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A Survey on different Rotor Fault Detection Methods for Induction Motor

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ABSTRACT

This survey paper shows the literature review of different type induction motor rotor fault detection Preventive maintenance is one of the major concerns in modern industry where failure detection on motors increases the useful life cycle on the machinery. Broken rotor bars are among the most common failures in induction motors. Early detection of faults in electrical machines are imperative because of their diversity of use in different fields. Asui table fault monitoring scheme helps to stop propagation of the failure or limit its escalation to severe degrees and thus prevents unscheduled downtimes that cause loss of production and financial income. In this study, a survey of methods based on the Park transform and based on other transform methods. In this survey paper discuss the different methods of fault detection like Artificial Neural Network (ANN), fuzzy logic, Fast Fourier Transform (FFT) based.

Keywords-- Health Monitoring, Induction Motor Faults, Fault Detection, Motor Current Signature Analysis, Identification, Support Vector Machine, Artificial Neural Network and Diagnosing Techniques

I. INTRODUCTION

Induction motors are most widely used industrial load and consumes a major part of overall electrical consumption. Fault identification in electrical machines and power systems is increasing interest research area for academicians as well as for industry. The wide variety of environments and conditions motor exposed to, mis-operations and manufacturing defects can make it subject to incipient faults or gradual deterioration and can lead to motor failure if left undetected. Most electric motor failures interrupt process, reduce production and may damage related machinery. Sometimes a small HP motor failure can also create hours of plant stoppage in continuous processing.

The Squirrel cage induction motors are most widely used electrical machines for industrial, domestic and commercial applications. These motors have advantages such as robustness, simplicity of its construction and highly reliable [1-2]. Since, Induction motors are undoubtedly reliable but we cannot avoid the possibility of failure also. These failure conditions are taking place because of its component failure. If the failure occurs in the machine that failure ought to be diagnose as early as possible. If these failure conditions are not diagnosed on time, the failure component will affect whole motor operation badly and will become more catastrophic. Consequently, large revenue losses and maintenance will be needed [5].

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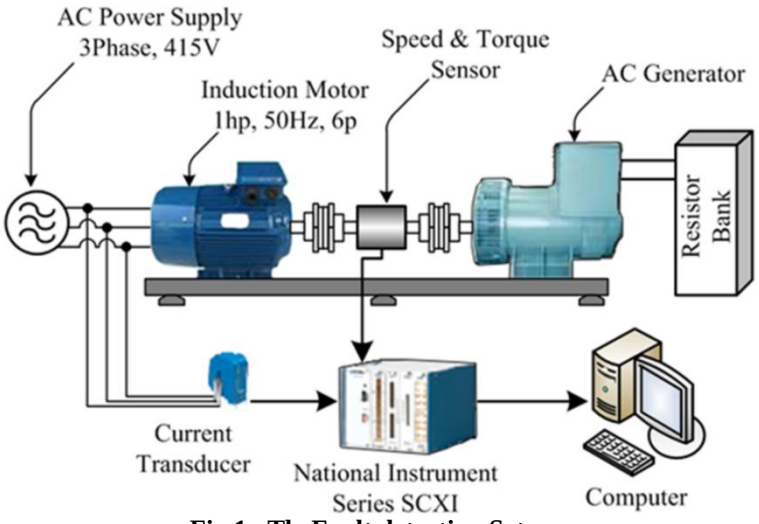
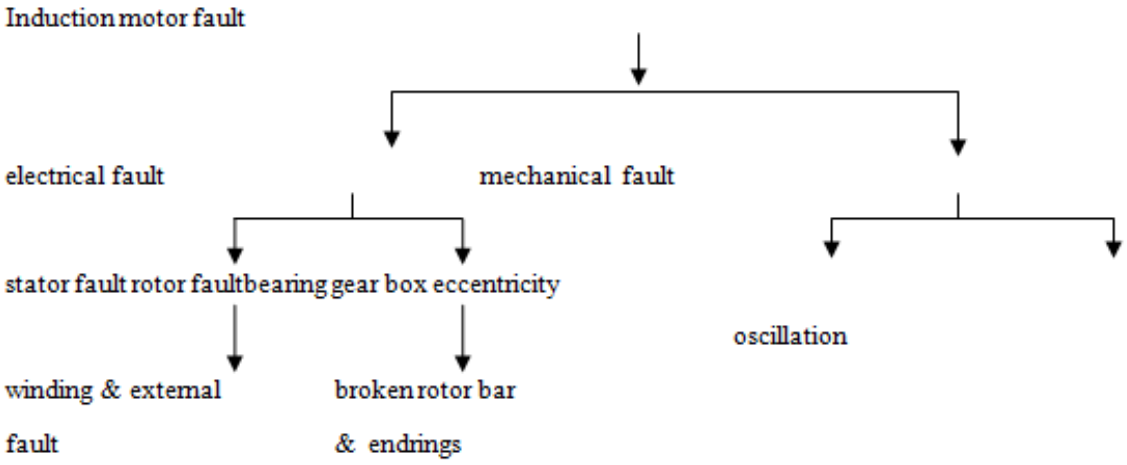


