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Diagnosis and Revelation of Faults in Induction Motors Using Integrated Techniques

Zahid Farooq[1], Anwar Shahzad Siddiqui[2], Aziz Ahmad[3]

[1]*M.Techstudent,Al-falah University, Faridabad, Haryana (India)*
[2]*Professor, Dept. EE, F/O Engg. And Tech., JamiaMilliaIslamia, New Delhi, (India)*
[3]*Professor, Department of EEE, Al-Falah University, Faridabad, Haryana (India)*

***Abstract*—*Induction motors are used on greater scale in industries due to their user friendly interface. As these induction motors are highly reliable, they are prone to many types of faults. These faults can become dangerous and can cause various problems such as personal injuries, low production thereby bringing losses to industries.In this work we present communication media based system to monitor the conditions of motor revealingthe faults interrupting smooth performance of machinery in a very short span of time. Here we show the results to show its effectiveness.*
***Keywords*—Android, Revealing,Faults, FIS, FLC.**

I. INTRODUCTION

Induction motors are very often used in industries as these have various advantages such as low maintenance, low cost, ruggedness etc. Although it is machinery and is prone to multiple types of faults and an intelligent monitoring can ensure smooth operation of these motors. Well the faults in these motors can occur from both mechanical and electric forces. If these faults were not detected at early stage they may lead to motor failure or any other such serious activity bringing losses to the industry.

Various fault observing methods have been developed and being effectively employed to track down machine faults at various stages by using different machine variables. Hence for economic and safety considerations,it is necessary to visualize the performance of motors. A systematic condition monitoring scheme provide alarms and tracks down the faults at early stage. The performance of machinery is done by efficient condition monitoring providing certain benefits such as increases machine life, reduces damage and also reduces breakdown maintenance.

II. MONITORING MOTOR CONDITIONS

Here the motor conditions are monitored by stator current conditions. The stator current amplitudes can be described by assigning fuzzy subsets by means of membership functions. To activate fuzzy inference a knowledge base comprising the situations liable for faults in the motor comprising rule base and data base can be constructed. An apparatus of fuzzy inference can be used for induction motor diagnosis .Using fuzzy inference we can have improved and precise diagnosis as it comprises human knowledge with its own computing capabilities and knowledge based training. They can be directly expressed by fuzzy system.Induction motor under consideration is of *1.8-KW, 220/360 V, 13/7.4 A, 50-Hz, 4 pole, squirrel cage* type. The motor fault is characterized by the stator current signal on the basis of set of rules, the fuzzy input makes the fault description robust in information processing. The electromechanical characteristics of the motor makes the out coming faults be influenced greatly by applied voltage, motor input current and internal temperature. The structure of Fuzzy Monitoring and Diagnosis is shown in Fig.3.

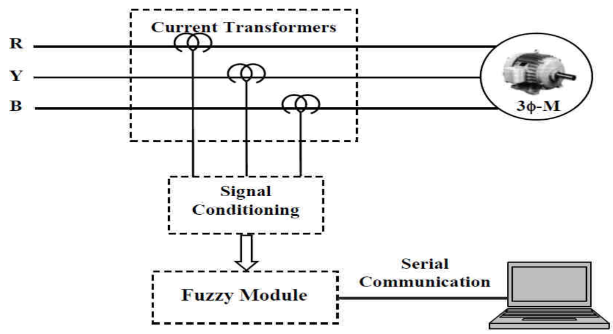

Fig. 3: Schematic representation of Motor condition Diagnosis layout

In the present study the motor phase currents have been monitored and based on the subsequent trend in the current values diagnosis of motor status has been judged. For Fault Detection and Diagnosis of Induction Motor stator current amplitudes *Ia, Ib, Ic*have been considered as the input variables to the fuzzy systems. The motor condition, *M*chas been chosen as the output variable. We have defined the

