Fault Diagnosis in Induction Motor Using Fuzzy Logic

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Abstract - *Induction motors are generally utilized as electrical load in all sort of industry. These motors are sensitive to different kinds of faults. When one of this faults occur in the induction motor then the motor has to be stopped for maintenance schedule. The cost of this maintenance schedule can be expensive and hence it is necessary to improve fault diagnostic methods. In online condition monitoring involves in monitoring the condition of the motor during operation and detect the faults which will reduce unexpected maintenance costs. In this paper a simulink model of induction motor is developed using Fuzzy logic controller to analyze the performance for short circuit, open circuit, overvoltage.*

Keywords—Induction motor,online monitoring,simulink,Fuzzy logic.

1.INTRODUCTION

Induction motors is mostly used as a industrial load and consumes a major part of overall electrical consumption. Fault determination has turned out to be practically vital especially when they are working in sophisticated automation production lines[11]. Operator in industry is under continuous pressure to reduce the maintenance cost and unscheduled downtimes which can lead to finical loss in industry. The present day industry has generally utilized condition-based maintenance strategies to reduce failures and downtime. According to the research made about 38% of the fault occur in the stator winding, hence it is necessary to spot this fault in time as it can lead to failure in the machine[1].

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II. VARIOUS TYPE OF FAULTS IN INDUCTION MOTOR

Induction motor is the most common machine that is used in manufacturing industries. They are reliable, efficient and can drive almost any kind of load however they are subjected to various types of fault[10]. This faults can be mainly categorized into two groups: Electrical fault and Mechanical fault[15].

A. Electrical Fault

The following electrical faults are very common in three-phase induction motor while operating in industries.

a) Rotor faults

In manufacturing industries low lower rating machines are manufactured by die casting techniques and high rating machines are manufactured with copper rotor bar[14]. Due to technological difficulties motor show some asymmetries in the rotor that can result in failures in the rotor.

b)*Shortturn faults*

About 40% of the fault in induction motor takes place in the stator winding [2]. Large portion of stator winding related failures are initiated by insulation. The organic materials used for insulations are subjected to deterioration from a combination of thermal overloading and cycling, mechanical stresses etc.

B. Mechanical Faults

The following Mechanical faults are very common in three-phase induction motor while operating in industries.

a)*Airgap eccentricity*

Air gap eccentricity produce the problem of vibration. When the rotor is not aligned with the stator boar it causes an unbalance magnetic pull[13]. This cause stator and rotor to rub against each other that can damage their winding.

b)*Bearing faults*

Bearing consists of two rings, inner and the outer rings. A set of rolling elements are placed in between the two rings. A continued stress on the bearings can result in rough running of the bearings which generates vibration and noise[4].

c)*Load faults*

Induction motor when used in robust environment they are subjected to various condition like overload, undesirable stressed, etc which put the motors under risk of faults or failures[12]. Hence there is a need to improve the reliability of motors due to significant positions in applications.

III. MODELLING OF INDUCTION MOTOR

Modeling is a process of analyzing a mathematical description which has the dynamic characteristics of the component, which can be easily determined in practice[3]. To carry out the dynamic model of induction motor we need to concentrate on the fundamental conditions of induction motor[5].

A. Induction motor equation

The stator and rotor equations are as follows:

Statorinductace

The air gap of the induction motor is assumed to be uniform and stator and rotor windings and sinusoidally distributed hence the self inductance is same which is given below:

$L_{AA}=L_{BB}=L_{CC}=L_{ls}+ L_{ms}$

Mutual inductance between any two stator winding is the is the same due to symmetry which is given by:

$L_{AB}=L_{BA}=-.5L_{ms}$
$L_{BC}=L_{CB}=-.5L_{ms}$
$L_{CA}=L_{AC}=-.5L_{ms}$

Rotorinductac:

In the same manner the mutual inductance between the rotor is given by:θ

$L_{aa}=L_{bb}=L_{cc}=L_{ls}+ L_{ms}$ $L_{ab}=L_{ba}=-.5L_{ms}$ $L_{bc}=L_{cb}=-.5L_{ms}$ $L_{ca}=L_{ac}=-.5L_{ms}$

$L_{Aa}=L_{Bb}=L_{Cc}=L_{msr}\cos\theta_r$
$L_{Ac}=L_{Ba}=L_{Cb}=L_{msr}\cos(\theta_r-120^0)$ $L_{Ab}=L_{Bc}=L_{Ca}=L_{msr}\cos(\theta_r+120^0)$

B. Simulink model of inductionmotor

In this section implementation of stationary reference model of three phase induction motor is done using simulink. Using all the equations the simulink model is designed which is shown in figure 1.The details of the subsystem is shown in figure 2.

