Detection of the stator winding fault in three phase induction motor using Fuzzy Logic

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Hoshiar Hassan
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1 The relevant questions in my opinion concerning this article are:

1. Why induction motors?
2. What is the basic construction of induction motor? What is the operation principle?
3. What are the parameters, which need to calculate?
4. How can the faults be classified?
5. What are the percentages of failures in induction motor?
6. Why is the online monitoring important?
7. What are the impacts of the faults and failures of induction motors?
8. What are the main used methods in the fault diagnosis field?
9. What is an accurate model to describe a faulty motor?
10. How can be the faults detected and monitored?
11. What is the best method to detect concerning accuracy and costs?

2 The most relevant articles:

[1] Pedro Vicente Jover Rodrı´guez, Antero Arkkio, Detection of stator winding fault in Induction motor using fuzzy logic. Available online 16 September 2007 at www.sciencedirect.com

[2] Incipient fault detection in induction machine stator winding using fuzzy-Bayesian change point detection approach, Marcos F.S.V. D'Angeloa, Reinaldo M. Palharesb, Ricardo H.C. Takahashic, Rosangela H. Loschid, Lane M.R. Baccarinie, Walmir M. Caminhasf. Available online 24 November 2009. Available online at www.sciencedirect.com

[3] Induction motor fault detection and diagnosis using current state space pattern recognition, João F. Martins, Vitor F. Pires, Tito Amaral. Available online 29 September 2010. Available online at www.sciencedirect.com

[4] A simplified scheme for induction motor condition monitoring, Pedro Vicente Jover Rodrı´guez, Marian Negrea, Antero Arkkio. Available online 28 November 2007. Available online at www.sciencedirect.com

[5] On-Line Fast Motor Fault Diagnostics Based on Fuzzy Neural Networks. DONG Mingchui, CHEANG Takson, CHAN Sileong. Volume 14, Number 2, April 2009. Available online at www.sciencedirect.com

[6] An Approach of Condition Monitoring of Induction Motor Using MCSA. Volume 1, Issue 1, 2007. Available at http://www.wseas.us/journals/saed/saed-3.pdf.

[7] Soft Computing Based Fault Diagnosis. K. Vinoth Kumar, *Member, IEEE*, S. Suresh Kumar, *Member, IEEE* and Badugu Praveena. International Journal of Computer and Electrical Engineering, Vol. 2, No. 4, August, 2010. Available at http://www.ijcee.org/papers/223-E624.pdf

[8] Fuzzy Logic based Fault Detection of PMSM Stator Winding Short under Load Fluctuation using Negative Sequence Analysis. J. Quiroga, Li Liu, Member, IEEE,

and D. A. Cartes, Senior Member, IEEE. June 11-13, 2008. Available at *http://www.nt.ntnu.no/users/skoge/prost/proceedings/acc08/data/papers/0917.pdf*

[9] Diagnosis and Fault Tolerant Control of the Induction Motors Techniques a Review. Khalaf Salloum 1 Gaeid and 2Haider A.F.Mohamed. © 2010, INSInet Publication. Available at http://insipub.net/ajbas/2010/227-246.pdf.

[10] Induction Machine On-Line Condition Monitoring And Fault Diagnosis. A Survey. M.L. Sin, W.L. Soong and N. Ertugrul. University of Adelaide 2003. Available at http://www.industrialecg.com/Library/Technical%20Papers%20by%20Third%20Parties/MCSA%202003%20Australia%20032%20Soong%20full%20paper.pdf

3 The comments of the relevant articles

3.1 Article [1]

Keywords: Induction motor, Fuzzy logic, Winding faults, Current and Detection.

The authors want to explain his goals in 8 sections. In section 1 (the introduction), the author wanted to give an abstract view of how the induction motor is important in our lives, and he referred to the induction motor as ''workhorses'' of industry. Electrical machines are most common in the industrial process.

Then, they began to bring up how the faults in the induction motor are classified, and the percentage of all kinds of faults. In the current research they found out that the stator winding fault is 38 %. Therefore we need to give this fault more attention. (Figure 1 &2)

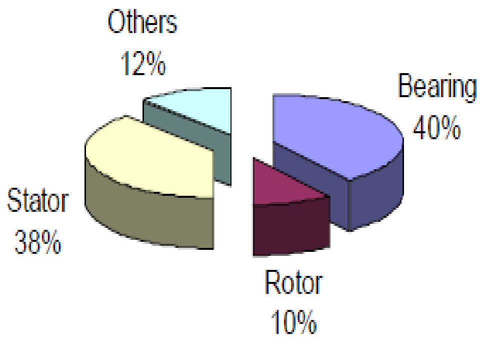

Fig.1 The fault the percentage

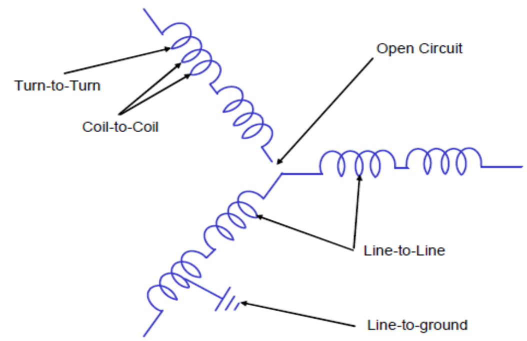

Fig. 2 Possible failure modes in stator windings

The other subject that he explained in the introduction is how the fuzzy logic approach may help to diagnose induction motor faults and how this method is important in industrial processes to store a certain knowledge, which allows it to make decisions with a high percentage of accuracy.

The authors say that: the lack of prepared processing of fuzzy input data, and the construction of the membership functions are presented as the major difficulties.

Hence this programme addresses this problem by using FEM(Finite Element Method) in order to generate reliable virtual data, which allows the construction of the membership functions in all faulty and load conditions.

In chapter 2 the authors talk about the kinds of stator winding faults. He said: pre-warning of the motor failures such as face to face short-circuit, and face to earth short-circuits can only be achieved if shorted turn within a coil, such as turn to turn short-circuit can be initially diagnosed by online diagnostic.

