Fuzzy Logic Based Fault Diagnosis of Induction Motor Using MATLAB

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***Abstract*-This paper represents a fault diagnosis method based on fuzzy inference system. The study of induction motors is becoming increasingly paramount. The main trouble in this task is the lack of a precise analytical model to describe a faulty motor. A fuzzy logic approach may avail to diagnose induction motor faults. Due to the perpetual running nature of induction motor more advanced techniques are required to opportunely quantify their impact. This paper proposes the utilization of fuzzy logic to analyze, compare & diagnose health condition of induction motor under sundry faults.**

***Keywords*— Induction Motor, Fault Detection, Fuzzy Logic, Stator current amplitudes, MATLAB.**

I. INTRODUCTION

Induction motor is the single most familiar electromechanical energy conversion tool available for various industrial applications because of the reason is the wide variety of characteristics like robustness, self-starting, high efficiency, low cost, reliability, speed control flexibility, etc. These are available at different ratings; predicated on the load requisite the motor is adopted. Running of an industrial plant in the safe and efficient mode, electric motors specially induction motors play very paramount role. Hence early detection of abnormalities in the motors will avail to costly failures [2]. While discussing the faults in induction motor, different parameters such as voltage, current, temperature are considered. If any faults occur in the motor, then it is compulsory to detect and diagnose the fault with utilize of one of the parameter from above.

The proposed work for project aims to detect different faults such as under current, overload, single phasing, two phase open by condition monitoring of induction motor taking current as the reference parameter utilizing soft computing technique such as fuzzy logic by developing working model of system[1][2].

II. DIFFERENT UNBALANCE CONDITION IN THREE PHASE INDUCTION MOTOR

- Single Phasing
- Short Circuit
- Over Voltage
- Under Voltage
- Unbalanced Phase Voltages

III. FUZZY LOGIC SYSTEM DEVELOPMENT

To develop the overall system it is necessary to predict which type of fault is occurred in the induction motor such as single phasing, over voltage, under voltage, overload condition, under current and no supply condition. These faulty conditions engender more heat on both stator and rotor winding. This leads to reduce the life time of induction motor. For prediction of fault stator current of induction motor is considered as reference parameter. The fuzzy based system can forecast the unhealthy condition of induction motor from different data and assumption, different rule assign for getting appropriate result [1].

Fuzzy System Input-Output Variables

The induction motor condition can be deduced by observing the stator current magnitudes as input variables. Exegesis of results is difficult as relationships between the motor condition and the current magnitudes are indeterminate. Therefore, using fuzzy logic, numerical data are demonstrated as linguistic information. In this case, the stator current magnitudes *R*, *Y*, and *B*are supposed as the input variables to the fuzzy system. The motor condition is chosen as the output variable. All the system inputs and outputs are defined utilizing fuzzy set theory [4].

Fuzzy Rules Extraction: The list of the extracted rules is given in Table 1. The extraction process consists on the following steps:

a) Fuzzification: Conversion of crisp facts (inputs) into fuzzy sets described by linguistic expressions.
b) Inference: Fuzzy if-then rules express fuzzy implication relation between the premise fuzzy sets and the conclusion fuzzy sets. In our case, a Mamdani-type fuzzy inference system is used.
c) Defuzzification: Various defuzzification methods can be applied. In our case, the system uses Max-Min composition and the centroid of area method for defuzzification.