The parameters inside the induction motor are stored in M file. By running this file all the parameters can be accessed.

MotorParamete:

The parameters that are used for designing the motor are as follows: Rated Voltage V=230v , Frequency f=50Hz Stator Resistance=25.3Ω, Rotor Resistance=17.35Ω. The stator and rotor self-inductances are equal to $L_{stator} = L_{rotor} = L_{leakage}+L_{mutual}$ = .035+.55 = .585H, The mutual inductance between any two stator and any tow rotor windings is equal to $L_{ss,mutual} = L_{rr,mutual}$ = -0.5Lmutual = -0.275H.The mutual inductance between a stator winding and any rotor winding is equal to $L_{sr,mutual} = L_{mutual}$ =0.55H Number of Poles p = 4, Inertial constant J = 0.025kg.m^2

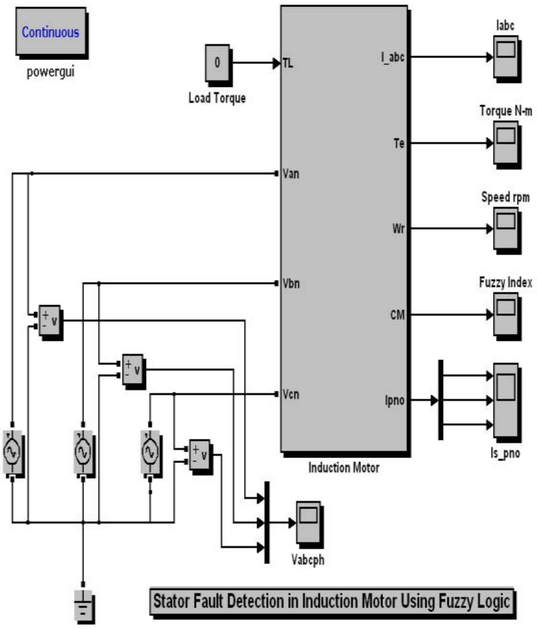

Fig. 1 Simulink Model of Condition Monitoring System

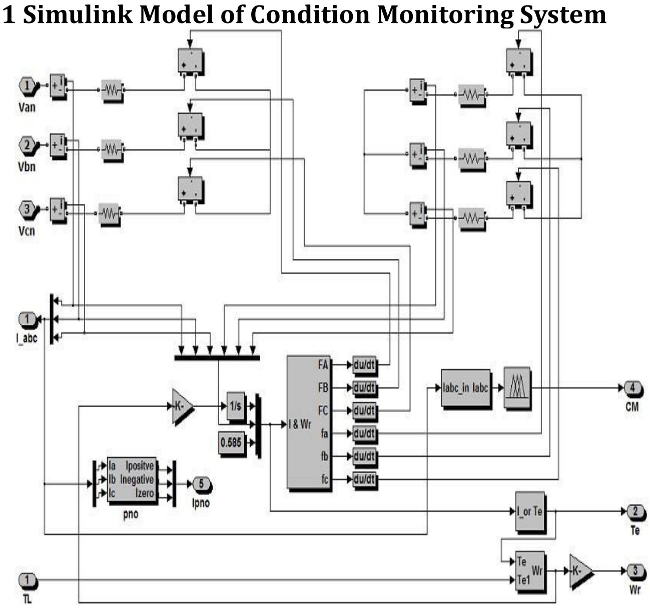

Fig. 2. Simulink Model of Induction Motor Subsystem

C. Sub Models of the Subsystem in Induction Motor

a) *The dynamic load model:*

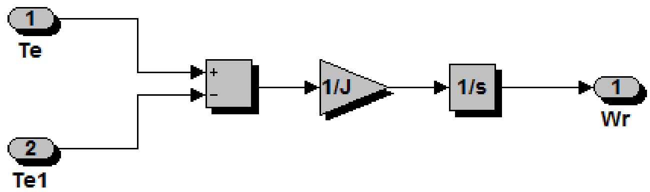

Fig. 3 Simulink dynamic load Sub model

b) *Torque Model*

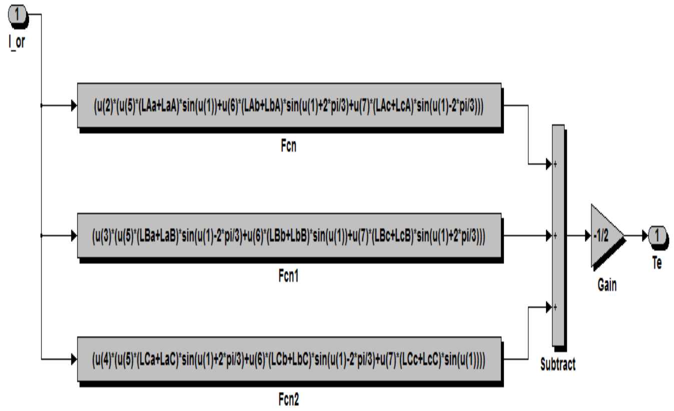

Fig. 4 Simulink Torque Sub model

c) *Flux Linkages Model*

Fig. 5 Simulink flux linkage Sub model

IV. FUZZY LOGIC APPROACH IN ORDER TO DETECT FAULT IN INDUCTION MOTOR

Fuzzy logic is a multi valued logic which relates to classes of objects with undefined boundaries. It is a profitable tool which is used in various applications such as cameras, camcorders, washing machines etc. It allows intermediate values to be defined between conventional evaluations like zero/one etc[7]. These notations are mathematically process by computer and it allows human ways of thinking in programming a computer.