There is a common technique for online detection of the motor faults. This is known as Motor Current Signature Analysis MCSA. (Figure 3)

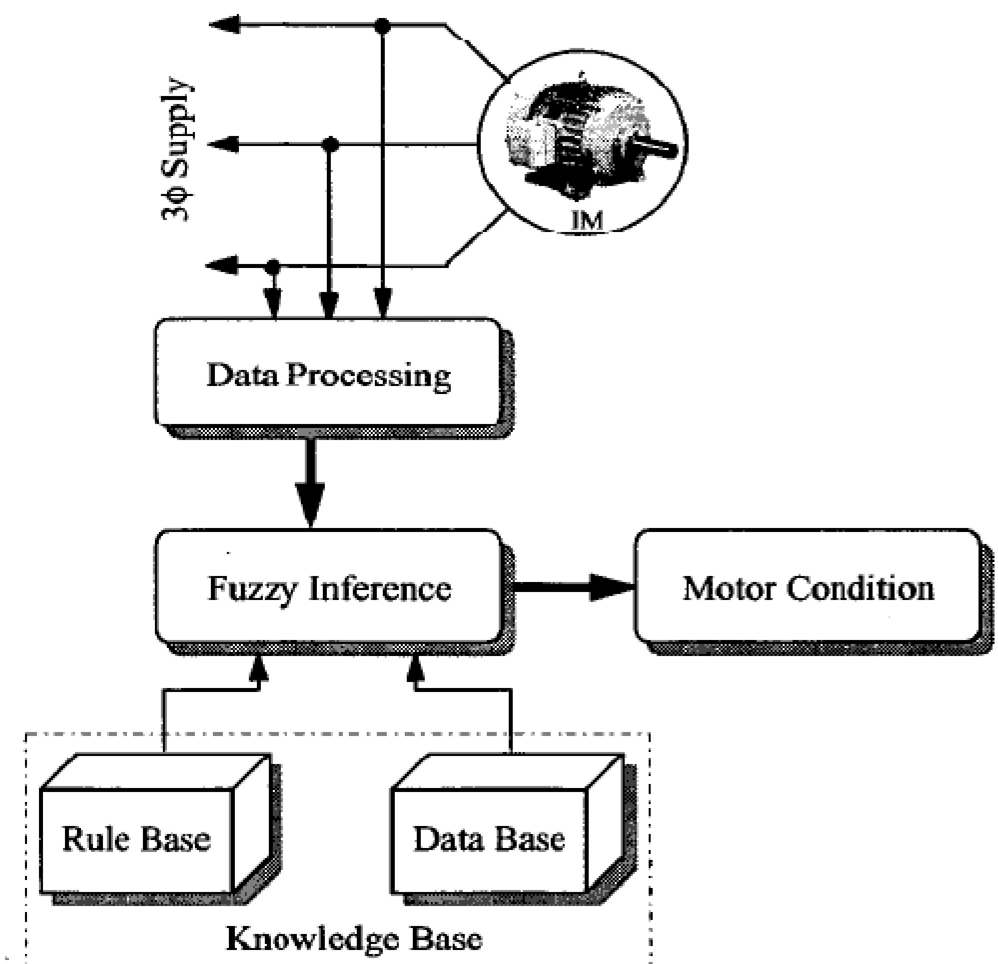

Fig. 3 The detection block diagram

In chapter 3, FEM software is used to solve the electromagnetic problems, which are described by the Maxwell equation.

In chapter 4 the detection system is described, and the block diagram also shown. This system detects the amplitudes of the motor phase currents Ia, Ib, and Ic. The root mean square (rms) of each phase (line) current is calculated using the standard formula:

$$rmc = \sqrt{\left| \frac{1}{T} \cdot \int_{t}^{t+T} I(t)^2 \, dt \right|}$$

These analogical measurements are converted in digital data, with A/D converter.
Any asymmetric in the stator winding produces unbalance in the motor currents. The most difficult case to identify might be when there is only inter- turn short circuit, as is shown in Fig. 5, where the lowest unbalanced is shown. Figs. 4 and 5 correspond to measured data. The main idea of the developed monitoring system is to spot the unbalance in the input currents as fast as possible avoiding a major failure. The system should be able to detect a short-circuited coil and open phase.

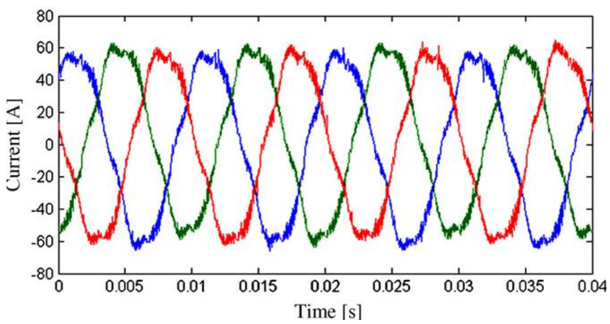

Fig. 4 the phase currents in a healthy motor

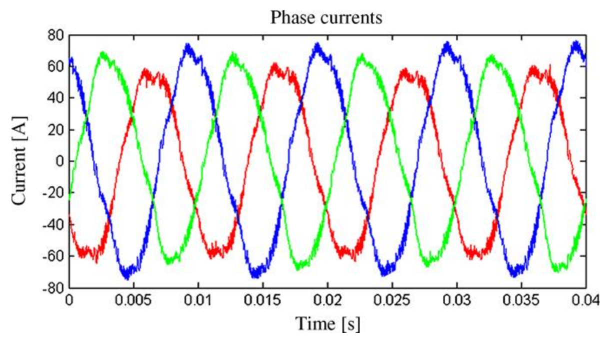

Fig. 5 A faulty motor during an inter-turn Short- circuit.

In 4.1, we can know the stator condition by observing the phase current amplitude, being the relationship between the stator and the current vague. Therefore, the collected numerical data are presented as linguistic information.
The input (Phase currents) and the output (Stator Condition SC) are categorized using four linguistic variables for the input and three for the output. These categories are very small (VS), small (S), medium (M) and large (L) for the input (Figure 5). The linguistic variable ‘‘stator condition’’ (SC) (output), interpreting the stator condition could be ‘‘good’’ (G), ‘‘damaged’’ (D) or ‘‘seriously damaged’’ (SD) (Figure 7). ‘‘G’’ refers to a stator with no faults, ‘‘D’’ might be a stator with current unbalance (inter-turn short circuit), and ‘‘SD’’ a stator with an open phase or coil short-circuited. The membership functions for the input and output variables are constructed by the analysis of data generated by FEM.