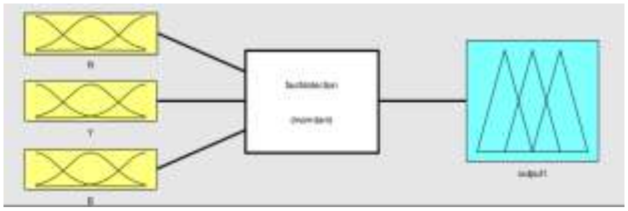

Fig.1. Proposed System

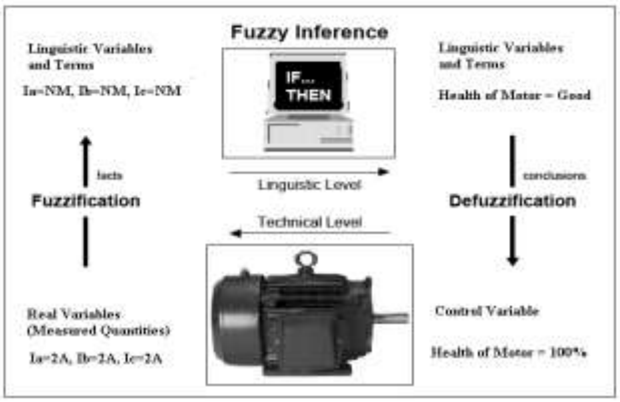

Fig.2. Fuzzy InferenceSystem.

IV. Fault Detection Using Fuzzy Logic

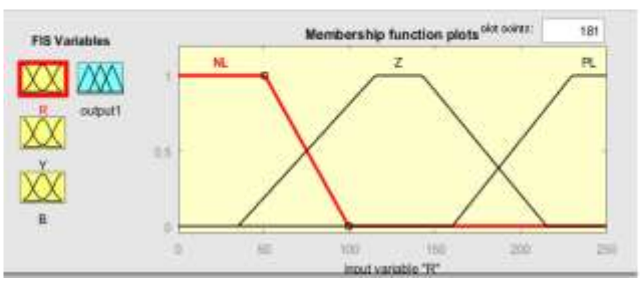

Fig.3. Membership function for Input Current

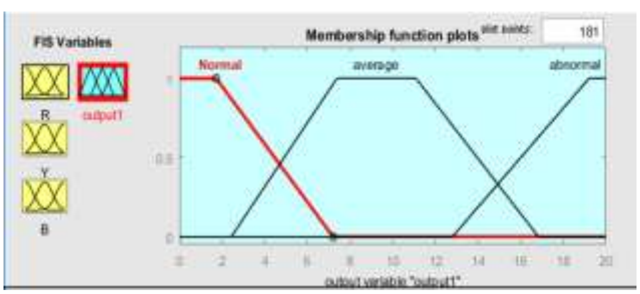

FIG.4.Membership function for Output Condition

In this paper, we have obtained the following 27 if-then rules

TABLE 1. FUZZY CONTROLLER RULES

I/p Sr. no	IF R	Y	B	THEN OUTPUT
1.	NL	NL	NL	Normal
2.	NL	NL	Z	Normal
3.	NL	NL	PL	Normal
4.	NL	Z	NL	Normal
5.	NL	Z	Z	Average
6.	NL	Z	PL	Average
7.	NL	PL	NL	Normal
8.	NL	PL	Z	Average
9.	NL	PL	PL	Abnormal
10.	Z	NL	NL	Normal
11.	Z	NL	Z	Average
12.	Z	NL	PL	Average
13.	Z	Z	NL	Average
14.	Z	Z	Z	Average
15.	Z	Z	PL	Average
16.	Z	PL	NL	Average
17.	Z	PL	Z	Average
18.	Z	PL	PL	Abnormal
19.	PL	NL	NL	Normal
20.	PL	NL	Z	Average
21.	PL	NL	PL	Abnormal
22.	PL	Z	NL	Abnormal
23.	PL	Z	Z	Average
24.	PL	Z	PL	Abnormal
25.	PL	PL	NL	Abnormal
26.	PL	PL	Z	Abnormal
27.	PL	PL	PL	Abnormal

NL-Negative large, PL-Positive large, Z-Zero.

In this paper, we have selected ranges for input and output membership functions for predicting motor condition while it is in operation. For input membership function that is in this case for each input stator current we have selected range in between 0 to 250. Similarly for output membership function which is motor condition status in this case is in between 0 to 20. Above mentioned rules and from selected ranges for input and output membership functions, we are following rule weights for motor condition.

