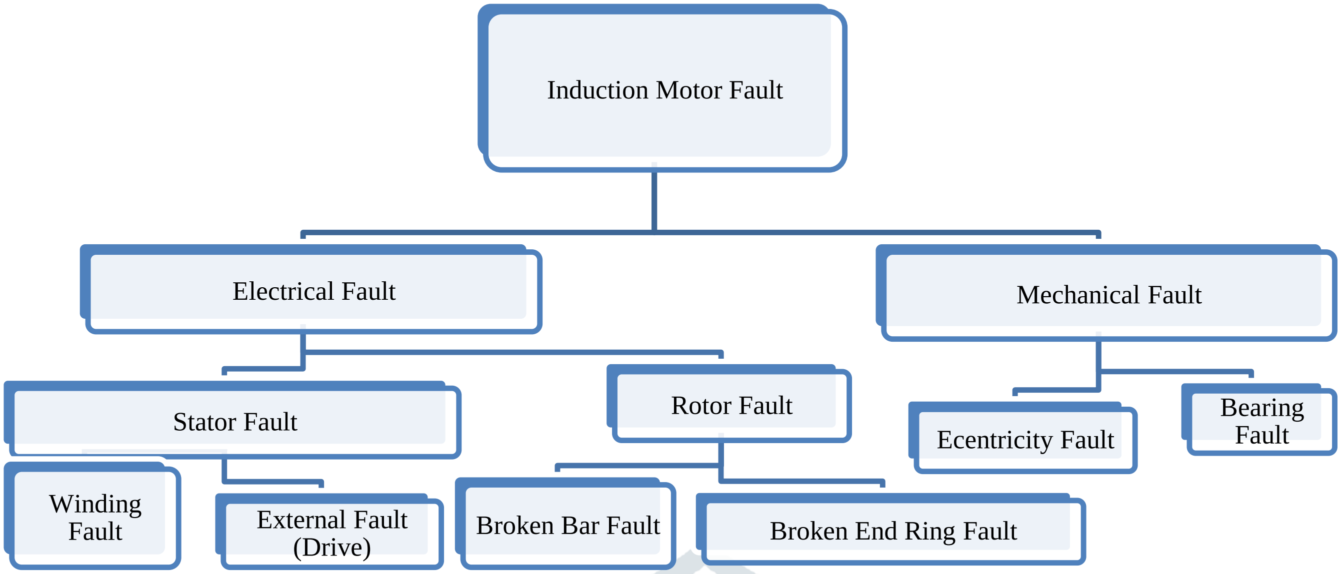


Figure 1: Classification for different faults in induction motor

### 2.3.1 Stator fault

Stator related faults are very use to in induction machines and their actuality can rapidly lead to catastrophic consequences for the machine and the drive system. This is the reason why there is continuous research on methods for timely detection. These faults produce mechanical vibration, unbalanced air gap voltages and line current, increased torque pulsation etc.

### 2.3.2 Broken Rotor Fault

The detection of broken-rotor-bar faults basis on common steady-state-analysis at loading condition of Induction motor operating IM with BRB (Broken Rotor Bar) not only damage the motor itself, but can also have a catastrophic impact on the related machines.[4-7]

The frequency fault is given by

$$f_b = (1 \pm 2s)f_s \qquad (1)$$

where $f_b$ is equal to sideband frequency associated to the BRB,s is the motor slip per unit and $f_s$ is fundamental frequency.

### 2.3.3 Bearing Fault

Types of Bearing failures are the most common failures in induction motors [8-10]. The major reason of failures are: damages on inner or outer races of the bearing due to thermal or dynamic mechanical stresses. the current harmonics at the specific frequencies will be affected by bearing vibration. The current spectrum can also be used to detect bearing failures.