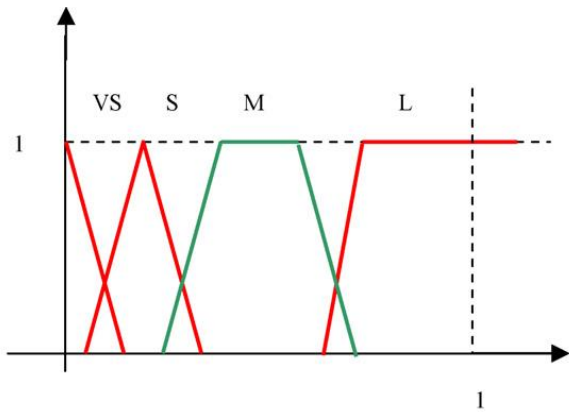

Fig. 7 Input membership functions

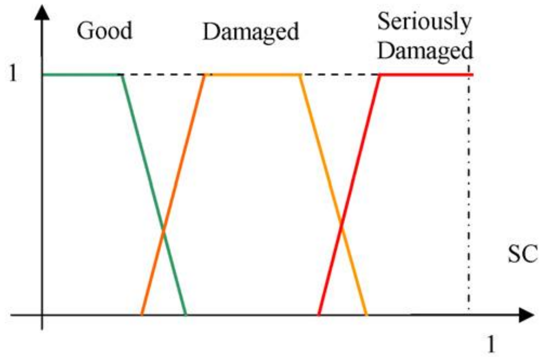

Fig. 8 Output membership functions

The 4.2 is about the inference system and design of the rules based on the expert understanding. The process consists of two parts: knowledge acquisition and formation of rules and combination of rules. Hence, the inference system will perform as a power engineer with an Ammeter. From the optimization of all different possible combinations between the three currents and four linguistic variables, the following set of rules is obtained. This set of rules contains the knowledge and description of the machine condition. They are universal for all three phases induction motors.

- Rule 1: If Ia is VS then SC is SD.
- Rule 2: If Ib is VS then SC is SD.
- Rule 3: If Ic is VS then SC is SD.
- Rule 4: If Ia is L then SC is SD.
- Rule 5: If Ib is L then SC is SD.
- Rule 6: If Ic is L then SC is SD.
- Rule 7: If Ia is S and Ib is S and Ic is M then SC is D.
- Rule 8: If Ia is S and Ib is M and Ic is M then SC is D.
- Rule 9: If Ia is M and Ib is S and Ic is M then SC is D.
- Rule 10: If Ia is M and Ib is M and Ic is M then SC is G.
- Rule 11: If Ia is S and Ib is S and Ic is S then SC is G.
- Rule 12: If Ia is S and Ib is M and Ic is S then SC is D.
- Rule 13: If Ia is M and Ibis S and Ic is S then SC is D.
- Rule 14: If Ia is M and Ib is M and Ic is S then SC is D.
- Rule 15: If v is L then SC is D.

This inference system is universal for all kind of three- phase induction motors. However, the membership functions must be defined from a FEM calculation. They depend of the motor size.

In section 5 and 6, we see the simulation and measurements results for Two different motors, a 15 kW delta connected and 35 kW star connected. The fault detection method was first tested online with data from FEM motor simulation program. As the FEM program takes into account the non-linearity and inhomogeneous characteristics of the materials, it is a good approximation to the actual motor.
During every data set, the fuzzy filter executes 25 validations of the stator condition.
A measuring setup was arranged to get data from a working motor. The insulation of winding wires was scratched and two wires were soldered to them. These were long enough to be closed from outside the motor through a switch. The short circuit was made active during a short time, just enough to take the 0.75 s of data.

In section 7 and 8, throughout this work, fuzzy logic was used to analyze the data and make decisions. The method was able to detect the motor condition with high accuracy as can be seen in Table 3. Fuzzy logic is a good option because there is no general and accurate analytical model that describes successfully the induction motor under fault conditions.

3.2 Article [2]

Keywords: Incipient fault detection, Induction machine stator-winding, Fuzzy clusters, Bayesian analysis and Metropolis‐Hastings algorithm.

This paper consists 14 pages in five sections.
Already section one, talks about how the induction machines important are in the different industrial applications. Faults in the stator windings of three-phase induction motor represent a significant part of the failures that arise during the motor lifetime. When these motors are fed through an inverter, the situation tends to become even worse due to the voltage stresses imposed by the fast switching of the inverter.
The stator winding of induction machine is subject to stress induced by a variety of factors, which include thermal overload, mechanical vibrations and voltage spikes. Deterioration of winding insulation usually begins as an inter-turn short circuit in one of the stator coils. The increased heating due to this short circuit will eventually cause turn to turn and turn to ground faults which finally lead the stator to break down.
In this paper, a new two-step formulation for incipient fault detection in the stator windings of induction machines is proposed. The proposed methodology deals with the fault detection problem as a change point detection problem over the time series of the root mean square (rms) values of stator currents. The change point detection algorithm is based on a fuzzy set technique and a Markov Chain Monte Carlo (MCMC) method. The proposed method, differently from former techniques, does not require any prior knowledge about statistical properties of the time series before the application of the MCMC procedure. This is made possible by the first step, in which a fuzzy set technique is applied in order to cluster and to transform the initial time series (about which there is no a priori knowledge of its distribution) into a time series whose probability distribution can be approximated by a beta distribution.
In section two, we see how the induction machine becomes modeled and simulated with turn- to-turn short- circuit in the stator winding. The deterioration of insulation usually begins as a short circuit fault of the stator-winding. This section describes the model that is employed here for the simulation of inter-turn short-circuits in the stator windings of induction machines.
Fig. 9 represents the schematic diagram of a motor with an inter-turn short-circuits.

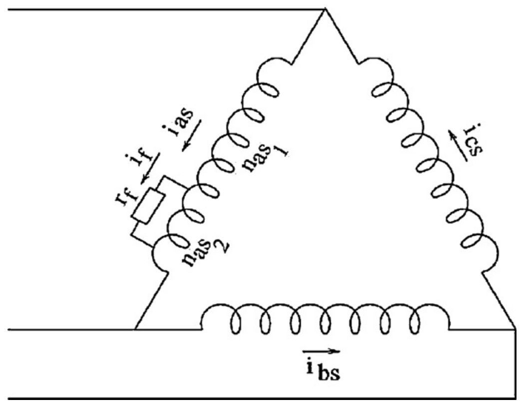

Fig. 9 representation of stator windings of a motor with inter-turn short circuit.