TABLE 2.RULES FOR MOTOR CONDITION

Motor Status	Rule Weight
Two phase open	Below 1.5
No supply	In between 1 to 2.8
Single phasing	In between 3 to 5
Under current	In between 5 to 10
Good condition	In between 10 to 12
Over voltage	In between 12 to 17
Critically loaded	Above 17

V. RESULTS

This simulation involves fuzzy inference system. The fuzzy logic inference structures evaluate the inputs and then diagnose the motor condition. The simulation model is shown in figure no. 5.

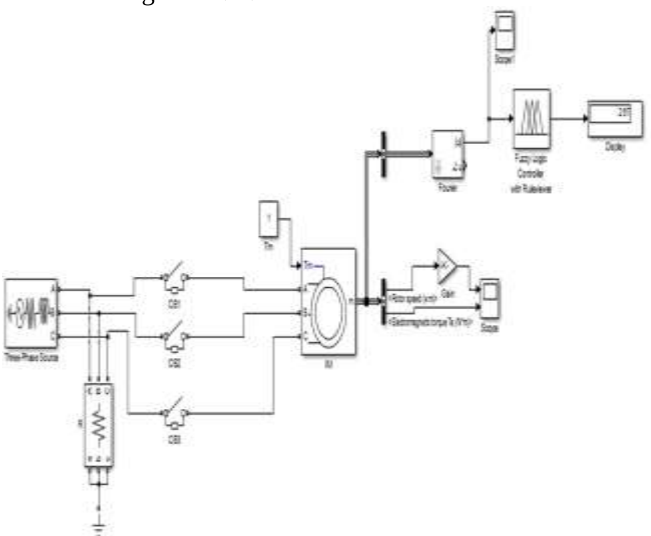

Figure 5. Simulation model in MATLAB Simulink

A. Good condition mode

While simulating the induction motor, the rated voltage was applied. From this, it is observed that fuzzy inference motor condition value comes to 11.4. This indicates the motor is in Good condition and it is highlighted in fig.6.

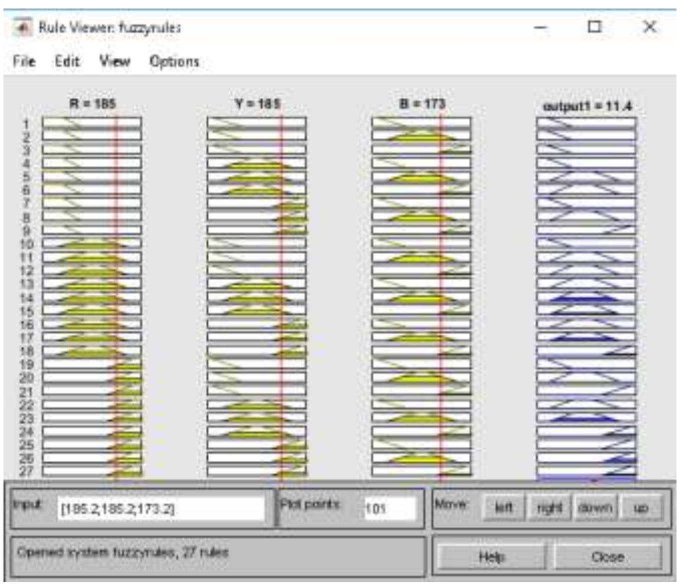

Fig.6.Rule viewer for Good condition

B. Unbalanced input voltages

The simulation of induction motor is energized with any kind of unbalance in voltage can be created by adding resistance to one phase or by simply varying the voltage magnitude and no other parameter needs to changed. The motor is start up with normal parameters. After that a fault has been created by changing the voltage by using three phasevariac ranging 0 to 480 V. In this case the rated voltage was reduced first to create under-voltage condition. Which result to reduction in current and fuzzy motor condition value comes to 7.12.This indicates the motor is in under current condition and motor is isolated from the supply by relay tripping. It is shown in fig.8. Similarly, if we increase the input supply voltage by using three phasevariac, we can manage overvoltage condition which gives fuzzy motor condition value 13.0. Hence the motor is disconnected from the supply by relay to prevent it from effects of overvoltage. It is shown on fig.8.