A.InputMembership Function

Input membership function it mainly consist of three input variables. They are I_r, I_y and I_b which is the stator current. In this trapezoidal membership function is used. The input variables are interpreted as Zero (Z), Small(S), Normal (N) and Big (B). The range of the input membership function is from 0 to 2.

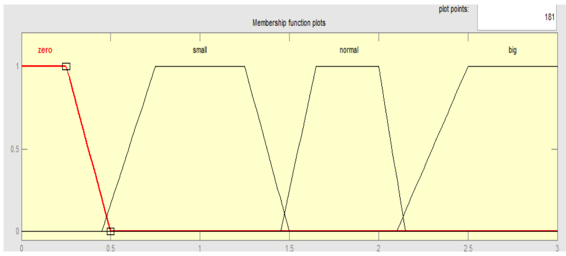

Fig. 6 Input membership function

B. Output Membership Function

The output membership consist is interpreted as Good (G), Damaged (D) and Seriously Damaged (SD). In this trapezoidal Membership Function is used. The range of output membership function is from 0 to 100.

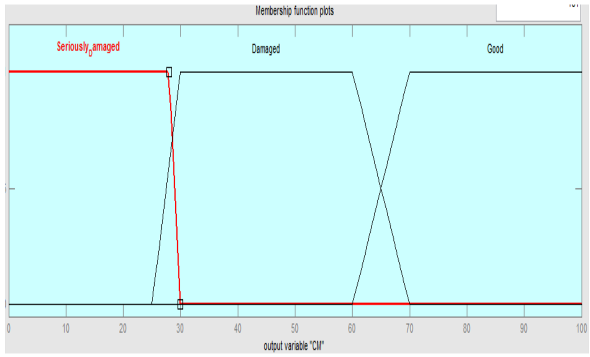

Fig. 7 Output membership function

C. Fuzzy Rules

The important part of fuzzy fault detection system is a rule base[8]. The rules are derived from expert knowledge and are analyzed with respect to input and output membership functions. Depending on the motor operation "If-Then" rules are set which is given in the table below:

TABLE 1. RULE BASE OF FUZZY FAULT DETECTOR SYSTEM

Rule Number	If part			Then part
	Stator current(I_r)	*Stator current(I_y)*	*Stator current(I_b)*	*Stator condition(SC)*
1	Z			SD
2		Z		SD
3			Z	SD
4	B			SD
5		B		SD
6			B	SD
7	N	N	N	G
8	N	S	S	D
9	S	N	S	D
10	S	S	N	D

11	S	N	N	D
12	N	S	S	D
13	S	N	S	D

V. SIMULATION RESULTS

A. Normal Operation

By using all the equation, motor parameters and using simulation stop time of 2 seconds the motor is simulated starting from rest with rated voltage applied and no mechanical load. It is seen that from the output of the fuzzy logic the health of the motor remains good after the transient time. Figure 8 shows the output of the fuzzy logic.