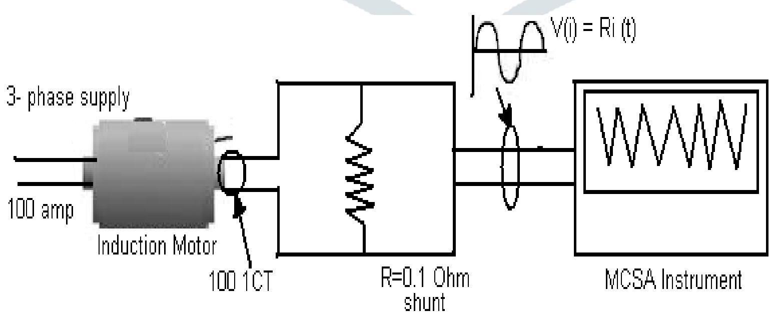


Figure 2: MCSA Instrument system

$$f_{current} = f_s \pm kf_c \qquad (2)$$

Where,

$f_{current}$ Frequency component of bearing damage in current

fc Characteristic vibration frequency

$f_s$ Supplied frequency

### 2.3.4 Air Gap Eccentricity

Air-gap eccentricity is a condition in which there is an choppy air gap between the stator and the rotor [10]. Air-gap eccentricity unbalances the attractive draw and causes vibration, acoustic commotion, bearing wear, and rotor deflection. In static eccentricity, the position of least air-gap is fixed. Air-gap eccentricity prompts stator current harmonics at specific high and low frequencies[11][12].

### 2.4 Different types of motor failure

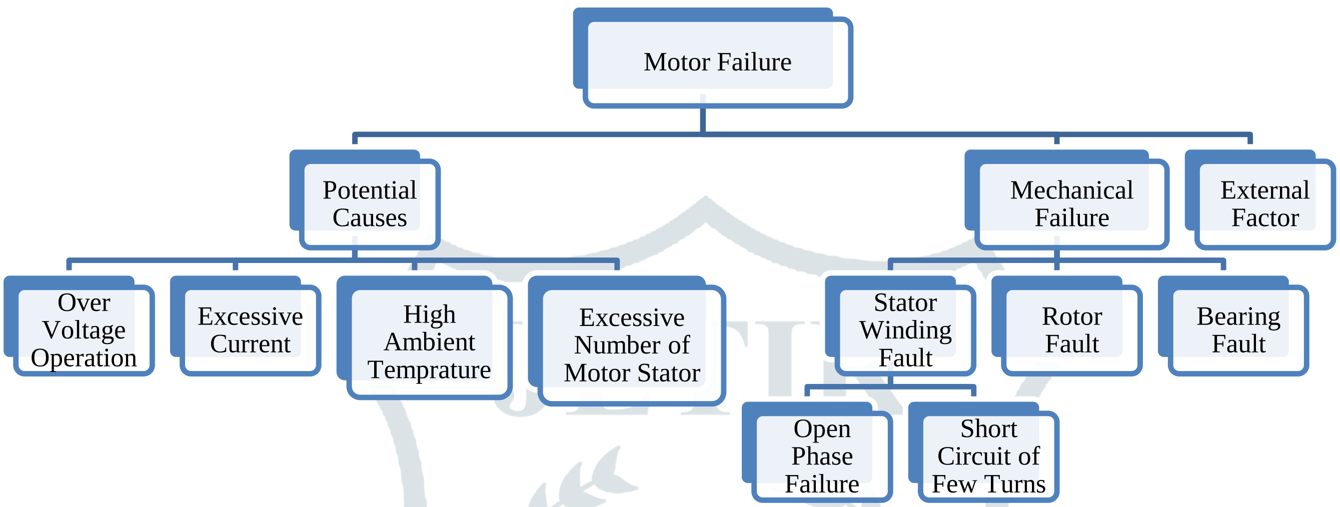


Figure 3: Different type of motor failure

## III. Methods of Faults Diagnosis

There are different methods of faults diagnosis. Here review about some fault diagnosis techniques

### 3.1 Motor Current Signature Analysis (MCSA)

The current drawn by a solid enlistment induction motor contains a solitary segment in the range of stator current[13].Presence of any asymmetry in enlistment induction motor creates additional part in the range which is comparing to the issue. It is one the popular method to detect common machine fault like bearing fault, turn to turn short ckt , broken rotor bar etc.

