Fuzzy Logic based Fault Detection in Induction Machines using Cloud

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***Abstract* -** This paper presents monitoring system for an induction motor based on Internet of Things (IOT) for safe and economic data communication in industrial fields. The main purpose of this paper are to monitor fault analysis on an induction motor using experiments as well as simulation along with failure identification techniques applied for condition monitoring of the motors and to design an on-line condition monitoring system with fuzzy logic controller using cloud. In this paper, work is divided in to two phases. The phase one was modelling of single phase induction motor, in single phase reference frame using Matlab/Simulink and designing an intelligent system for condition monitoring of the motors[4]. The phase two was implementation of on-line condition monitoring system through cloud[1][6].

Keywords: - Cloud, Condition monitoring, Fuzzy logic, Induction motor, Internet of Things (IoT), MATLAB/Simulink, Raspberry Pi.

I. INTRODUCTION

Induction motor is the single most common electromechanical energy conversion device available for various industrials applications because of the reason is the wide variety of characteristics like robustness, self starting, high efficiency, low cost reliability, speed control, flexibility etc[1]. An induction motor has two electric circuit which are placed on the two main parts of the machine: (i) the stationary part called the stator and (ii) the rotating part called the rotor[2]. Power is transferred from the part to the other by electromagnetic induction. In this paper condition monitoring system for induction motor has been developed in both simulation model (Matlab/Simulink) as well as in real time (Cloud) [3].The possible detection methods to identify the motor faults are listed as follows.

1. Vibration measurement.

2. Noise measurement.

3. Temperature measurement.

4. Voltage measurement.

5. Current measurement.

The performance of the AC Induction motor depends on on top of mentioned electrical, mechanical and environmental parameters of the motor, in order that the dominant strategies for prime performance measure terribly sensitive to motor parameters. All electrical, mechanical, environmental parameters like current, voltage, speed, vibration, temperature, noise, and external moisture of the induction motor are very important for a drive system. The performance of an induction motor is directly affected by the above mentioned parameters. If any parameter of induction motor crosses its cut off levels then quality of product also changes, hence controlling the machines during the process of production becomes a dangerous operation in some specific industrial application. As an emerging technology in modern wireless telecommunication Internet of Things (IoT) has a lot of attention and to provide many applications. The concept of “Internet of Things" (IoT) is providing a best way for industrial automation. In IoT each device are constituting a system will be able to communicate with the other devices. Which will help in industries to have better productivity, management, safe environment and increased throughout. Here in the proposed work the IoT is used for monitoring and controlling the AC induction motor to avoid the system failures.

II. DEVELOPED FUZZY LOGIC SCHEME

Fuzzy logic is a multivalued logic, allows to intermediate values which is to be defined between conventional evaluations like as yes/ no, true/ false etc. Fuzzy controllers ar the foremost necessary application of fuzzy theory. The result of induction motor condition made based on fuzzy inference which is capable of giving accuracy detection model. The structure of fuzzy abstract thought system is shown in figure 1.

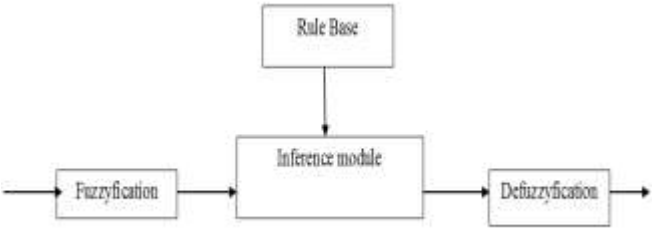


Fig 1. Structure of fuzzy Inference System

Fuzzyfication is defined as the conversion of crisp data in to fuzzy data. After the fuzzy data goes to the block of inference module. It is a rule base block .Rule or Logic can be apply for the condition monitoring of motor to obtain the logical output. After output of inference module goes to the defuzzification block. This Defuzzification block converts fuzzy output in to crisp output.