Fig 1 –TheFault detection Setup

Induction motors appears to different kind of faults or abnormalities which can majorly divided in two parts, external and internal faults. Overload (OL), under voltage (UV), Over voltage (OV), Single phasing (SP), voltage unbalances (VUB), locked rotor, earth fault between supply feeder and motor terminals and three phase fault at the terminals are categorized as external faults and short circuit, Stator interterm failure, bearing, rotor faults, eccentricity as internal faults. Internal as well as external faults accurate diagnosis is equally necessary and which can be lead to development of comprehensive protective scheme for all faults. There are invasive and noninvasive methods for fault detection. The noninvasive methods are more preferable because they are based on easily accessible and inexpensive measurements to diagnose the machine conditions without disintegrating the machine [1]



II. FAULT DETECTION

An Automated fault diagnostics and condition monitoring are important parts of most of the world's industrial processes. It is difficult to develop an analytical model that adequately describes induction motor performance in its all operation points with any power source in case of induction motor fault identification. If the expert knowledge of process is available a simple signal-based diagnostics can be adopted with knowledge-based models. It is difficult for a human expert to distinguish fault from the normal operation. Multiple information sources may need for accurate decision. Thus, the data-based models are the most interesting approach for the induction motor diagnostics [10]. In this presented work, the fault identification system is built using RMS features retrieved from the voltage and current signals and decision

making part relies on data-based (pattern) classification model.

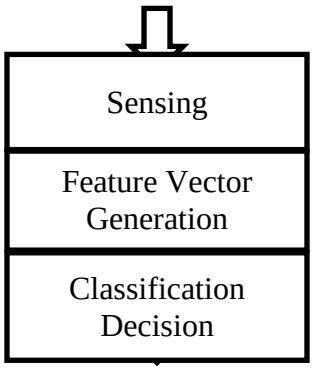


Fig 3: Basic Pattern Recognition System

III. REVIEW OF DIFFERENT METHODS

ANN Based **-**The present paper deals with the detection of broken rotor bar of an induction motor. The problem is approached through mathematical modeling of induction motor. Both the models, for healthy as well as faulty motor, are developed using MATLAB simu link. The model is used to simulate different conditions of fault with varying number of broken bars. Parameters like three-phase voltage, three phase current and THD of all voltages and currents are acquired from the simulated model. The data thus generated is used to train Artificial Neural Network which diagnoses the condition of motor. The results obtained prove the effectiveness of proposed method. Detection of broken rotor bar of induction motor with the help of ANN was the focus of the paper. The mathematical models of induction motor in both healthy as well as fault condition were developed in order to simulate the faults of varying intensity at different load conditions. Various parameters of induction motor are recorded in all the different conditions. These recorded parameters are used to train the Artificial Neural Network. The output of the ANN shows that proposed technique successfully detects the presence of broken rotor fault of induction motor. [1]

Fuzzy Logic Approach- The online monitoring of induction motors is becoming increasingly important. The main difficulty in this task is the lack of an accurate analytical model to describe a faulty motor. A fuzzy logic approach may help to diagnose induction motor faults. This work presents a reliable method for the detection of stator winding faults (which make up 38% of induction motor failures) based on monitoring the line/terminal current amplitudes. In this method, fuzzy logic is used to make decisions about the stator motor condition.