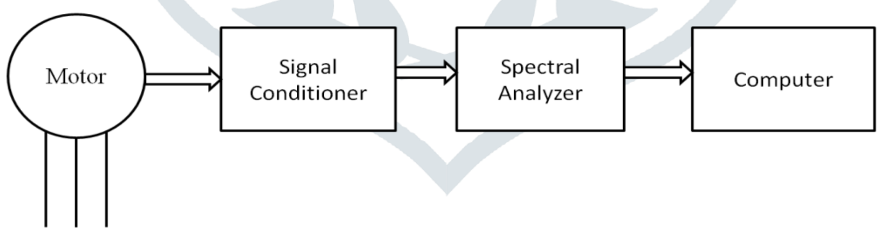


Figure 4: Stator Current Monitoring System

### 3.1.1 Basic Steps for Analysis

There are various basic advances that can be utilized for investigation utilizing MCSA. The means are as pursue[14]:

(i). Guide out a review of the framework being dissected.

(ii). Decide the grievances identified with the framework

being referred to. For example, is the purpose behind investigation because of inappropriate activity of the hardware, and so on and is there other information that can be utilized in an investigation.

(iii). Take data.

(iv) Audit data and dissect:

1. Audit the 10 second preview of current to see the activity over that time span.

2. Audit low recurrence demodulated current to see the state of the rotor and distinguish any heap related issues.

3. Audit high recurrence demodulated current what's more, voltage so as to decide different shortcomings counting electrical and mechanical wellbeing. Most blames can be resolved initially, with numerous principles being comparable for both MCSA and vibrational analysis.

It,s high senstivity , selectivity , cost effective monitoring of industrial IM. MCSA can be used in conjunction with other technologies such as motor circuit analysis. MCSA is detecting an electrical signal that contain current components that are produced by unique rotating flux component caused by IM Faults. (Fast Fourier Transform) FFT and other methods extract features in motor stator current compare with steady state conditions.

In Fig. 4 MCSA can be detect problem in early stage . it will present secondry stage damage of motor.

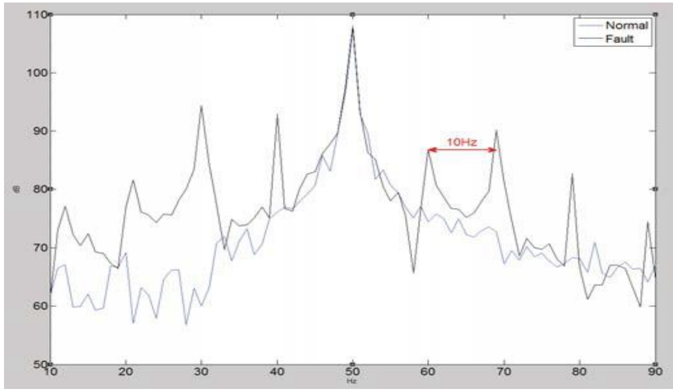


Figure 5: MCSA Waveform under normal and faulty operation in frequency domain

### 3.2 Fast Fourier Transform (FFT)

It's also one of the signal processing technique. The monitoring of the spectral analysis technique of the signals thus consist of perform a simple Fast Fourier Transform (FFT) x(f) of a continues signal over time[15].

Frequency Spectrum expressed by;

$$x(f) = \int_{-\infty}^{+\infty} x(t)e^{-j2\pi f t}\, dt \quad (3)$$

To analysis signal over a finite period therefore necessary to choose a weighting window for the analysis to correct the effects of a finite fleeting windowing. The frequency accuracy depends on the sampling frequency $f s$ and the number of N samples;

$$\Delta f = f_s / N \quad (4)$$

Let,s consider the case of Broken Rotor Bar . The debilitate of the bars leads to the increase of the amplitude of the oscillations in the couple and the speed which generates mechanical vibrations. The frequencies generated around the frequency of the supply voltage fundamental by a fault of a broken bar are given by the expression as shown in Fig 6:

$$f_{defect} = (1 \pm 2.k .s )\, f \quad (5)$$

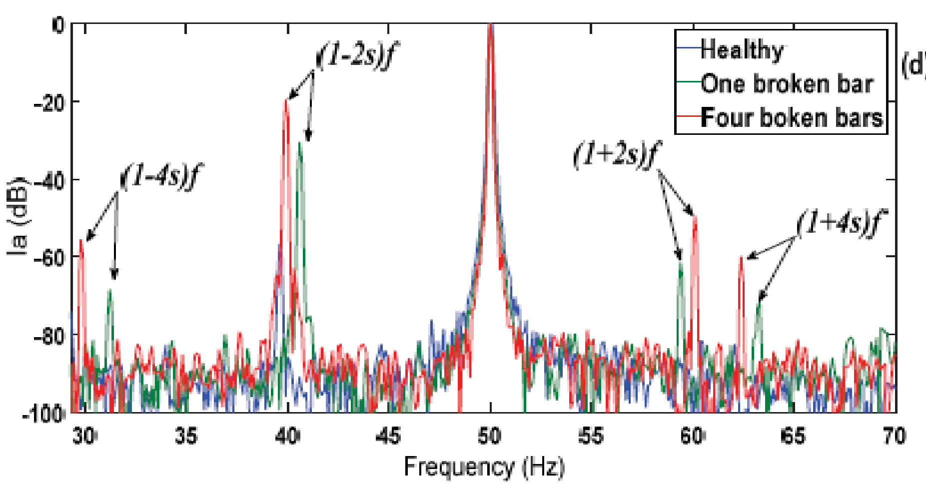


Figure 6: Spectrum of stator current Ia phase under full-load: (a) healthy state, (b) one broken bar, (c) four broken bars, (d) comparison of the three spectra

### 3.3 Discrete Wavelet Transform (DWT)

It's time frequency analysis technique for signals in steady state used to improve signal analysis. Motor current in transient regime can be complitely describe either in time domain or in frequency domain.

DWT of the motor current has been utilized broadly for distinguishing, in transient system, faults for example, eccentricity , stator faults , broken bars rotor asymmetries and short-circuit faults among others types of flaws. As expressed in , this analytic strategy is a four-advance procedure that includes the accompanying Steps for Fault Diagnosis of Rotating Electrical machine using DWT[16]

1) Transient motor current sampling with sampling frequency $f_{s,}$ during an acquisition time $T_{acq.}$

2) Wavelet Transform's (WT) computation of the current signal after a proper selection of mother wavelet and the number of decomposition levels.

3) Analysis of wavelet coefficients

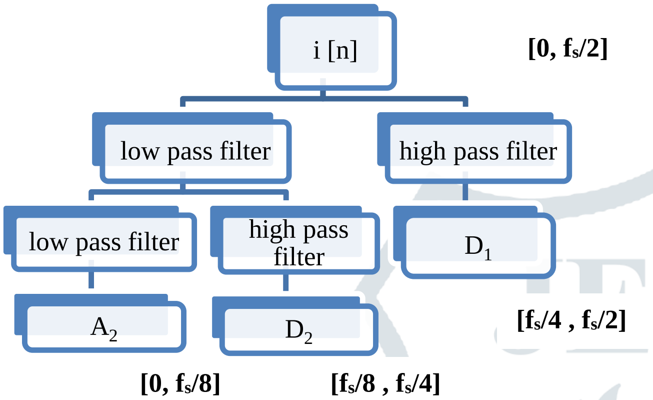


Figure 7: DWT coefficients computed with a sub-band coding algorithm for number of levels *k* =2

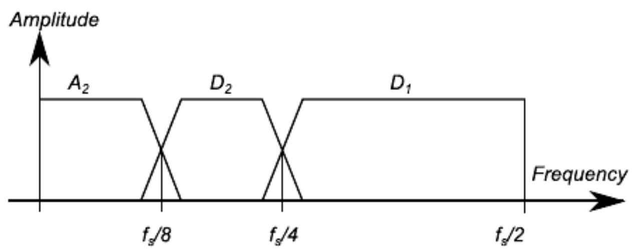


Figure 8: Filter bank used in the DWT, for a number of levels k = 2

4) Diagnostic Conclusion

### 3.4 Support Vector Machine (SVM)

SVMs were presented by Vapnik in the late 1960s on the establishment of factual learning theory[17] SVM is use to change the signal to a higher dimensional feature space. At that point the SVM takes care of a parallel issue in which information are isolated by a hyperplane. The hyperplane is portrayed using support vectors, which are a subset of the data accessible for the two cases and characterize the limit between the two classes. In a two-dimensional case, the activity of the SVM can be effectively clarified with no loss of all inclusive statement.