In section three, we see the detail of the proposed two step formulation to the change point detection problem. The first step consists in transforming the given time series into another one with beta distribution using a fuzzy set technique.
Hence, we see also as the pervious article the same detection system, but with another name as follow in Figure 10.

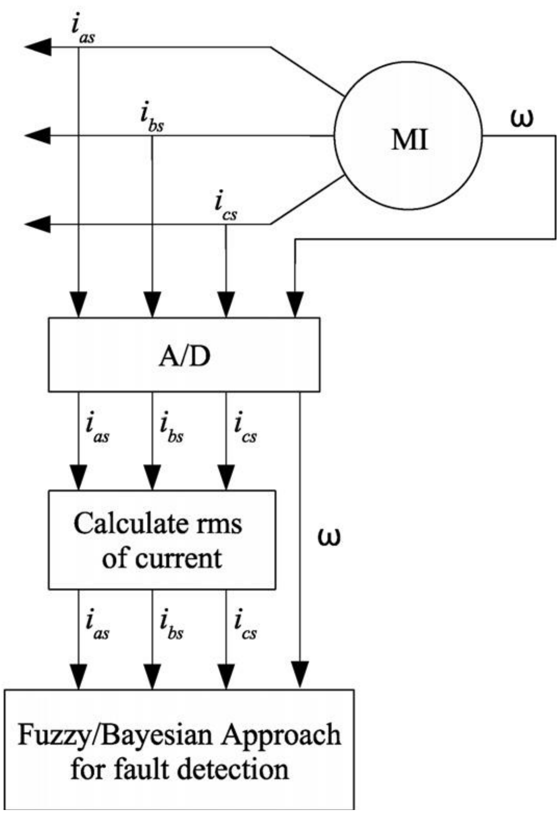

Fig. 10 Block diagram of the detection system

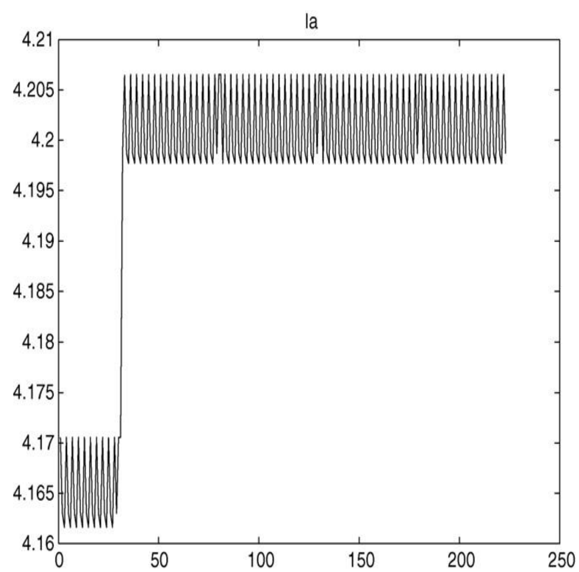

Fig. 11 rms phase current with 0.1% of turns In short- circuit in phase a

In section four, the implementation details are described, and both simulation results and experimental results are presented. The system monitors the instantaneous values of the motor currents ias, ibs, ics and the rotor speed ω. Firstly, the analogical measurements are converted

in digital data through an A/D converter. Then the root mean square (rms) value of each phase current is calculated over a period of time.
In 4.1 and 4.2, the simulation and practical results are presented. The simulation results have been obtained by simulation of the induction machine using the model described in section two. In all experimental tests, the stator windings of the motor have delta connection. When short-circuits were introduced, a shorting resistor was used in order to limit the value of the short-circuit current, thus protecting the motor windings from complete failure.

3.3 Article [3]

Keywords: Fault diagnosis, Induction motor, Stator currents, Current patterns and Features extraction.

This paper consists of five sections in eight pages.
In the introduction (section one), the authors give at first, how the fault detection can be specified as binary decision: the system is working well or something went wrong. Expressing it this way may lead the reader to think that this is a trivial issue. The truth is that to be useful, the fault must be identified and classified, before it can be labeled serious and handled accordingly. Several drawbacks, such as disturbances, imprecise measurements and uncertainties, all together contribute to make fault detection a very difficult task.
Then, we see also how the role of induction machine important is in the current industrial life.
In fact, in the last years monitoring induction motors has become very important to reduce maintenance costs and prevent unscheduled downtimes. For that reason, there has been a substantial amount of research to provide new condition monitoring techniques for induction motors, which is described in the next section.
A common fact in the usual techniques is that the user must have some degree of expertise in order to distinguish a normal operation condition from a potential failure mode. Therefore, fully automatic pattern recognition methods are required to identify induction motor fault.
In this paper, they want to say, that they propose new procedures to detect three-phase induction motor stator winding and rotor faults. These procedures are based on the image identification of the 3- D current state space patterns, and will allow the identification of turn faults, in both stator winding and rotor broken bars, as well as their correspondent severity. The identification of the faulty phase, in the case of the stator fault, is another important feature of the proposed algorithm.

The section two is the pattern recognition approach. As we see here, that the Most of the common methods used to identify and classify a faulty induction motor are based on the analysis of the stator currents. The proposed approach also uses the analysis of stator currents, however, in this methodology this problem is converted into a pattern recognition analysis. Thus, considering a three-phase induction motor without neutral connection, ideal conditions for the motor and an unbalanced voltage supply, the stator currents are given by (1), where ia, ib and ic denote the three stator currents, Imax their maximum value, x their frequency, / their phase angle and t denotes time.

$ia = Imax \sin(\omega t - \varphi)$,
$ib = Imax \sin(\omega t - 2\pi/2 - \varphi)$,
$ic = Imax \sin(\omega t - 4\pi/2 - \varphi)$.

In the proposed approach the currents are recognized as typical patterns for each faulty mode. This is accomplished by analyzing them in a 3-D current state space. For a healthy motor the corresponding current pattern is a circle centered at the origin of the coordinate's degrees, as the stator currents differ from each other by 120 electrical degrees (Figure 12a and 12b).