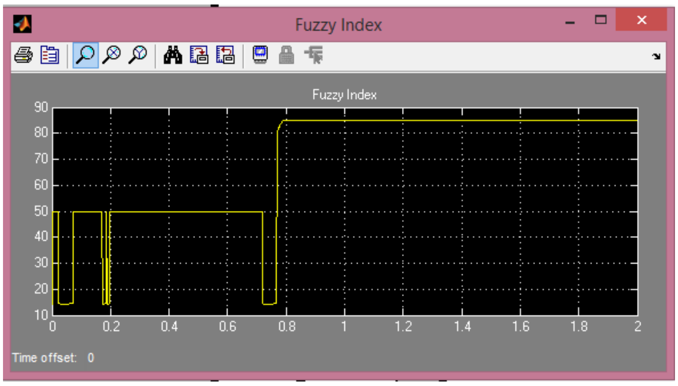

Fig. 8 Fuzzy logic output for normal operation

B. Short in one phase winding

For simulation of the short circuit in the stator winding at R Phase is carried out by placing the value of the stator resistance and the stator inductance[6]. For this condition the value of the stator resistance at short circuit fault is equal to Rstator, fault = 23.1Ω,This is obtained by using the ratio between the value of the resistance at both normal and fault condition. Thus the value of the new inductance is given by : $R_{stator,normal}/R_{stator,fault}=L_{stator,normal}/L_{stator,fault}$
25.3/23.1=0.585/X X=.534H

By replacing the above values in phase R the obtained results are shown in the figure 9[9]..From the output of the fuzzy logic we conclude that during normal operation the health of the motor is good once the fault is generated health of the motor goes in seriously damaged state.

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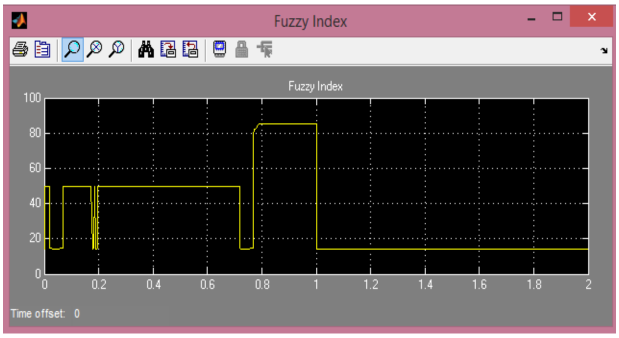

Fig. 9 Fuzzy logic output for short in one phase

C. Overvoltage

For simulating overvoltage in induction motor is done by varying the magnitude of C phase. In this case the 10% of the rated voltage in C phase is increased to generate overvoltage. After simulating it is seen that during normal operation the health of the motor is good once the fault is generated health of the motor goes in damaged state which is shown in figure
10.

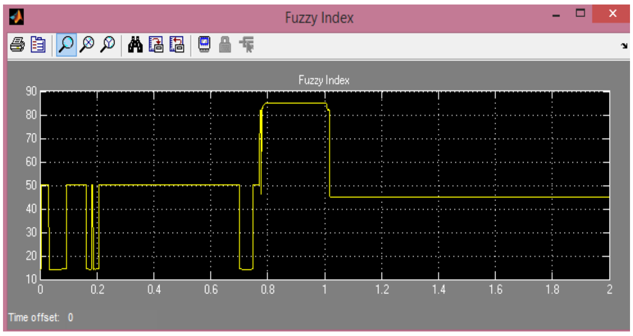

Fig 10 Fuzzy logic output for overvoltage

VI.CONCLUSION

In this paper induction motor is simulated with the help of dynamic equations. A fuzzy logic was designed which shows the health of the motor for different types of fault conditions. This method has very high accuracy and easy to implement.

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