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fuzzy subsets $\tilde{I}_a \tilde{I}_b$ and $\tilde{I}_c$ for input variables given to the fuzzy subsets and $\acute{M}_C$ for output variables as follows-

$$\tilde{I}a = {}^{\mu a(ia)}/_{ia} \quad , \forall ia \in Ia$$

$$\tilde{I}b = {}^{\mu b(ib)}/_{ib} \quad , \forall ib \in Ib$$

$$\tilde{I}c = {}^{\mu c(ic)}/_{ic} \quad , \forall ic \in Ic$$

$$\acute{M}C = {}^{\mu mc(mc)}/_{mc} \quad , \forall\, mc \in Mc$$

Where *ia, ib, ic* and are elements of the discrete Universe of Discourse (UoD) i.e., *Ia, Ib, Ic* and *Mc*. Fuzzy logic works with linguistic variables whose values are words or sentences in a natural or artificial language. This provides a means of systematic manipulation of vague and imprecise information. The term set (T) is a collection of linguistic values assigned to linguistic variable. The term sets used for stator current and motor condition are as follows-

T (*Ia, Ib, Ic*) = {Zero (*Z*), Small(*S*), Medium (*M*), Big (*B*), Very Big (*VB*)}

T (*Mc*) = {Open Phase, Damage, Critically Overloaded, Overloaded, Good}

The optimized rule base has been developed so as to encompass all possible healthy and faulty conditions of the motor.

III. MEMBERSHIP FUNCTIONS CONSTRUCTION

After detailed study of the motor and various fault prone situations, we could identify various situations where motor condition is unhealthy. Well we can say it is the most important part of fuzzy system. These rules along with their firing weights are enlisted as-

1) If Ia is Very Big then Mc is Damaged
2) If Ib is Very Big then Mc is Damaged
3) If Ic is Very Big then Mc is Damaged
4) If Ia is Big then Mc is Critically Overloaded
5) If Ib is Big then Mc is Critically Overloaded
6) If Ic is Big then Mc is Critically Overloaded
7) If Ia is Small and Ib is Small and Ic is zero then Mc is Good
8) If Ia is Small and Ib is Small and Ic is Medium then Mc is Overloaded
9) If Ia is Small and Ib is Small and Ic is PS then Mc is Damaged
10) If Ia is Small and Ib is Zero and Ic is Small then Mc is Damaged

After detailed analysis of all rules we developed a rule base comprising only 5 rules covering whole health condition of motor.

Table: 1 Rule Base for Motor Health

Rule	If $I_{a\ is}$	Or If $I_{b\ is}$	Or If $I_{c\ is}$		Motor condition	Rule weight
1	Z	Z	Z	then	Open phase	(1)
2	B	B	B	then	Critically overload	(0.9)
3	M	M	M	then	Over load	(0.8)
4	S	S	S	then	Good	(0.7)
5	VB	VB	VB	then	Damage	(1)

The output on health of motor at any instant of time is obtained by inference input conditions of Stator currents being mapped with output motor health. The de-fuzzy processor follower which indicates motor health by rule firing of fuzzy inference. The Centre of Area type of d-fuzzy method is chosen for the study because multiple rule overlap of two areas are counted only once. The Slight voltage unbalance and faults are generated by FIS output corresponding to damage. The data pertaining the fault is stored for further time analysis. Severe faults like open phase, open coil, SLG, LL generate high damage outputs and the machine function should be terminated from the supply. The stator currents from fuzzy inference are shown as good, overload, critically overload, damaged or open phase. Thus motor condition is determined by Fuzzy ruler.

IV. SIMULATION AND RESULTS

As we know these induction motors play very important role in these textile industries and hence these monitoring is very essential. The machine parameters should be known for using real machine as a model. These machine parameters can be found by performing various tests such as no load test, DC test and short circuit test.The complete set up of Fuzzy based Fault Detection and Diagnosis for Induction Motor has been built around the Fuzzy Inference System designed in Simulink for detection of motor health condition and it is shown in Fig. 4.