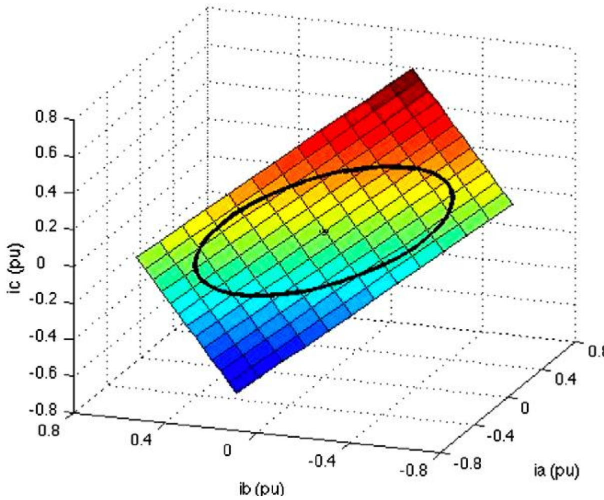

Fig. 12a Stator current pattern for healthy motor 3D

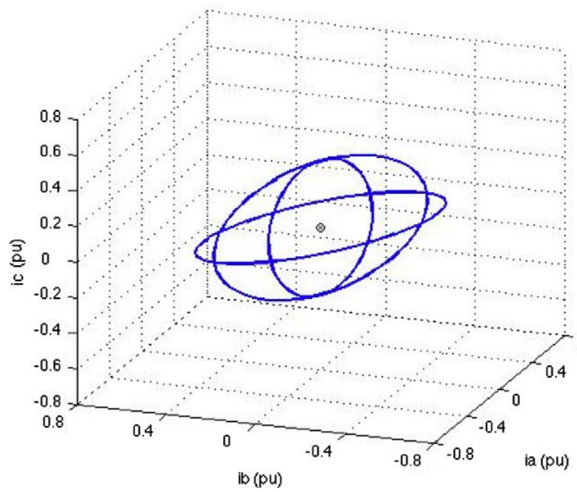

Fig. 12b Stator current with winding faults

In section three, we see how the structure of the image processing is built up. The proposed image-processing algorithm is divided into three steps: the stator current state space transformation, the image composition, and the feature extraction (Fig. 13). The inputs for the image processing based system are the three-phase stator currents and the output is the identification of the motor working condition.
In the image composition stage, the three-phase stator current vector is transformed into a binary image contour. The feature extraction step will identify the type of fault and its correspondent severity. The obtained images for healthy and faulty motors are distinct, and their differences are detected and analyzed in the feature extraction step.

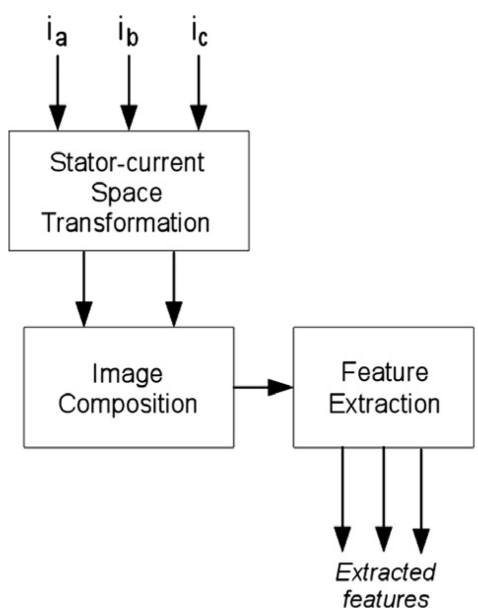

Fig. 13 Structure of the image processing system

In the image analysis and recognition step, it is usually necessary to extract the foreground from the background of an image in order to obtain useful information. Image segmentation is one of the most critical tasks in automatic image analysis. It consists in subdividing an image into its constituent parts and extracting the parts of interest (objects or patterns). Segmentation is typically based on either finding boundaries that separate regions or combining similar sub-regions into larger regions.

In section four, we see also here the simulation and the experimental results and comparing between them. If the stator severity index is greater than zero then the motor has a stator fault (Table 1). The analysis of the pattern's orientation identifies which stator winding presents the turn fault.

Table 1
Simulation results

Fault type	Stator severity index [Sst]	Contour orientation
No fault	0.001	–
Stator fault – phase a	0.389	326.1
Stator fault – phase b	0.389	207.6
Stator fault – phase c	0.389	89.8

3.4 Article [4]

Keywords: Induction motor; Fault detection; Fuzzy logic; Predictive filter; Condition monitoring

This paper consists three sections in 21 pages.
In the introduction (section 1) is a mostly the same information as the previous papers.
There have been some integrated motor protection systems for monitoring electrical fault in induction motor by analyzing the motor current. The authors arrived to the conclusion that for this failure the motor current is a very poor indicator.
Hence, the online system for induction motor fault detection based on artificial neural network. Firstly, the system utilized a selective filter in order to reduce the amount of harmonics to a manageable number. After sufficient training period, the neural network is able to sign a potential failure condition. While this technique has demonstrated success in identifying an incipient failure, a prerequisite for its operation is a priori fault data, which is clearly not available.

The section two is named as methods.
2.1 Motor Current Signature Analysis (MCSA) methods. The authors based on experimental observation and on knowledge of the machine constructed a knowledge-based system. The motor condition identification task requires the interpretation of data and makes a decision from this data. From the point of view that sees induction motor condition as a fuzzy concept, there has been some fuzzy logic approaches for diagnosis. The lack of proper processing of fuzzy input data and the construction of the membership functions are presented as the major difficulties.
2.2 Finite Element Method (FEM). FEM (finite element method) simulations can remove this requirement by predicting the machine behavior under various operational conditions. FEM is used in our investigation to foresee the changes of motor performance due to the changes in the internal parameters when the motor is working under fault conditions. Numerical simulations generate useful data, which are used to test the diagnostic techniques (Figure 14).