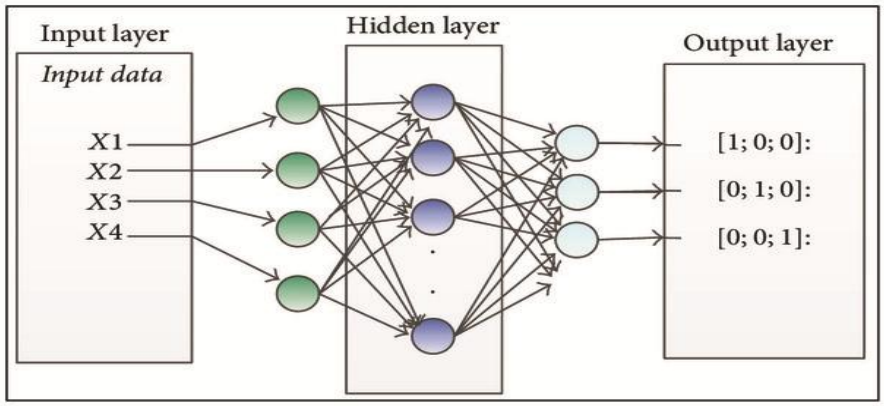


Fig. 4 ANN based Motor Rotor Fault Detection

In fact, fuzzy logic is reminiscent of human thinking processes and natural language enabling decisions to be made based on vague information. Therefore, this paper applies fuzzy logic to induction motors fault detection and diagnosis. The motor condition is described using linguistic variables. Fuzzy subsets and the corresponding membership functions describe stator current amplitudes. A knowledge base, comprising rule and data bases, is built to support the fuzzy inference. The induction motor condition is diagnosed using a

compositional rule of fuzzy inference. Experimental results are presented in terms of accuracy in the detection motor faults and knowledge extraction feasibility. The preliminary results show that the proposed fuzzy approach can be used for accurate stator fault diagnosis. In this paper, the realization of the fault in stator winding in a three-phase induction motor has been considered. In the first place, the induction motor was simulated by dynamic equations to that effect; afterwards, the equations were revisited by accounting faults in one of the phases. As for the issue of fault realization, the fuzzy logic and its application in clustering have been used. As an advantage of this method, we can refer to its high accuracy, online state as well as its deprivation from an accurate model for the system.[2]

DWT Based -This article presents ways of identifying induction motor rotor cage fault using Stockwell case analysis and Wavelet transform of the stator start-up current. Faults are simulated by the mathematical model of the three-phase induction machine. That specific induction machine has 28 rotor cage bars. It is shown that time-frequency analysis (that highlights the time variation concerning a stator current) allows an accurate identification of broken bars. This identification is done with both the Wavelet and the Stock well transform, in order to compare efficiency. The main contribution consists in the fact that it provides a comparison between a technique of detecting the induction motor cage faults by extracting parameters of DWT coefficients of motor current reconstructed signal at different level, corresponding to different spectral bands and a cage fault detection technique using motor current ST analysis. The stator current waveform experimental data of the induction motor with cage faults will be analyzed. An on-line diagnosis of the rotary three-phase induction motor's broken bars, containing the characteristics of the A4 approximation and D5 detail signals of DWT analysis (similar to Fig. 3), becomes necessary in revealing incipient faults of the induction motor rotor cage The fundamental frequency contour of the stator current at 40Hz and 60Hz ST. We can observe the difference between several rotor fault depths and the number of broken rotor bars. Also, in Table 6, the faults are highlighted through the ST energy values of the entire signal and fundamental component of the transient current and by the energy values of D5 wavelet decomposition level.[3]

