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INTERNATIONAL JOURNAL OF CURRENT ENGINEERING SCIENCES

RESEARCH ARTICLE

ISSN: 2320- 9046

International Journal of Current Engineering Sciences- Vol. 5, Issue, 05, pp. 30-33, May, 2016

A REVIEW: FAULT DIAGNOSIS OF STATOR AND ROTOR OF INDUCTION MOTOR USING FUZZY LOGIC TECHNIQUE

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ARTICLE INFO

Article History:

Received 10th Feb, 2016
Received in revised form 29th March, 2016
Accepted 15th April, 2016
Published online 28th May, 2016

Key words:

Induction Motor, Fuzzy Logic, Stator, Rotor, Bearing, Fault Diagnosis, Expert System.

ABSTRACT

The studies of the induction motor behavior during the abnormal condition due to presence of unexpected failures and the chances to diagnose this irregular condition is very difficult task for the field engineers and researchers. Accordingly, monitoring of induction motor has turned into the basic need of commercial ventures for recognition of faults. Condition monitoring of induction motors is necessary strategy for the detection of incipient faults as to avoid the unexpected failure. The technologies like Expert system, fuzzy logic system, and artificial neural networks have been extensively reported in literature. This paper has been focus on fuzzy logic approach which helps to diagnosis induction motor fault and also fulfills the requirement of stability and reliability in system. This paper also provides clear idea of different faults within induction motor and reason of occurrence of different fault with in induction motor. Within fuzzy logic given data or item are described as having a certain degree of membership in a set normally constrained to 1 and 0.

INTRODUCTION

An induction motor is viewed as the workhorse of the modern industry due to its large amount application, cost effectiveness, easy control and use as well as high reliability and robustness. In modern industrial, induction motor has been growingly receiving popularity in various industries including power station, automotive, petrochemical, and aerospace.

Induction motors are prone to failure, the problem of monitoring and prevention of unexpected failure are Incorporated to the exceptional challenges we face in industry in spite of high reliability of these machines. Induction motor may encounter with electrical, mechanical and thermal stress that result in different type of faults. Researchers have always deal with the different kind of faults within induction motors, mainly the fault related to stator winding, asymmetry, and rotor and eccentricity ones. In the context of fault in induction motor, various techniques are divided into a few general categories of which can refer to model based, signal based and smart methods. Smart methods; refer to fuzzy logics, neural networks and genetic algorithm. The fuzzy logic can be incorporated to the context of fault detection and in effect to the linguistic concepts of the function of motor in different circumstances and in return to seen faults; that is to say, it turns the combination of expert knowledge and linguistic concepts into rules that delineate the functional status of motor and deal with the problem of fault detection. The purpose of this paper is to give a brief knowledge of faults within induction motor and provide a quick review on different techniques that are dealing with these faults and providing methodology to diagnosis these faults main focus is on the issue of the fault in induction motor by means of a fuzzy logic technique.

Classification of Faults

Various kind of fault within induction motor is explained below in form of table:

Table1 Percentage of failures in induction motor component

Type of fault	Percentage of occurrence
Bearing related faults	40%.
Stator winding faults	38%
Rotor related faults	10%
Other faults: 10%	10%

A. Stator Faults

Percentage of fault within stator occurs largely due to inter switch winding faults caused simply by insulation breakdown, phase-to-ground, and phase-to-phase faults.

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[8]Practically 30%-40% faults are stator faults. It is most important to find these faults in time because they can cause damage to motor which result in further damage to machinery and risk to human life also. Current signal analysis is a popular technique to determine stator winding faults with in induction motor

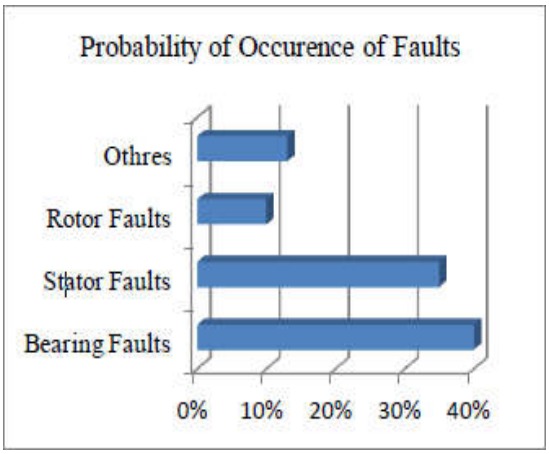

Figure 1 Faults by % in Induction Motor [2]

