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A Review Paper on Fault Diagnosis Schemes for Induction Motors

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Abstract: ***About 70% of the machines used in industries today are now induction motors. As the ac power is used in generation, transmission and distribution, induction motors have now occupied a significant place in industrial drive applications thus removing the dc motors that are less advantageous and were earlier used in industrial applications. Due to reliable and safe operation of induction motors, they are in much demand. Though a situation may occur when there is a fault and due to which it may lead to a failure that might result in excessive shutdowns and generate great losses in terms of revenue as well as maintainence. Therefore, there rises a requirement for an early fault detection tool for protection of of motor. With various emerging technologies, different fault detection methods are coming into existence. Here in this paper, we are going to discuss about some effective soft computing based fault detection methods for induction motors.***

Keywords: Induction motor, motor faults, broken rotor, fuzzy logic, stator current envelope, vibration signals, GA, feature selection, ART-KNN.

I. INTRODUCTION

Induction motors are electro-mechanical devices that are being used in most of industrial applications. Although induction machines are effective, reliable and robust due to their simple design and better technology of manufacturing, but still there is a probability that faults may occur and lead so some mishap. If such faults are not detected in their earlier stage, they may keep on increasing and lead to failure and effect the industrial processes. Different types of faults such as: Stator winding faults, unbalanced stator and rotor faults, broken rotor bars, eccentricity and bearing faults, single phasing faults, crawling, over voltage-under voltage-overload and blocked rotor faults may occur in an induction motors. To Several fault identification methods havebeen developed and been effectively applied to detect machine faults at different stages by using different machine variables such as current, voltage, temperature, efficiency, and vibrations. In this paper we will review about the main faults, their causes and their fault detection scheme. The percentage data of various motor faults occuring in an induction motor is being given below:

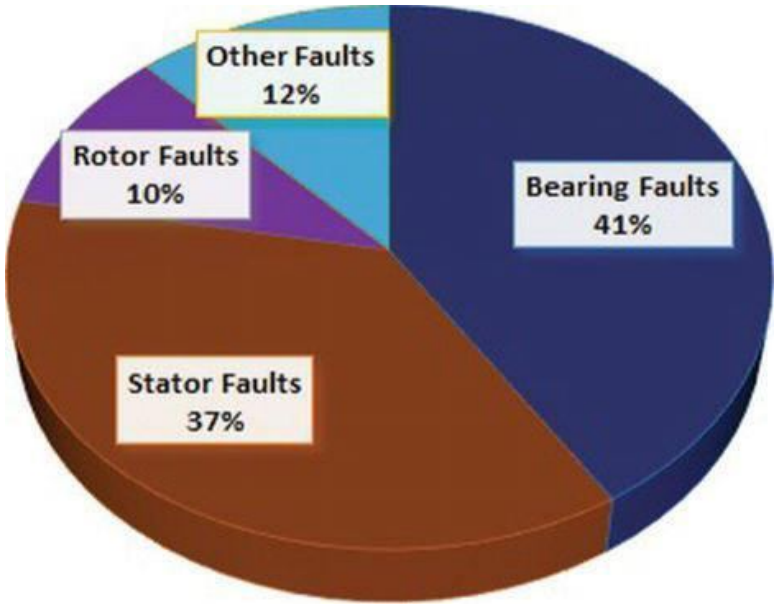

Fig.1 Percentage fault data as per IEEE

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II. DESCRIPTION OF INDUCTION MOTOR

An induction motor comprises a magnetic circuit interlinking two electric circuits which are places on the two main parts of the machine: a) Stator b) Rotor. Fig.2 given below shows a dissected induction motor for better understanding.

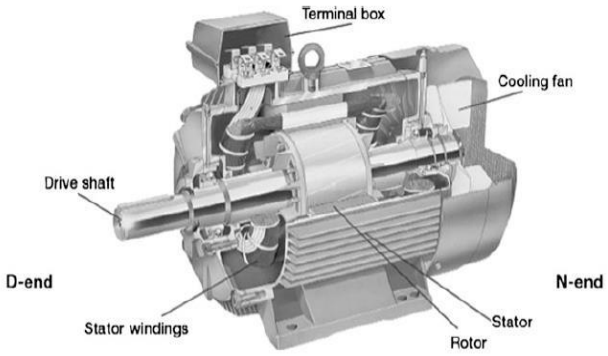

Fig.2 Induction motor (dissected)