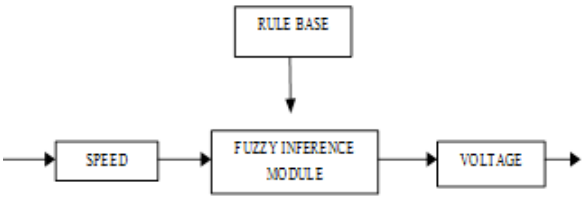


Fig 2. Complete structure of Fuzzy Controller

From the above figure 2. Shows complete structure of fuzzy controller. Fuzzy Inference System for motor fault detection has created using Fuzzy Tool Box of MATLAB. Fuzzy rules and membership functions are construct and observing the data set. Speed is used as an input and voltage is used for output. So for the measurements related to the motor speed, more insight in to the data are needed, so membership functions will be generated for To Slow, Just Right, and Too Fast. For the measurement related to the voltage condition will be generated Less Voltage (Down), No Change, More Voltage (Up). Membership functions are created by observing the data set and the behaviour of stator currents which are likely to cause faults in the motor. In this study trapezoidal membership functions are used. The membership functions for input (speed) and output (voltage) variables are shown in figure3 and figure 4.

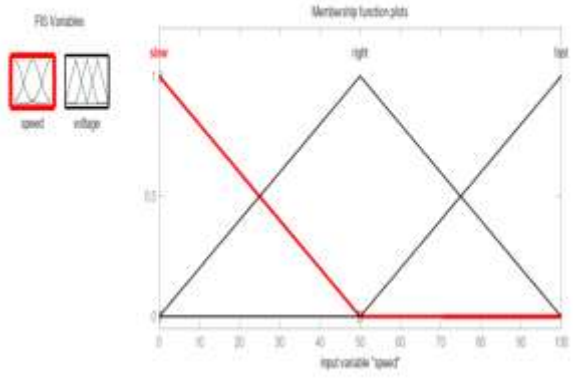


Fig3. Membership Functions of input motor Speed

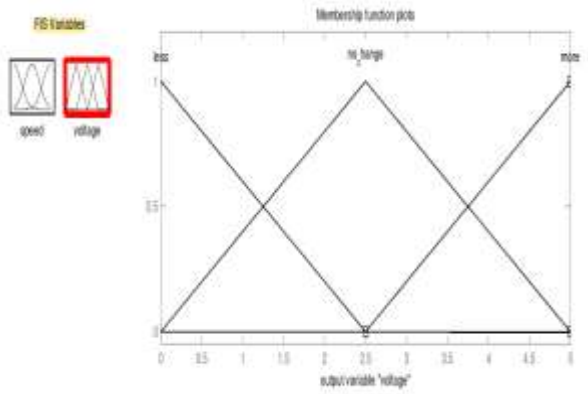


Fig 4. Membership Functions for Output Motor voltage

Fig 5. Motor condition for membership function

Once the form of initial membership functions has been determined, the fuzzy if-then rules can be add as shown in above figure 5.

1. If motor speed is running too slow then more voltage.

2. If motor speed is about right then no change voltage.

3. If motor speed is fast then less voltage. In this paper, we've designated ranges for input and output membership functions for predicting motor condition whereas it's operational. For input membership functions that is in this case for each input stator speed we have selected range between 0 to 100. Similarly for output membership functions that is voltage of motor standing during this case is between 0 to 5. There are various methods of defuzzification are available. But during this paper we've got utilized the centre of mass methodology for defuzzification. The output of the fuzzy controller is used as the command signal for the closed loop operation. If any slight voltage unbalance occurs, then the output of

fuzzy inference system sets the output corresponding to fault. Immediately the fault and the speed are stored in a file for analysis purpose.

The proposed system consists of Temperature sensor, Vibration sensor, Speed (IR) sensor, Temperature sensor, Current sensor, Voltage sensor for measurement circuits and AC induction motor. The block diagram of proposed system is below.