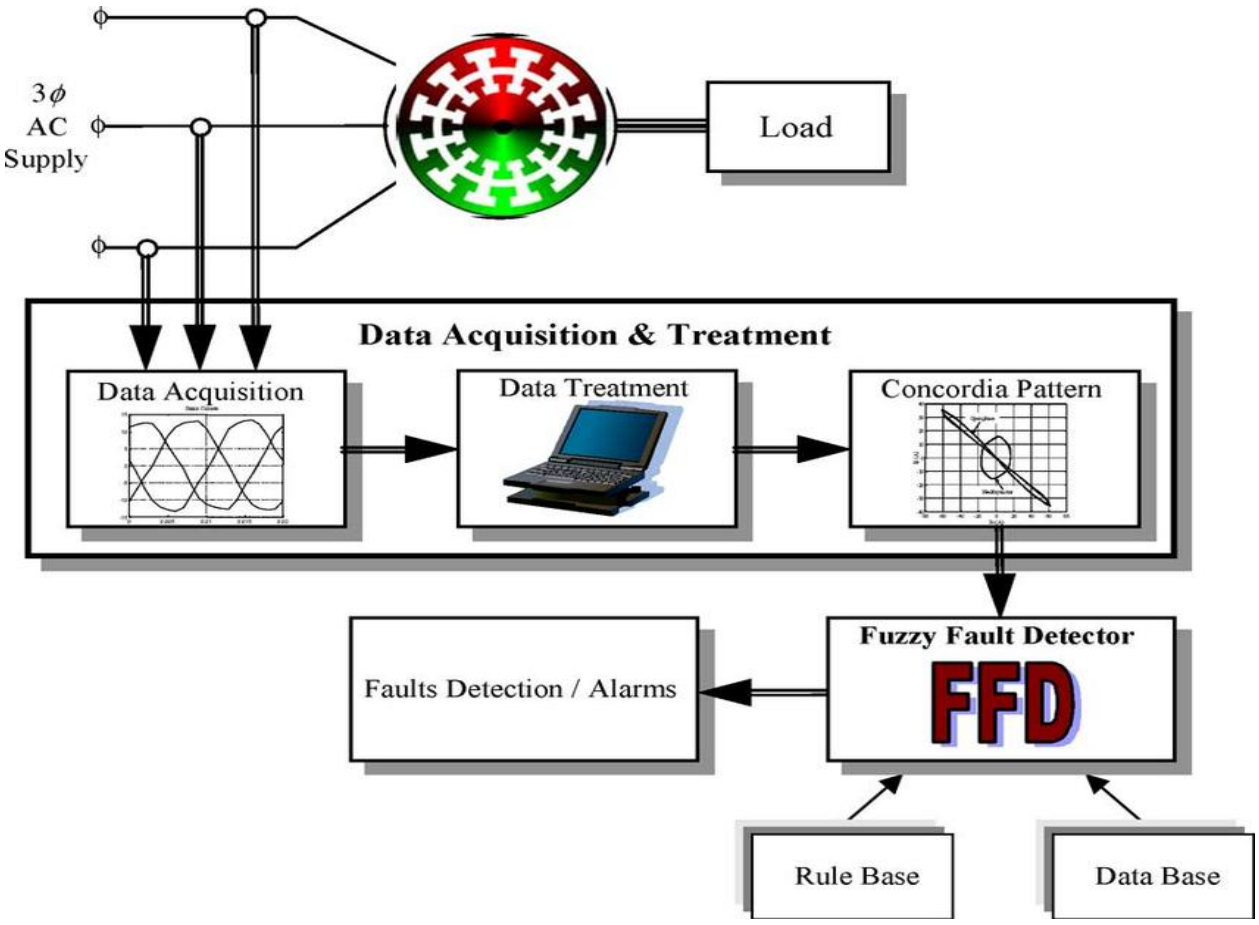


Fig. 5 The Fuzzy based Fault Detection method

SVM Based- This paper proposes method for broken bar detection in induction motors at very low slip. The proposed method consists of extracting reliable discriminative feature from a steady state one-phase current signal and design of optimal classifier via a support vector machine. The fault related features are extracted from frequency spectra of a modulus of a motor phase current Hilbert transform series. The features are fed to the support vector machine input and the output indicates rotor condition in respect of broken bar appearance independently of a slip value. Tests are conducted on 1.1kW two poles induction machine in an industrial environment. It is shown that proposed method is accurate, fast, reliable, not hardware costly. This paper is focused into the design of the SVM based induction motor broken bar classifier. The motivation for this work is the realization of a classifier which will give satisfactory classification results for wide load range with a great concern of low load cases. Used feature space consists of two features which reliably represent the appearance of the broken bar fault. Based on the results

problems start and how they evolve. Specific cases, such as when the voltage contains low-frequency components or when the motor drives an oscillating load, still require expert analysis. presented in chapter IV it can be concluded that the presented SVM classifier is capable to successfully classify rotor condition in respect of the broken bar fault for a wide load range. The main advantage of the proposed classifier is its applicability in various working conditions, and its design is based on real working data, which is not case with well-known analytical broken bar classifiers. In this case there is no need for development of mathematical fault models, which is an expensive and time consuming process the proposed method is non-invasive, fast, and sufficiently accurate. The developed system is mobile and has potential to become a standard maintenance tool in electrical machine drives. [4]

FFT Analysis Based **-**Broken rotor bars in induction motors can be dependably detected by analyzing the current signatures under sufficient motor load conditions. Detection becomes less dependable under light motor load conditions. There are also cases in which tolerable motor operating conditions generate current signatures similar to those of motors with broken rotor bars. These cases may present security concerns when the detection element is set to trip the motor and to send alarms. The broken bar detection element with zero settings, along with the event history and the Fourier transform function, allows us to detect broken rotor bars under a wide variety of motor conditions. The detection element identifies the most common broken bar cases. The event history shows when For these cases, the Fourier transform function speeds up the measurement process because no extra measurement equipment needs to be connected to the motor. [6]