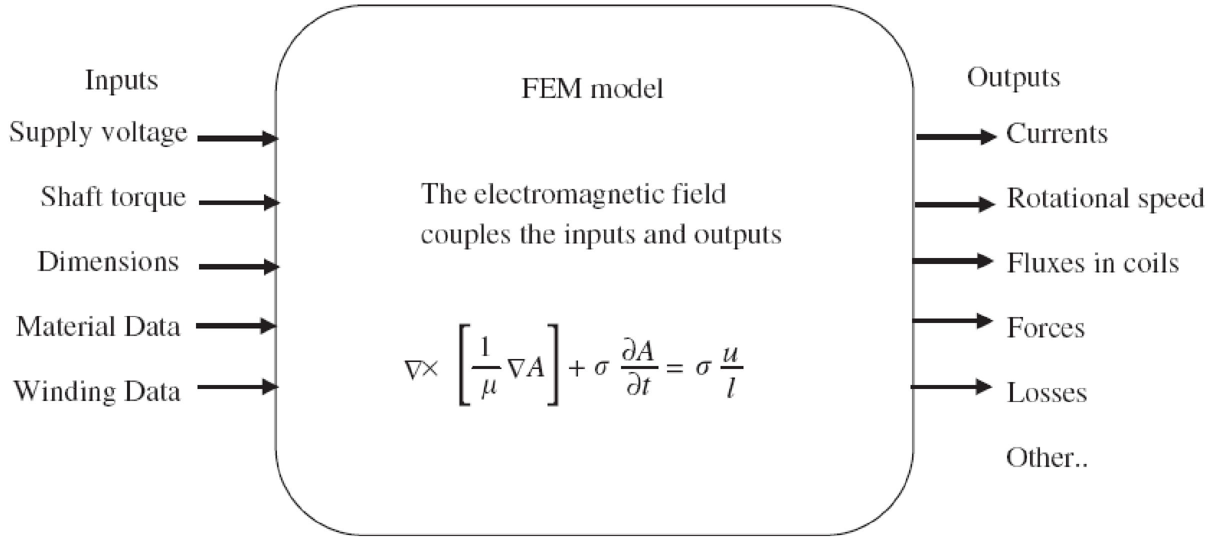

Fig. 14 Electrical machine modeling by FEM

It is important for condition monitoring strategies to make clear the dependence between the amplitude of the sideband currents and the machine loading. The load dependence is studied for the case of a pure dynamic eccentricity (Figure 15).

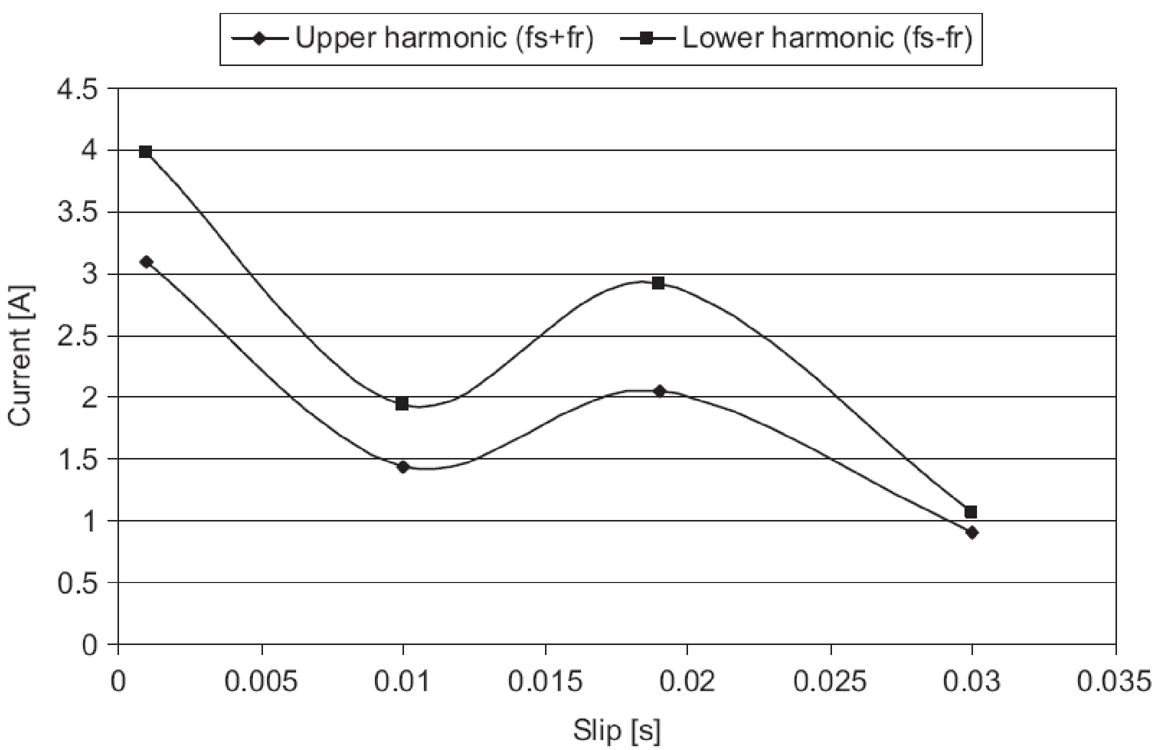

Fig. 15 Load dependence of the sidebands currents Motor working with 33% pure dynamic eccentricity

2.3 The proposed motor protection system

The proposed detection system in this work is a consequence of the analytical results. The scheme of the system can be seen in Fig. 16. The system consists of two main blocks. The left-hand block to spot electromechanical faults from the rotor (broken rotor bars and eccentricity) is based on monitoring the content of the spectrum of the current. The right-hand block to spot faults from the stator is based on monitoring the amplitudes of the motor currents.