III. PROPOSED SYSTEM

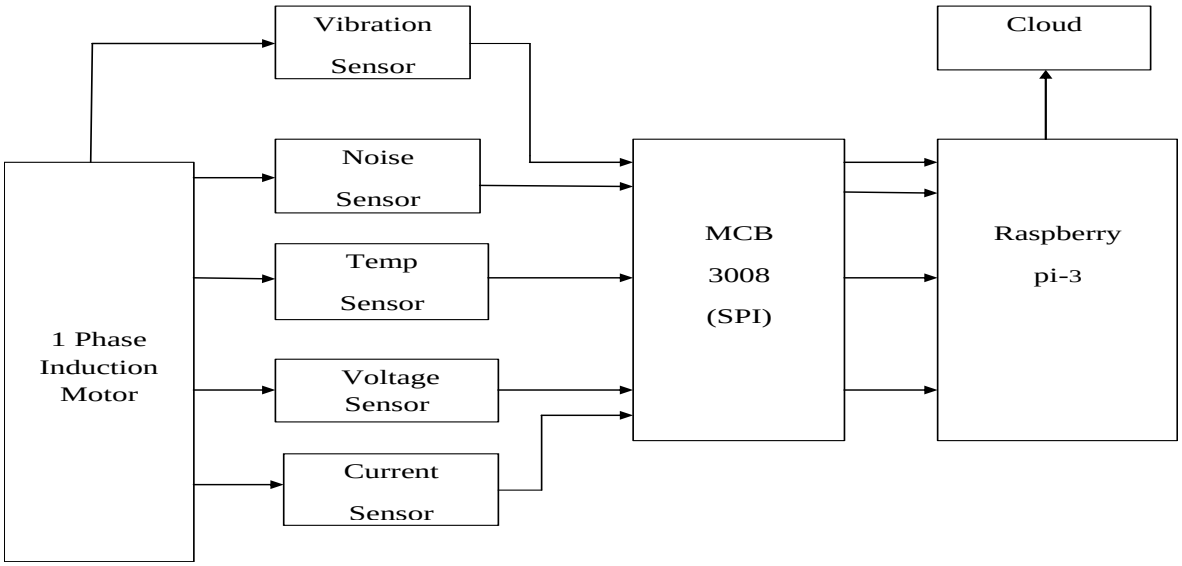


Fig 6. Block diagram of proposed system

IV. SYSTEM WORKING

For induction motor parameter monitoring we are using light weighted and easily configurable sensors like Vibration sensor, Noise sensor, Temperature sensor, Current sensor, Speed sensor, and Voltage sensor. All this sensors are mounted on single phase motor. The single phase induction motor has 230 V, 50 Hz power supply. The single phase induction motor has to covert the analog signal in to digital form. This is the main part of hardware. The induction motor blocks goes to Vibration sensor. It measure the vibrations of motor and they have a transducer that converts mechanical force caused by vibration. Noise sensor is the sensor which converts air pressure vibrations due to sound in to electrical current. The function of Temperature sensor is to measure the temperature through an electrical signal. Voltage sensor converts voltage measured between two point of an electrical circuit in to a physical signal which is proportional to the voltage. Then current sensor detects and converts current to an easily measured output voltage. Vibration sensor measure the heat of an object as well as detects the motion. All sensor has analog output hence it is connected to the input of the MCB 3008(Serial Peripheral Interface). It is also serial peripheral interface. The main function of MCB3008 IC is the analog to digital converters. It has low cost 8 channel 10 bit A/D convertor. All type of analog data converts in to digital forms. Its output goes to the Raspberry pi- 3 board has been used to for this research which has the ability to acquire sensor data, and communicate with other devices, store information in local, cloud server and alert when fault is detected and display this message according to values of sensors and also display values of sensor i. e overload/over current, over voltage, noise exceed, vibration exceed, temperature exceed. Data that's obtained from the sensors area unit transferred wirelessly to the native and cloud server for analysis. The program has been set to process real-time data and store it to the cloud with Thing speak cloud computing platform. This saved data is available from anywhere via internet. Figure 6. Shows block diagram of the hardware connections.