B. Rotor Faults

From the survey in [8], it has been showed that 10% problems of total induction motor failures result from brake rotor winding. Because of pulsing load and direct online starting induction motor brake disc faults which are cracked rotor bars occur. Rotor faults results in fluctuation of speed, torque pulsation, vibration, overheating, hump in the rotor and rotor laminations damages [1]. The cause of rotor bar and end ring breakage are [4] Thermal strains, Magnetic stresses, Residual stresses, Powerful stresses, Environmental challenges, Mechanical stresses.

C. Bearing Faults

This kind of faults contains over 40% as seen from the Fig.1 of all motor failure. Bearings are common factors of any electrical motor. The rotary motion of shaft is permitted simply by the bearings. From the table it is concluded that bearings happen to be single major cause of induction motor failures. Basically bearings involve two rings which in turn are referred to inner and the outer rings. A set of balls or rolling factors located in raceways move inside these rings. A continuous stress on the bearing results into the fatigue failures. These failures are at inner or outer races with the bearings. This sort of failures results in rough running of bearings which results in detectable vibrations and elevated noise levels. Contamination, corrosion, improper lubrication, improper set up is the factors which result in bearing faults. Temperature is also one of the main reasons for bearing failure. And so it is also a requirement that temperature should not really exceed beyond its particular limit. Fault in bearing like tiny hole, a pit or a missing piece of material on the matching elements.

D. Eccentricity related faults

Unequal air gap that exist between stator and rotor is called as eccentricity fault. When the eccentricity becomes larger, the resulting unbalanced radial forces can cause stator and rotor rubs, and this can result in stator and rotor core damage. The eccentricity is divided into two parts one is Static eccentricity and other is Dynamic eccentricity. In the case of static eccentricity the position of the least radial air gap length is fixed in space. Incorrect positioning of the stator or rotor core at the commissioning stage results into static eccentricity. In the case of dynamic eccentricity, the center of the rotor is not at the center of the rotation and the position of minimum air gap rotates with the rotor.

This paper deals with two main categories of fault and to monitor these two faults with the help of fuzzy logic techniques. Fig 2 represents the two main fault and sources of these two faults.

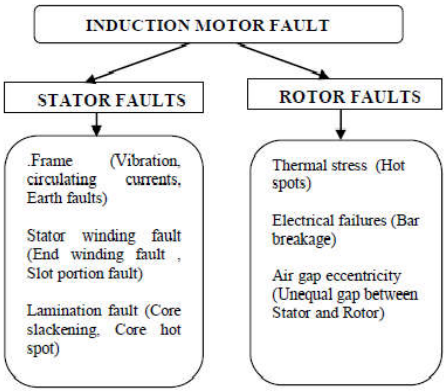

Figure 2 Source of induction motor faults

Fuzzy Logic Technique

This fuzzy logic (FL) approach aids to identify induction motor failure with really basic way since it present vagueness with linguistic terminology along with show people understanding in the pure way, FL could summarize the characteristics regarding professional process having linguistic terminology. Fuzzy systems are built on a set of rules. These rules, while apparently similar, allow the input to be fuzzy, same as the way that humans express knowledge. This linguistic input can be testifying directly by a fuzzy system. Therefore, the natural format greatly eases the interface between the engineer knowledge and the domain expert. Benefit of utilizing fuzzy technique is lot more flexible. It is easy to understand. It is more robust than standard non-linear programs, as it may work with imprecise and also noisy feedback.