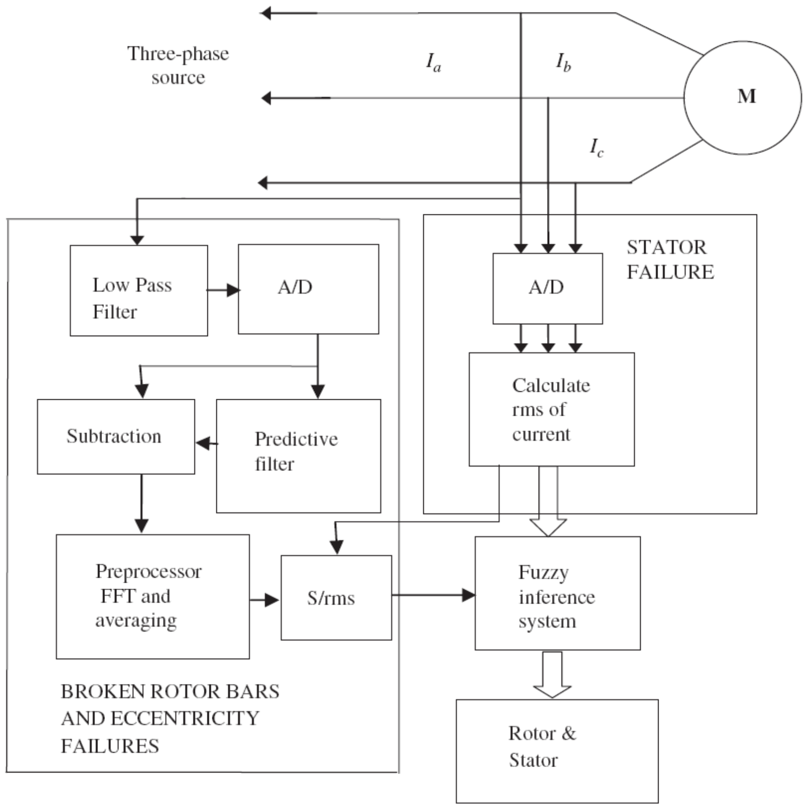

Fig. 16. Block diagram of the proposed integrated motor protection system.

The left-hand block has a new idea with respect to the traditional scheme given by Nandi and Toliyat, in order to make the system able to work in variable frequency and avoid the detailed spectral analysis carry out by a traditional MCSA. After the A/D block, a predictive filter is used to remove the fundamental component. This filter is able to work in variable frequency keeping the filtering properties. The role of this filter is very important. This filter does not produce delay between the incoming signal and the filtered signal.

In 2.4 and 2.5, we see the simulation and measurement results. During every data set, the fuzzy filter executes 25 validations of the stator condition. In order to prove the performance of the SIMULINK model under noise condition, a source of noise to each phase was added. Table 2 shows the percentage of correct detection of stator condition under noise.

Table 2
Percentage of correct detection of stator condition under noise

Motor condition	Data sets	Accuracy (%)
Healthy motor	3	96
Open phase	9	100
Inter- turn short	3	92
Coil short- circuited	3	100

3.5 Article [5]

Key words: Fault detection and isolation; Gravity-average method; Supervisory learning; Fuzzy neural Networks

Fuzzy neural Networks
In this nine pages paper with five sections, the authors want to say that they on- lion method was developed to improve diagnostic accuracy and speed for analyzing running motors on site. This paper describes a diagnostic algorithm utilizing on-site pre-measured data sets that eliminate the variability between motors to construct the FNN membership functions as well as for network training to reduce the effect of static factors and increase the accuracy.

We see in the introduction, briefly about the historical of the fault diagnostics of induction motors with stator winding inter-turn short circuits and failed rotor bars as the major causes of motor failures. The early math-model-based diagnostics, such as parameter estimation, finite element analyses, and adaptive observer schemes, had the drawbacks of relying upon accurate mathematical models and a detailed understanding of the motors. Later approaches, such as motor current signature analysis (MCSA) and wavelet analyses require complicated signal preprocessing like fast Fourier transform (FFT) or wavelet transform (WT).
The main concerns in motor fault on-line diagnostics are the diagnostic accuracy and speed while diagnosing multiple running motors. Various static factors, such as imbalanced input power and motor misalignment, strongly affect the diagnostic accuracy and speed, requiring complex hardware designs and computational ability for motor fault diagnosis.

In section one, it is about how the symptoms of various motor faults captured from test data and expert diagnostic knowledge and experiences are combined into membership functions to define fuzzy sets. The mapping relationship from the motor symptoms to the type, location, and severity of the fault inside the motor can then be deduced.
Hence, the fuzzy sets for the motor faults are constructed based on six fault symptoms for three-phase induction motors.
There are various types of functions, such as Gaussian, triangle, π (pi), and S-type, can be used as the membership function, along with the fault test data and the expert knowledge.

The section two is about the FNN structure. In this paper FNN has 6 layers with 3n input signals *m* fault conditions, and 4*m* possible output conclusions indicating the fault type, location, and severity. For every layer, there is a special formula and processing.

In section three, we see the fault diagnosis results for a single phase induction motor after the iterative supervisory training.

We see in section four, the scheme of motor's inner fault on- line fast diagnosis. The hardware for the on-line fault diagnostics is illustrated in Figure 17. The probes and the sensors sample simultaneously 3*n* signals from each motor and transmit them through the CMOS transmission gate array and data bus to the upper A/D converter.