Condition Monitoring (CM) Techniques **-** Increasing interest has been seen in condition monitoring (CM) techniques for electrical equipment, mainly including transformer, generator, and induction motor in power plants, because CM has the potential to reduce operating costs, enhance the reliability of operation, and improve power supply and service to customers. Literatures are accumulated on developing intelligent CM systems with advanced practicability, sensitivity, reliability and automation. A literature survey is felt necessary with an aim to reflect the state of the art development in this important area. After introducing the concepts and functions of CM, this paper describes the popular monitoring methods for and research status of CM on transformer, generator, and induction motor, respectively. The paper also points out the potential benefits through the utilization of advanced signal processing and artificial intelligence techniques in developing novel CM schemes Condition monitoring has become a very important technology in the field of electrical equipment maintenance, and has attracted more and more attention worldwide. The potential functions of failure prediction, defection identification, and life estimation bring a series of advantage for utility companies: reducing maintenance cost, lengthening equipment's life, enhancing safety of operators, minimizing accident and the severity of destruction, as well as improving power quality. Due to these benefits and the pressure to best utilize the existing assets under a competitive environment, CM is now a hot topic to power system managers and engineers as well as researchers. The development of CM for power transformers, generators and induction motors is now at different stages. Several types of transformer monitoring systems have already put into practice. However, monitoring and data analysis methods are not satisfied for special problems such as partial discharge, hotspot temperature and OLTC. Online diagnosis of all the measured quantities is still under development. To large extent, CM systems for generator and induction motors are not practicable yet. Great efforts are focused on the use of PD online monitoring system for generators, while more work has been carried out on vibration signal analysis and the implementation of current monitoring. Research sin recent years clearly show that advanced signal processing techniques and artificial intelligence techniques are indispensable in developing novel Conditioning Monitoring systems. Benefiting from the development of computer techniques and communication techniques, signal processing and Artificial Intelligent have become the most powerful tools to make next generation CM equipped with high level of sensitivity, reliability, intelligence, and cheapness. [7]

Motor Current Signature Analysis (MCSA) **-** This paper deals with the diagnosis of electrical defects of Squirrel-Cage Rotor Induction Machines (IMs). The failures of induction machine and the diagnosis methods

are presented. Among the methods, Motor Current Signature Analysis (MCSA) is used in the experimental study to detect broken rotor bars and end-ring segment. The load level and the load effects on the diagnosis are also studied. Support vector machines (SVM) is applied to classify faults. In this paper, we used the SVM classifier for rotor fault detection and separation in squirrel cage induction motor on the basis of the acquisition of some electrical quantities such as stator current and voltage. These signals in particular the current is transformed to frequency domain are used for detection of specific components which their magnitude increases while the fault appears. Also, we showed that selections of these components in association with others obtained from the instantaneous power spectrum are good features for SVM classifier. [08]

IV. CONCLUSION AND FUTURE SCOPE

This paper presents a brief review of various motor fault detection techniques. Here main objective of this review paper is to focus on Induction Motor Rotor Fault. We conclude techniques also review previously done work. In the above literature survey mainly focus on different parameters for fault detection in Induction Motor. In the present paper, a comprehensive review of induction motor faults and their detection techniques have been carried out. The accurate health monitoring technique of the induction motor can improve the reliability and reduce the maintenance costs. It has been observed from previous year's research papers that the fault diagnosis in the induction motor is still a challenging task for researchers and academicians. Many researchers found that the stator current is much suitable signal for the fault diagnosis purpose. It has been observed from the various research papers that the majority of work was oriented towards constant speed induction motor. There are various methods which are used to diagnose faults for the constant speed induction motor like fuzzy logic, neural networks and genetic algorithm etc. By the invention of several digital signal processing techniques, it will be easier to diagnose faults of the variable induction machines also. A lot of work has to be carried out for variable speed induction motor. So, for small rating induction motor faults has been analysed but for the large rating motors that the fault diagnosis and analysis will be challenging task. From the comprehensive survey, it has been found that the Fast Fourier Transform (FFT) method used for steady state analysis and the Wavelet Transform (WT) used for transient analysis with Digital Signal Processing (DSP) methods gives outstanding results. But, it has been found that the FFT method is not able to diagnose fault in the no-load conditions unlike WT. These methods are called Motor Current Signature Analysis (MCSA) methods with motor current.

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