The essential SVM deals with two-class issues—in which the data are separated by a hyperplane characterzied by a number of support vectors. A short introduction of SVM is presented here for completeness[18] The SVM can be considered to make a line or hyperplane between two sets of data for classification. In case of two-dimensional situation, the action of the SVM can be clarified easily without any loss of generality.[19]

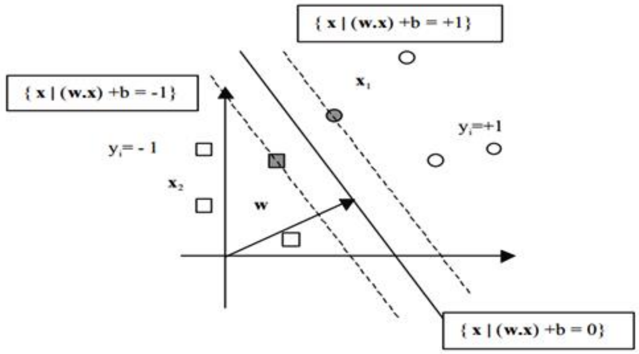


Figure 9. Classification of data by SVM

In SVMs, Use of a transformation that converts the data from an N-dimensional input space to Q-dimensional feature space.

$s = \emptyset(x)$

transformation from input space to feature space where the non-linear boundary has been transformed into a linear boundary in feature space.

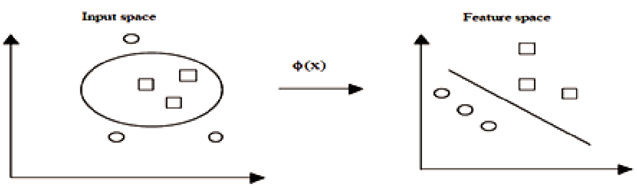


Figure 10: Non linear Separation of Input and Feature Space

**IV. Future Scope**

In different fault diagnosis method i prefer Support Vector Machine for fault diagnosis. We should use support vector machine in Industry 4.0 by the help of IoT. Industry 4.0 is a name for the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things (IoT) , cognitive computing etc

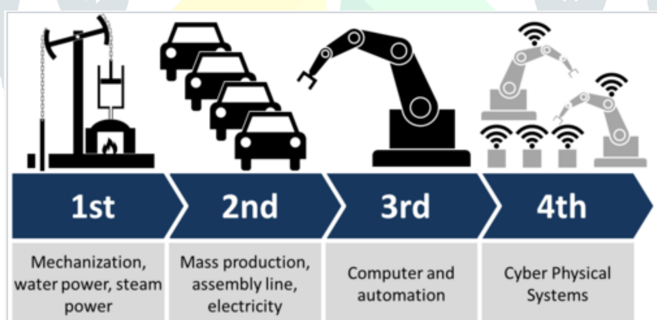


Figure 11: Growth of industry till fourth generation

A **cyber-physical system** (**CPS**) is a mechanism that is controlled by computer-based algorithms, tightly integrated with the Internet and its users. CPS displays a higher combination and coordination between physical and computational elements. CPS include fault diagnosis by help of SVM in Induction machine, smart grid, automation automobile system etc.

**V.CONCLUSION**

In different types of faults in IM like bearing faults, stator faults, eccentricity fault Bering fault we have different fault diagnosis techniques to like MCSA (Motor current Signature Analysis), signal processing technique like Fast Fourier Transform (FFT) , FFT with wavelet, Discrete wavelet transform (DWT) and then finaly to know about Support Vector Machine (SVM).There are some specified boundaries in every technique like MCSA focus in spectral analysis . Use of power spectrum restricts the application of MCSA to machine working in steady state. MCSA technique is enable to operate correctly in transient regime. Due to this region use DWT .But after review all techniques SVM technique is the best technique for motor fault diagnosis and optimize to.

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