Review on Fuzzy Techniques

There are many proposed methods given by different researcher to detect fault within stator and rotor of induction motor using fuzzy logic techniques. PedroVicente Jover *et al*. in 2008 [2] proposed the work on online monitoring of induction by using fuzzy logic method. The main approach was for the detection of stator winding faults; fuzzy logic technique has been used to make selections approximately the stator motor situation. The finite element method (FEM) is utilized to generate digital information that assist the construction of the membership functions and give the possibility to online detection of fault within system. The layout has been performed in MATLAB/SIMULINK; with both data from a FEM motor simulation application and actual measurements. In this work by monitoring the motor current amplitudes with the help of fuzzy logic showed the feasibility of spotting stator failures in an induction motor. The fuzzy logic model was able to explain the motor stator

situation with high accuracy. This work was also an example of fusion between fuzzy logic and FEM in order to design a reliable system.

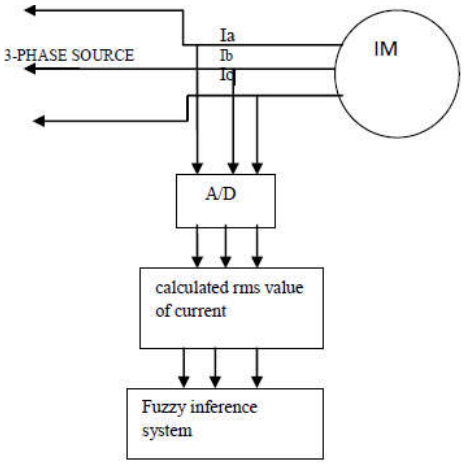

Figure 3 Block diagram of the stator protection system. [2]

The main drawback of this methodology is current unbalance originating from the supply source may be identified as a fault condition of the motor. But even this drawback can be overcome by monitoring the voltage and introducing new rules in the inference system.

R. SaravanaKumar *et al*. [4] in 2009 provide work on lab view with the assistance on fuzzy strategy. The principle goals was to perform shortcoming investigation on an induction motor utilizing both experiments and simulation, and to study failure distinguishing proof procedures applied for condition checking of the motor . On-line condition monitoring framework with fuzzy logic controller utilizing Lab View has been used. The work provide demonstration of three-phase induction motor in three stage reference outline utilizing Matlab/Simulink and framework for condition monitoring of the motor. Work was also concerned with the execution of On-line condition monitoring framework through Lab View. This technique permits quick failure state estimation. This is an exceedingly adaptable innovation for condition observing and fault examination of motors. It takes care of the shutdown Problems and guarantees safe workplace in nonstop processing industry [4].

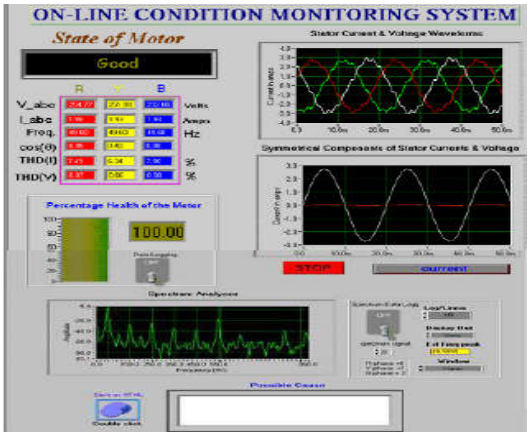

Figure 4 Stator current and Percentage health of induction Motor (one phase open) using lab view [4]

Mr. ChavanMayur *et.al* [5] in 2013 has presented research work on the application of fuzzy logic to study, compare & identify health condition of induction motor under various faults. The proposed work aims to detect various faults like under current, overload, single phasing, two phases open by condition monitoring of induction motor taking current as the reference parameter using technique such as fuzzy logic by developing working model of system. The stator current is an important parameter for fault diagnosis process. The fuzzy system depends on a set of rules. In this purposed work the motor phase currents have been monitored and based on subsequent trend in current values detection of motor status has been analyzed. Experimental setup is based on step in which a fault detection system is developed and tested on a three phase, 440 v, 50 Hz, 0.37 KW, 1390 RPM induction motor. The result of motor condition determination were analyzed and tested for the different mode of operations such as good condition, single phase open, no supply, undercurrent, overvoltage, critical loaded in [5]. MATLAB fuzzy tool facilitates the insight to fuzzy inference process vide the rule viewer option on fuzzy inference system Edit menu. Fig.5 gives the clear idea about the whole system for fault diagnosis in this research work. This greatly helps for proper designing of fuzzy sets, fuzzy rules and overall performance of fuzzy inference system in terms of output targeted for all possible range of inputs.