Power is transferred from one part to other by electromagnetic induction. For this, induction machine is referred to as an electromechanical energy conversion device which converts electrical energy into mechanical energy. The magnetic circuit diagram is being shown in fig.3

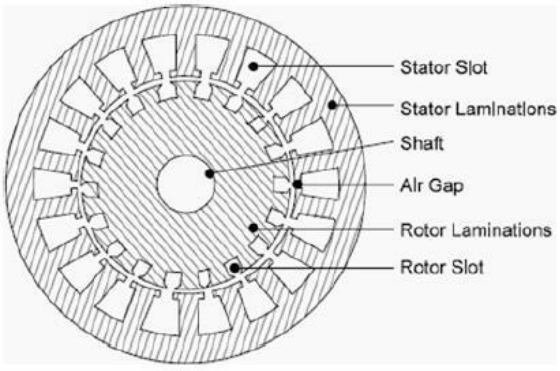

Fig.3 Magnetic circuit of stator & rotor

III. DIFFERENT FAULTS DETECTION METHODS

A) Rotor Side Fault Diagnosis Using Fuzzy Based Controlled Identifier

This method comprises of detection and diagnosis of rotor side broken bars which is based on the spectral analysis with the help of fast Fourier transform (FFT). The classification of the spectral response is based upon the fuzzy controlled identifier. For fault diagnosis, two features that are selected from the spectrum of the stator current are:

1) Amplitude of the harmonics that represent the broken bars defect 2sf, and

2) The dc value. By using these parameters, a fuzzy identifier identifies the number of broken bars. For designing of this fuzzy identifier the above two parameters will be used as inputs where the decision about the state of the rotor will be made based upon it.

Fig.4 Broken rotor bar

The technique that is being used is the Amplitude Modulation (AM) of the stator current being induced by rotor asymmetry that is exploited in the aid of diagnostics. Also, the rotor fault effect is being localized in the stator current envelope spectrum at frequency fo=2ksf. The formula for frequency of broken rotor w.r.t the fundamental frequency is given as frbb=(1+2sf).

Now, the most important components of the amplitudes are being localized in the lower frequency bandwidth. In this range, the important components of the amplitude are related to the rotor broken bars (2sf) and the dc term. In this technique, the Hilbert transform is being used for extracting the stator current envelope. Then this signal is being processed with the help of Fast Fourier Transform (FFT). In order to extract the fault frequency component (2sf) from the envelope spectrum of the stator current, the frequency bandwidth being affected by broken bar can be easily limited at a frequency (fm,fM), where they are selected according to the type of machine. These two observed amplitudes combined with fuzzy logic technique (as artificial intelligence diagnostic tool) can be defined as an efficient fault detection method.

B) Fault Detection Of Induction Motors Using Vibration Signals

A fault diagnosis system for induction motors with the use of vibration signals is being designed which is based on pattern recognition. For feature reduction and neural network tuning, genetic algorithm is being used.

This method of fault detection is based on feature recognition technique with a combination of steps

1) Feature extraction
2) Genetic algorithm
3) Neural networks

In this advanced method, the fault diagnosis of induction motors is performed by combining techniques like: feature calculation, genetic algorithm and artificial-*k* nearest neighbour algorithm based on the motor vibration signals.

Architecture for the proposed method is being shown below:

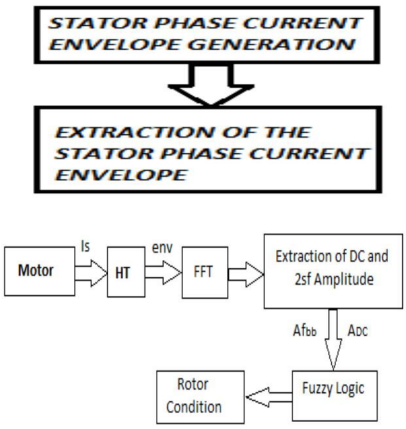

Fig.5 Motor Fault Diagnosis Using Fuzzy Logic

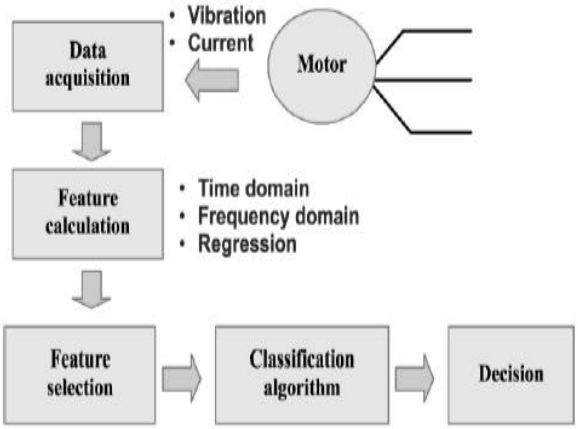

Fig.6 Architecture of diagnosis system

Now the main and most important part is the feature selection process with the help of genetic algorithm. Methods that can be used for the above are:

a) Principal Component Analysis (PCA)
b) Forward Selection Method (FSM)

i) *PCA:* Though it is a advanced method for the feature selection process but it is less computationally intensive that the genetic algorithm based approach. A drawback point for this approach is that all the available features must be there for the transformation matrix for creating the rotated feature space. The main point is that the drive behind the feature selection process requires little processing with a high level of accuracy. Using this PCA method requires computation of all the features before the application of the transformation matrix, that increases the cost of this method.

ii) *FSM:* In this method, two relatively poor and individually acting features are being combined to give much better result. Using genetic algorithm here faces not much problem, because the features are selected as a unit and the interaction between different features is being tested as a group rather than being tested individually. Now, the GA based selected features are being applied to the neural network ART-KNN for generation of the actual and corresponding running motor signals.

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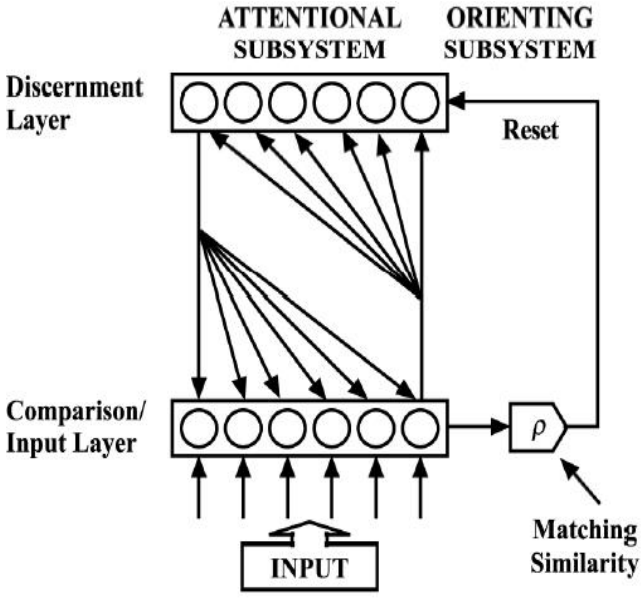

Fig.7 Architecture of ART-KNN network

On the basis of real time experiments performed by the researchers, combination of GA and NN using motor vibrations gave an effective diagnosis feature for fault in motors.

IV. CONCLUSION

An efficient scheme for monitoring the condition of the working motor that can perform an early fault detection and diagnosis and can give a warning alert, is the requirement of the present time. Condition monitoring promises the safe operation of the motor drive systems in the industrial processes and has attracted many of the researchers to perform different methods for testing.

Effective monitoring of the motors increase their availability and performance with a reduction in the consequential damage that results in increased life of motor leading to reduced maintaenance costs and increased overall efficiency.

The above two researched methods that are being reviewed in this paper have their own importance and parameters for fault diagnosis applications.

A fuzzy logic based fault diagnosis system promises to determine the state of condition of the induction motor. Effective diagnosis at low slip is being made using stator current envelope technique via Hilbert transform and then it is used as a diagnostic signal. This method gives a correct number of broken bars after the diagnosis.

Whereas, in vibration signal based fault detection method vibration signals are being utilized for effective fault diagnosis of induction motors. In this method, Genetic Algorithm for feature selection and optimized monitoring system is being build up that gives an effective tool for easy operation of the machine reducing the occurrence of faults with early detection and alarming.

An motor fault diagnosis system (ideal), should take minimum measurements that are necessary from a motor, which can give a clear indication of incipient fault modes in a minimum possible time. In recent years, the fault diagnosis of motors and its monitoring have greatly moved from traditional techniques to modern AI techniques. The main problem that exists in traditional methods is that they need a constant human interpretation which is unacceptable these days. In order to automate the entire diagnostic process, AI techniques are now being used. However, the development in AI techniques for induction motor fault diagnosis are still in its infancy, and despite of the considerable work that has been done in this area, much more is now required to bring such techniques into the mainstream of fault diagnosis.