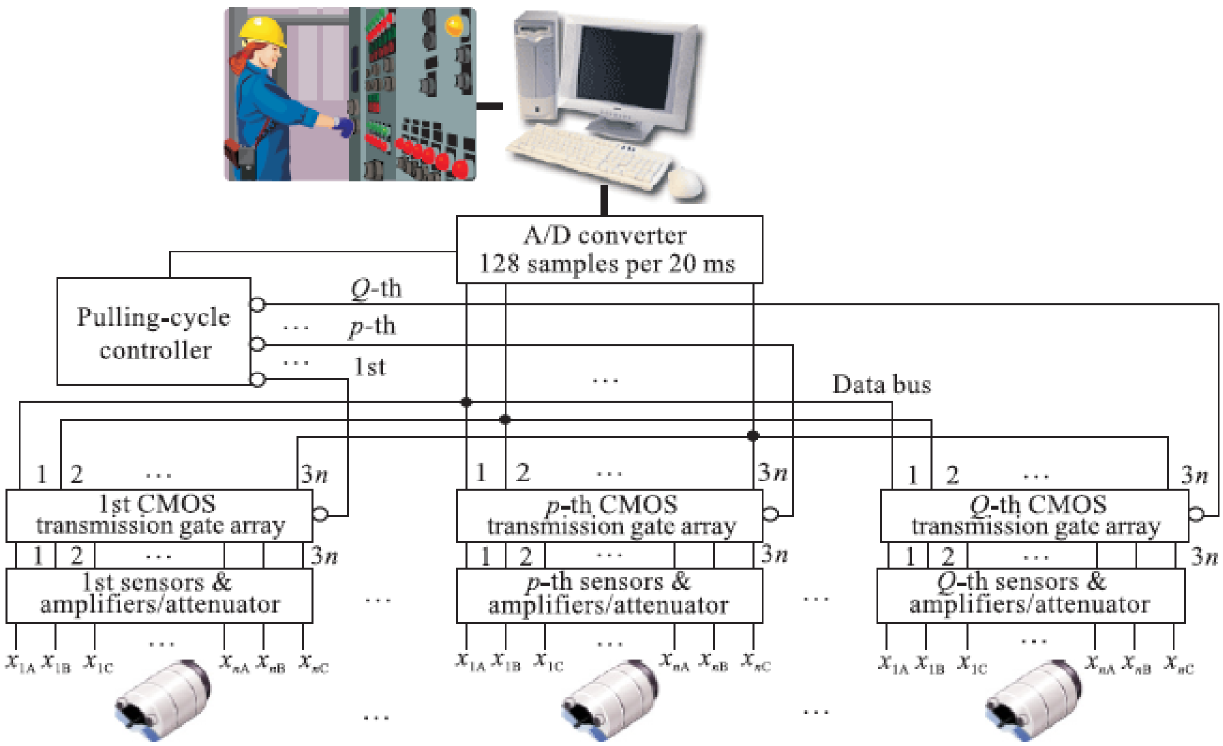

Fig. 17 Hardware for on-line fast fault diagnostics

Currently, electrical motors are amongst the most useful equipments in the industry. Generally, they are critical components in the industrial processes. Therefore, questions concerning their protection against failures have received considerable attention by maintenance engineers and experts.

3.6 Article [6]

This paper consists of a very briefly describing to condition monitoring of induction motor using MCSA method in eight sections in five pages.

In the introduction (section 1), the authors want to explain the reasons of the monitoring, that we have had already in the previous pages. A crucial point about motor current signature analysis (MCSA) is that it is sensing an electrical signal that contains current components that are a direct by-product of unique rotating flux components caused by faults such as broken rotor bars, air gap eccentricity, and shorted turns in low voltage stator windings, etc. MCSA can detect these problems at an early stage and thus avoid secondary damage and complete failure of the motor. In the figure 18 below is shown the basic components of this method of detection.

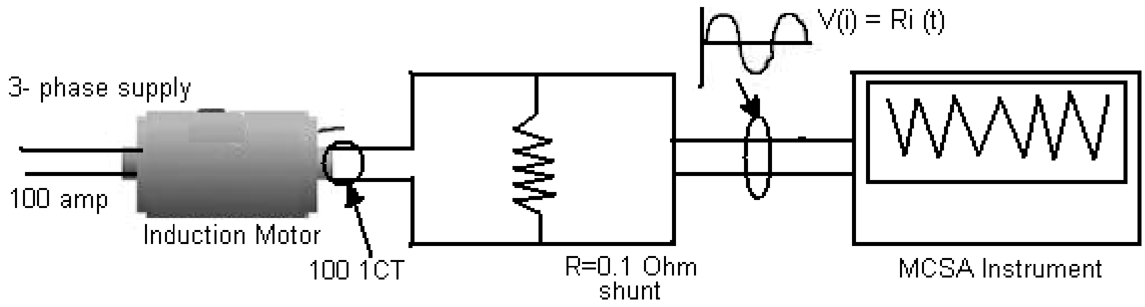

Figure 18 Basic MCSA Instrumentation Systems

In section two is explained the proper analysis of MCSA results, that will help the technician in identifying:

- Incoming winding health
- Stator winding health
- Rotor Health
- Air gap static and dynamic eccentricity
- Coupling health, including direct, belted and geared systems
- Load issues
- System load and

The basic steps for analysis are explained in section 3. The steps are arranged as follow:

- Map out an overview of the system being analyzed.
- Determine the complaints related to the system in question. For instance, is the reason for analysis due to improper operation of the equipment, etc. and is there other data that can be used in analyses.
- Take data.
- Previews data and analyse:

1) Review the 10 second snapshot of current to view the operation over that time period.
2) Review low frequency demodulated current to view the condition of the rotor and identify any load-related issues.
3) Review high frequency demodulated current and voltage in order to determine other fault including electrical and mechanical health.

Most faults can be determined at a glance, with many rules being similar for both MCSA and vibration analysis. In addition, there are several rules that should be considered such as:

Pole Pass Frequency (PPF), Harmonic Pole Pass Frequency and Non- PPF….. etc.

The historical of the theory of MCSA is explained in section four.

Section five, talks about the most common kind of faults related to the stator winding of induction motors, and they are: phase- to- ground, phase-to-phase and short-circuit of coils of the same or different phase.

Section six is about the rotor faults, and that not include in this review.

In section seven, there is a describing of the fault diagnosis and fuzzy logic. We have taken this subject in earlier papers.

The rest articles are a mostly the same as the previous papers that we have had, and also most subjects are repeated.

Therefore, I think that I have covered already the most important methods that I have needed it in this review.

4 The relevant derived questions that came up after reading the literature

Using fuzzy logic to detect the stator winding fault is the better method and accurate for stable, speed, parallel processing but of some of its architecture can't apply for dynamic processing and needs a lot of data compared with the other methods.
Accurate means for condition monitoring can improve the reliability and reduce the maintenance costs of induction motors.

It is useful to have a means for continuous remote monitoring of induction machines in unmanned/ hazardous locations (such as remote mining sites or petroleum processing plants) and in critical applications where the highest reliability is required.

After reading these articles, I have learned that the successful detection of induction motor faults depends on the selection of appropriate methods used, knowing this a few questions came to my mind, such as:

1. How the faults can be detected, if we monitor the phase voltages instead of the currents, which is the standard formula and how it can be modeled?
2. What could be changed in the modeling, if the motor is connected in delta instead of star?
3. What are the consequences of accuracy of the detecting using difference type of membership functions in the Fuzzy Logic?
4. How can the detection system be implemented, if we use Lab view?
5. What is about accuracy and costs, comparing between Lab view and Mat lab to detect the faults?
6. How can we convince the capital and owners of money about the feasibility of this method comparing with the classical methods?
7. Which of these methods can respond better and faster in the specified real- time?
8. How can be the detection, if the motor loaded with varying load conditions?
9. How can be the detection, if the motor is derived for example by Variable- frequency drive (VFD)?
10. What would be the difference in the detection system, if the motor is a synchronous type?

End