Flow chart:-

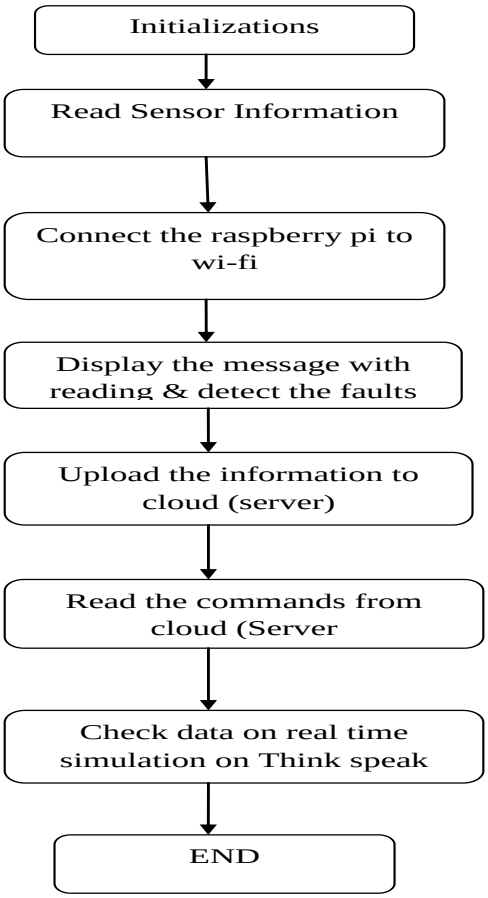


Fig 7: Flow chart of proposed system

The Proposed Algorithm are as follows:-

Step (0): Initialization: Initialize the username and password which is supported to the python.

Step (1): Read the sensor information.

Step (2): Connect the Raspberry pi to wi-fi.

Step (3): Display the message with reading and detects the fault in sensors.

Step (4): Upload information to cloud (Server).

Step (5): Read the command from cloud (Server).

Step (6): Check data on real time simulation.

Step (7): Check data on real time simulation on Think speak.

Step (8): End.

V. RESULTS ANALYSIS

In this work one section industrial AC motor was used for experimental purpose. The Sensor (vibration, temperature, noise, current, voltage sensors) are attached to the motor at right positions. Sensor data was collected and processed using Raspberry pi-3 and compared with the threshold values to avoid failure. The experimental setup of the proposed system is as shown in fig 8.