Fig.7. Rule viewer for Under current condition

.8. Rule viewer for Overvoltage condition

C. Single phasing or one phase open

In this case after normal start up, R-phase was open circuited and the corresponding results obtained are shown in fig. 9. Single phasing affects overheat in the winding which causes stator winding failure. Also single phasing represents the worst case of an unbalanced voltage condition. From the above result, it is concluded that, this is of great practical use as motor can be protected from the total damage and hence the complete breakdown of motor

Fig.9.Rule viewer for Single phasing condition

D. Critically loaded condition

Induction motor was started by means of normal operating condition. After that a mechanical load was applied in such a way that motor draws a current which was more than the rated values and caused to generate heat in the motor. This was sensed by fuzzy inference system. This motor condition is shown in figure 10 and motor is protected from the rise in heat.

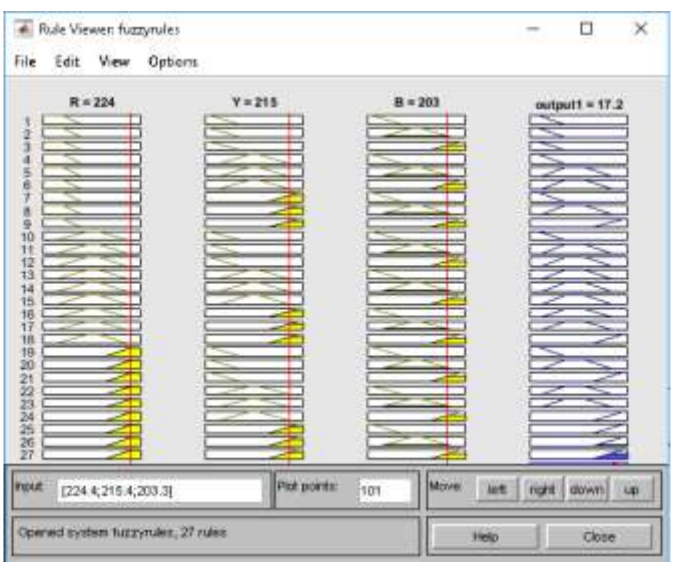

Fig.10.Rule viewer for criticallyloaded condition

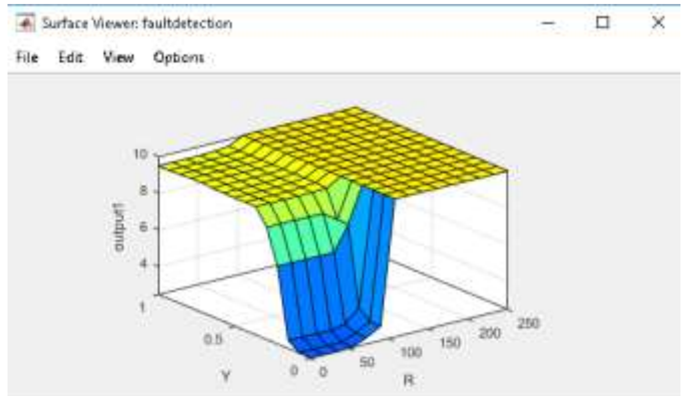

Fig.11. Operating surface between input current magnitude and output motor condition.

VI. CONCLUSION

Fault detection of induction motor using fuzzy logic is to avoid operation of the machine in unsafe condition and to reduce unexpected failures and downtimes. The diagnosis of induction motor using Fuzzy logic model further facilitates to improve motor operating life, minimize damage to the motor and associated equipment, to enhance personal safety and productivity. With the help of fuzzy model we can minimize the premature failures.The proposed method can be extended to identify as well as analyze the combined fault of an induction motor drive system. The work done can be extended to hardware implementation of the fault detection algorithm.

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