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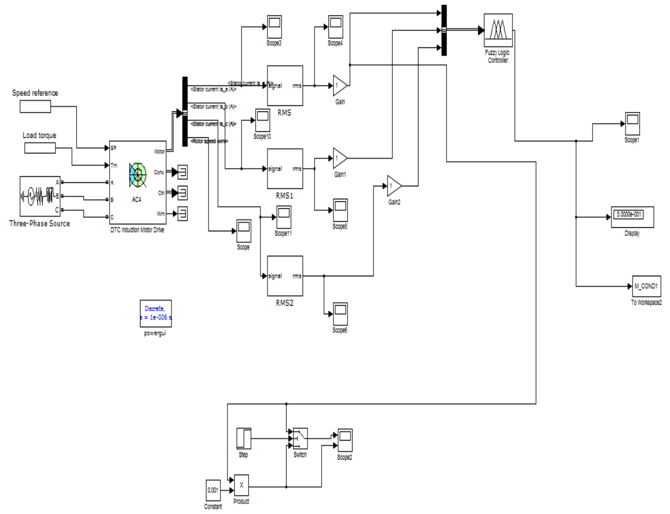

Fig.4: Simulink Diagram of Fault Detection Technique

The built-in block set of Induction motor has been employed for the purpose of study. Simulink model is categorized into different categories like Induction Motor Drive with Power Supply, FIS, and RMS to DC conversion and Fault creation. Three phase voltage supply is applied to induction motor. The induction Motor parameters are specified in the specific block like speed, torque as indicated in figure. Induction Motor Drive block includes the three phase induction motor in same block. The stator current of the induction motor is in AC form, it is necessary to convert it into DC. Therefore next block is RMS to DC conversion, which converts the RMS value into DC form. Different faults like open phase, unbalance of input voltage are artificially generated in this block. Different blocks like Sum, Product, Step input and Constant are used in fault creation.

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. Thus in our case is Stator current from each phase and output is condition of motor in linguistic form using fuzzy logic. The output is having range from 0 to 1 which is stored as variable M_COND in workspace and display on scope as well as its value on Display block. The mapping then provides a basis from which decisions can be made, or patterns discerned. The process of fuzzy inference involves all of the pieces that are Membership Functions, Logical Operations, and If-Then Rules. The motor condition may be good, damaged, overloaded, critically overloaded or open phase. The standard test input signals to the input of Stator current *Ia, Ib, Ic*are applied to fuzzy logic controller for observing the motor condition output.

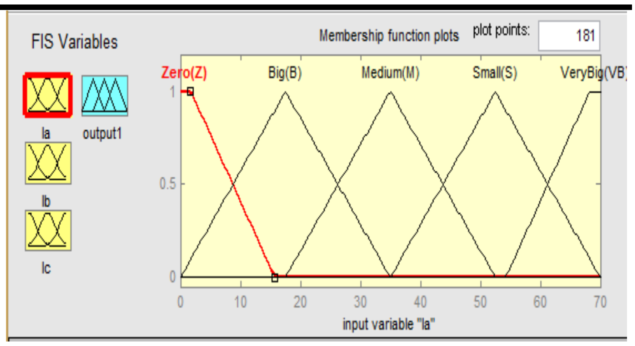

Fig.5: Implementing Rules to the FIS

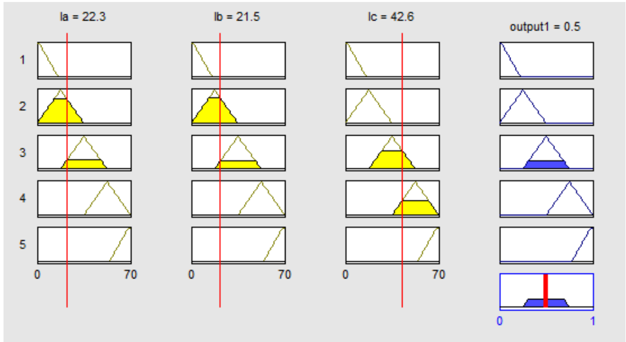

Fig.6: Representation of Implemented of Rules

After simulation for normal operation, the fault is created in part of winding R. Therefore the resistance value at this time is Rstator. Hence with the help of resistance ratios inductance values can be calculated.