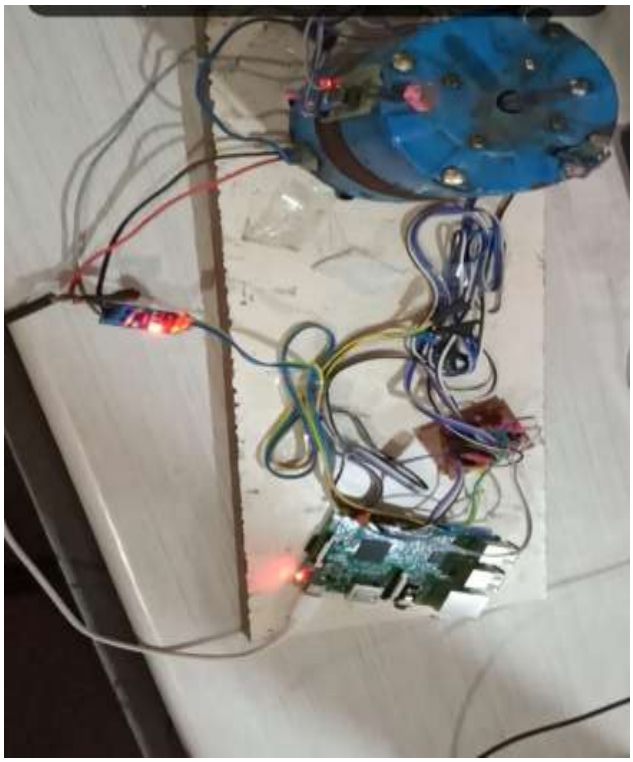
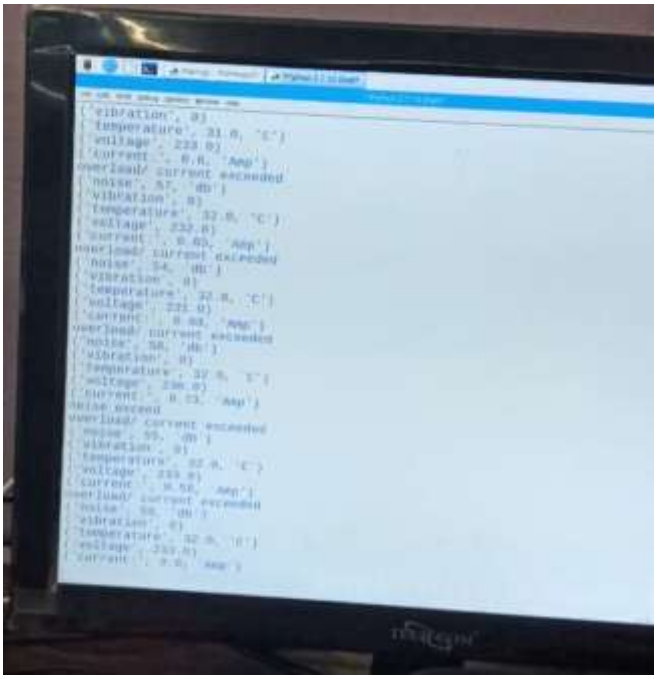
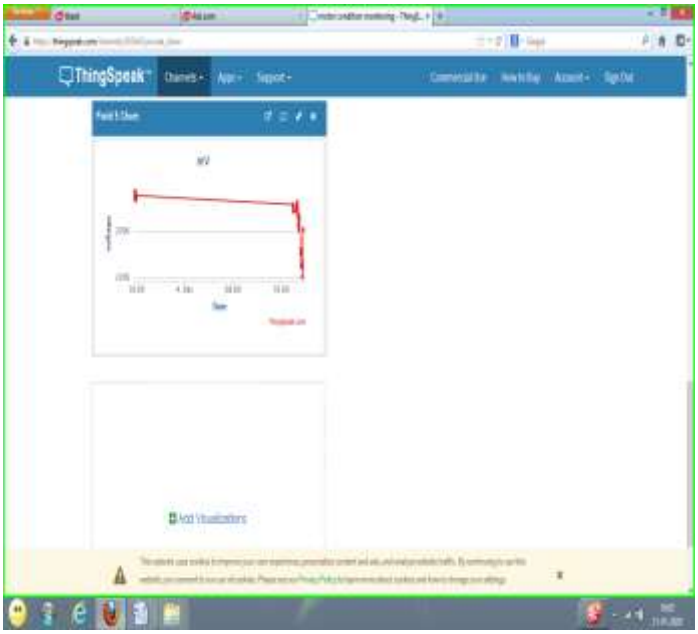


Fig 8: a) Setup of the proposed system



b) Motor display message with fault and reading



c) The above plots shows the real time simulation of the variation of vibration, noise, temperature, current, and voltage sensor with respect to date.

VI. CONCLUSION

This paper presents the idea of web of things for early detection and watching of motor system failures. The system has been designed to combine various parameter measurement in real- time, improving the delectability of different parameters namely vibrations, temperature, speed, moisture, voltage and current consumption. The concept of IoT is presented here controlling the motor. The data received by the coordinator node is stored and graphically presented in real- time by means of a application in visual basics. The proposed system can be

easily upgraded to add other sensors on the sensing node for the measurement of other parameters if required. The system has a high autonomy, easy installation and low maintenance costs. This is highly versatile technology for condition monitoring and fault analysis of motors.

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