In this paper, different works in the field of motor fault diagnosis are being reviewed. Major faults in induction motor and different fault detection techniques are being discussed.

This paper is an attempt that is made to review the internal and external fault as well as non-invasive detection methodologies considering recently utilized AI based, signal processing based and hybrid approaches. It also represents a methodology that is based on Park's vector approach for induction motor's electrical fault diagnosis.

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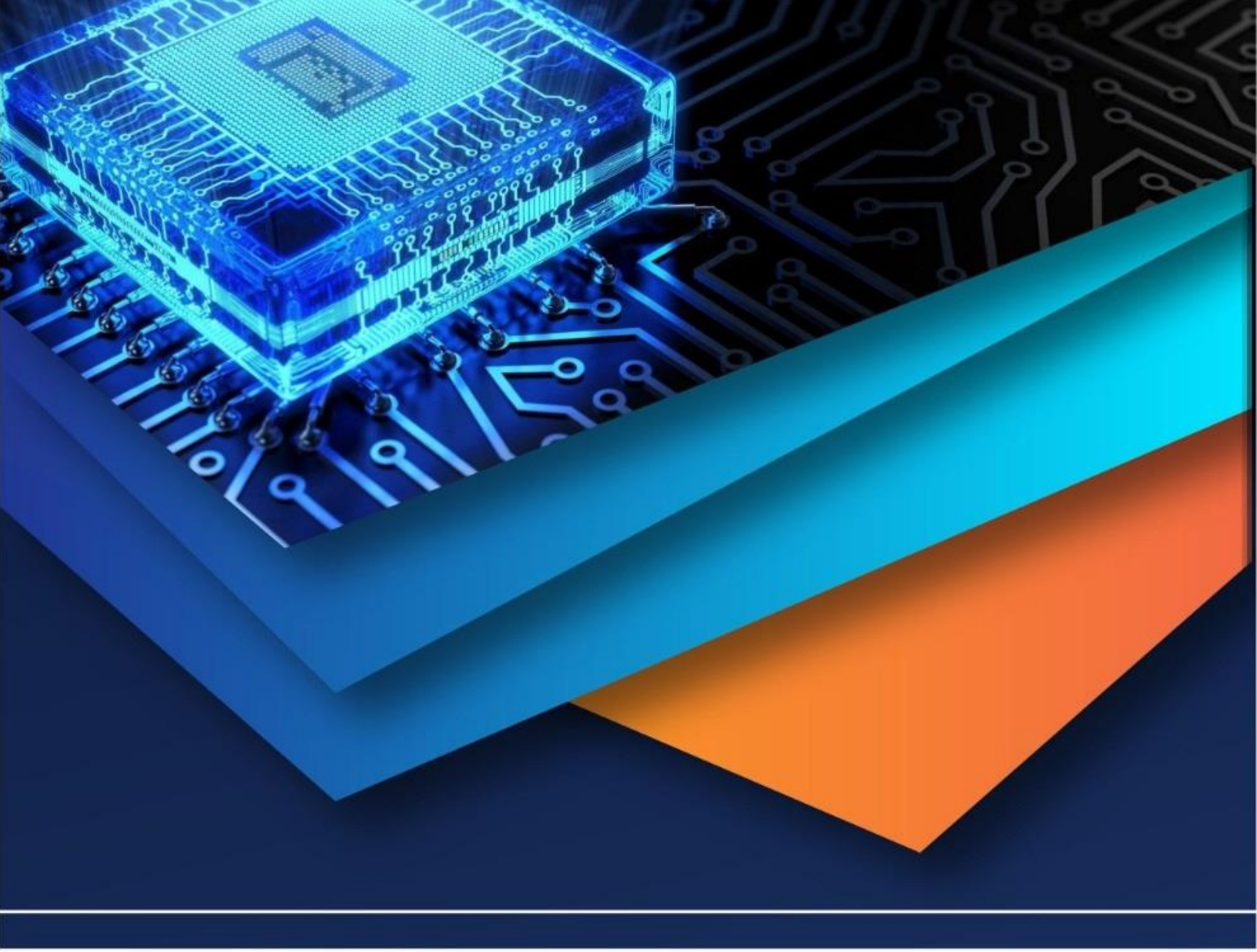

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