$$\frac{Rstator, normal}{Rstator, fault} = n = \frac{Lstator, normal}{Lstator, fault}$$

As usual the simulation is started by normal parameters, after 0.5 sec the fault is created by changing the above said parameters. With this we found motor conditions remains healthy during normal operation and obviously no negative sequence component found in both stator current and stator voltage. When fault is created the stator current does not remain in balanced condition and obviously motor does not remain healthy. We can see there is a presence of negative sequence components in both statorcurrent.

Figure 7 &8 shows the Stator current and health of induction motor, symmetrical components of stator current.

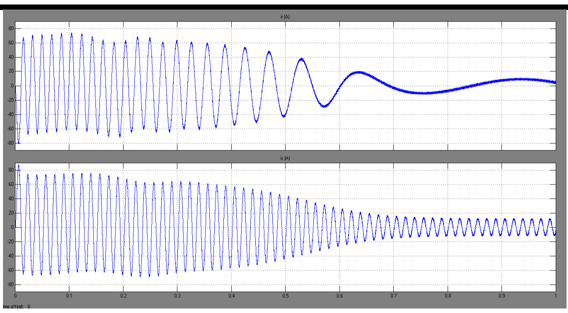

Fig. 7: (i) Rotor current (Ir), (ii) Stator Current Is,

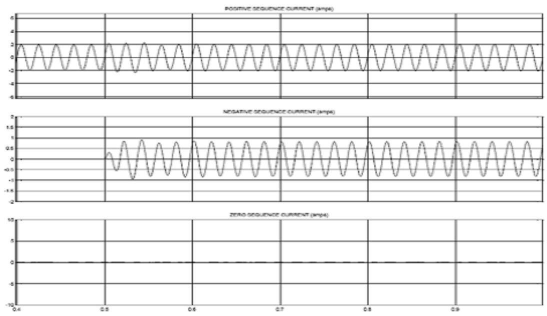

Fig. 8: Symmetrical component waveforms of stator current

4.1 AI Techniques with communication media device (Android):

In android library, they allow us an open source jfuzzy logic through which we can design and develop FLCs following the standard for FCL reducing the level of knowledge and accordingly experience in fuzzy logic control required of researchers, through which only less knowledge researchers will be able to successfully apply FLCs to their problems when using this library. This open source function permits complete implementation of a fuzzy inference system (FIS) and also provides a programming interface. Fuzzy logic is a fully functional and it has ability as eclipse plug-in which makes it easier to write and test FCL code.

With several advantages and functions, it makes the library open source software and increases standardisation to the fuzzy system community which reduces programming work. Since jfuzzy logic follows a platform independent approach that is why it can run as any hardware with operating system configuration that supports only java. Its developers can extend it easily due to the strict object oriented approach and the modular design of this library.

Jfuzzy logic's main goal is to facilitate and accelerate the development of fuzzy systems. We achieve this goal by:

i) Using standard programming language (FCL) that reduces learning curves;
ii) Providing a fully functional and complete implementation of FIS;
iii) Creating API that developers can use or extend;
iv) Implementing an Eclipse plug-in to easily write and test FCL code;
v) Making the software platform independent; and
vi) Distributing the software as open source.

The development and testing in industrial and academic environment of fuzzy system are extended by the above functionalities, which is useful for developers and researchers who are looking to accelerate the functionalities.

V. CONCLUSION

Detection and diagnosis of these induction motors provides good solution for detecting the various faults. Hence saving the motor from damage, also giving quick signals to the communication media devices connected to it. Thereby decreasing the losses in the industries. Its integration with communication media devices will provide an easy access to the remote operation and detection which can be easily adapted in the industrial atmosphere.

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