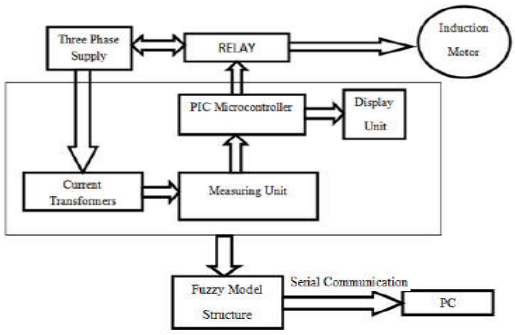

Figure 5 Overall block representation of system [5]

Rui Francisco Martins Marçal and Kazuo Hatakeyama in 2014 [6] present research work on failure detection in rotating machines based on a change of vibration pattern and provide the knowledge about operation conditions using fuzzy logic technique. A mechanic structure as an experimental prototype where faults can be inserted called Rotating System has been used. The faults in this work were caused due to insertion of asymmetric masses for unbalancing in the axle wheel "The Spectral Signature", has been achieved which were called as the vibration standard of the Rotating System. The changes in the vibration standard have been evaluated and used as parameters for detecting incipient failures, as well as their condition monitoring, allowing predictive evaluation. The Fuzzy System was calibrated to detect and diagnose the conditions: normal, incipient failure, maintenance, and danger, with the help of linguistic variables. The frequency of rotation and the amplitudes of vibration of the axle wheel were considered as parameters for analysis, diagnostic, for the decision by the Expert System based on Fuzzy rules. The results confirm that the proposed method is useful for detecting incipient failures, monitoring the evolution of severity and offering grants for planning and decision making about maintenance or prevention of rotating machines**.** The obtained results show that it is

possible to predict and diagnose incipient failures. The developed ES presents "sensibility" and "similarity", two requested characteristics for an efficient and consistent ES. The ease of altering rules and updating variables makes the ES versatile. It can accommodate the desired performance range of the system, the quality of the construction, risk factors, and tolerance due to the constant use of machines [6].

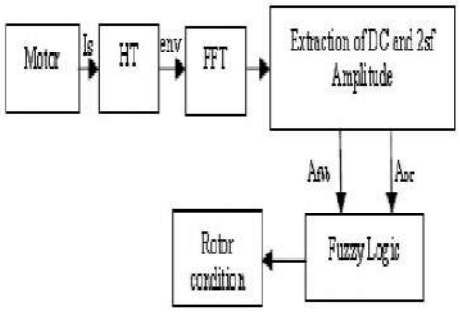

Figure 6 proposed Motor fault diagnoses using fuzzy logic [7].

Priyanka Dewangan *et al*. [7] in 2015 proposed research work on diagnosis of rotor side broken bars spectral investigation through Fast Fourier Transform (FFT) and bisurcapion of the spectral response in view of fuzzy controlled identifier. For the fault analysis objective, two elements are look over the range of the stator present, one is the amplitude of the harmonics representing the broken bars faults 2sf (where s is the slip and f is the fundamental harmonics) and the second is the dc value. With these parameters a fuzzy identifier recognizes the quantity of broken bars. Execution of the proposed framework a few tests have been performed for different motor and load conditions. The results of detection and diagnostic obtained from the developed system is found to be very prominent than the state of the art algorithms. This work analysis technique utilizing sugeno type fuzzy controlled identifier has been effectively created to decide the state of the induction motor. By utilizing acquired parameters a sugeno type fuzzy identifier was created to recognize the quantity of broken bars. This paper explained experimental setup as given in Fig.6 in which, the stator current envelope was obtained via Hilbert transform and then used as diagnostic signal. The amplitude of the dc and 2sf components of the spectrum stator current envelope were used as inputs to the fuzzy system which further converted to variables linguistic by fuzzy subsets and their corresponding membership functions. The output of this system supposed to be the good representation of the rotor condition. At the end of research the purposed system was capable to detect the correct number of broken bar.

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