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Online Fault monitoring of Industrial Motors using IoT

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Abstract—In general, the monitoring of induction motors through predictive techniques which reduces downtime, increases efficiency and reliability. Here we are monitoring the temperature, vibration, voltage and current of the induction motor. The analyzed signal easily shows the difference between the running operation of the healthy and faulty motor. Based on the vital signals the condition of induction motor is monitored using IOT.

Keywords— Internet of Things, Induction Motor, Vibration and Temperature Analysis

I. INTRODUCTION

Industries of this modern era are mainly concerned with quality and quantity of production over a period of time. Together with production requirements, an industry works to achieve its long and short term goals which determine the success or failures of that particular year. Almost every industry has incorporated the use of motor to accomplish its operational requirements.

Induction motors are the most common among AC motors used in industries today. There are in fact many types of induction motor available that are categorized under single phase and three phase motors. AC motors are chosen prior to DC motors as it requires a single power source whereas DC machines require separate power sources to the rotor and stator of the motor. Apart from this, there are other factors which make induction motors well suited to industrial usage.

Furthermore, motors are an essential machine and it also has a tendency to fail at some point in time. Taking industrial motors as an example, factors such as amount of lubrication, electrical considerations, motor ventilation, alignments and motor load are some possibilities that can be reason for motor failure. These factors result into motor vibrations or rise in motor temperature to critical levels.

The main aim of this research is to develop aonline fault monitoring the vibration and temperature of industrial motors. From the literature review it is known that motor failure can be detected through measuring temperature and vibration levels. By measuring the current and voltage which help to monitoring the load demand of the induction motor. This is accomplished through the use of sensors that take vibration and temperature data and interface this with the appropriate software. Upon which, the software displays sensor data for a span of time while also storing this data in a local database or to cloud. Also, an important aspect of this paper is to monitor system data for undesired conditions that may occur and alert these to maintenance team at work place

Finally, this paper presents various experimental data analysis. Data from the sensors is analyzed and transformed into an appropriate form (Acceleration vs Frequency) to monitor vibration peaks. At the same time temperature data is also recorded which helps to make a reliable decision

II. HARDWARE AND SOFTWARE CONFIGURATION

A. Hardware Components

For vibration measurement, mems accelerometer (adxl345) suited due to its light weight, easy placement and easy configuration. Microcontroller usage is best for acquiring data. Arduino UNO board with ESP8266 Wi-Fi module have been used for this research which has the ability to acquire sensor data, communicate with other devices, cloud server and alert the user when fault is detected. Fig. 1 shows block diagram of the hardware connections.

B. Cloud Storage

Data that is obtained from the sensors are transferred wirelessly to the local and cloud server for analysis. Once the data is received, a system has been devised that analyzes the raw data. The program has been set to process real-time data and store it to the cloud with IOT platform. This saved data is accessible from anywhere via internet.

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D:Block diagram

C. Sensor Placement

The two basic sensors incorporated in this project are thermistor (Temperature measurement) and MEMS accelerometer (Vibration measurement). Most important aspect is to determine an effective sensor placement technique. Improper sensor attachment would result in giving incorrect vibration data which is not suitable for motor failure detection. Bearing failure is the most common issue for motor failure. The two points, Fig.1 close to bearing location for vibration measurement and for temperature measurement, are possible attachment areas that would provide appropriate reading data.

The sensor data gathered from point A was pulsating peaks that are around a common region (group of points). On the other hand, the sensor data obtained from point B displayed a lot of distortions as the accelerometer does not seem to be stable around common region.

More importantly, the data set at point B seems to be incorrect when compared with the data set from A. Therefore, point A is selected for this Research, which would be a more effective point for vibration sensor placement.

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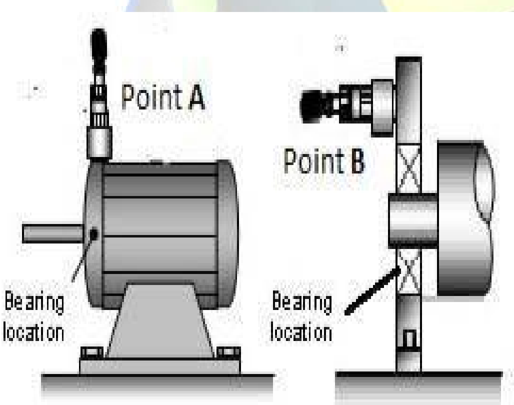

Fig. 1. Two possible position for sensor placement

The overall work method is shown in block diagram. The current and voltage given to the induction motor is monitored in the input level. [7] discussed about a project, in this project an automatic meter reading system is designed using GSM Technology. The embedded micro controller is interfaced with the GSM Module. This setup is fitted in home. The energy meter is attached to the micro controller. This controller reads the data from the meter output and transfers that data to GSM Module through the serial port. The embedded micro controller has the knowledge of sending message to the system through the GSM module. Another system is placed in EB office, which is the authority office. When they send "unit request" to the microcontroller which is placed in home. Then the unit value is sent to the EB office PC through GSM module. According to the readings, the authority officer will send the information about the bill to the customer. If the customer doesn't pay bill on-time, the power supply to the corresponding home power unit is cut, by sending the command through to the microcontroller. Once the payment of bill is done the power supply is given to the customer. Power management concept is introduced, in which during the restriction mode only limited amount of power supply can be used by the customer.

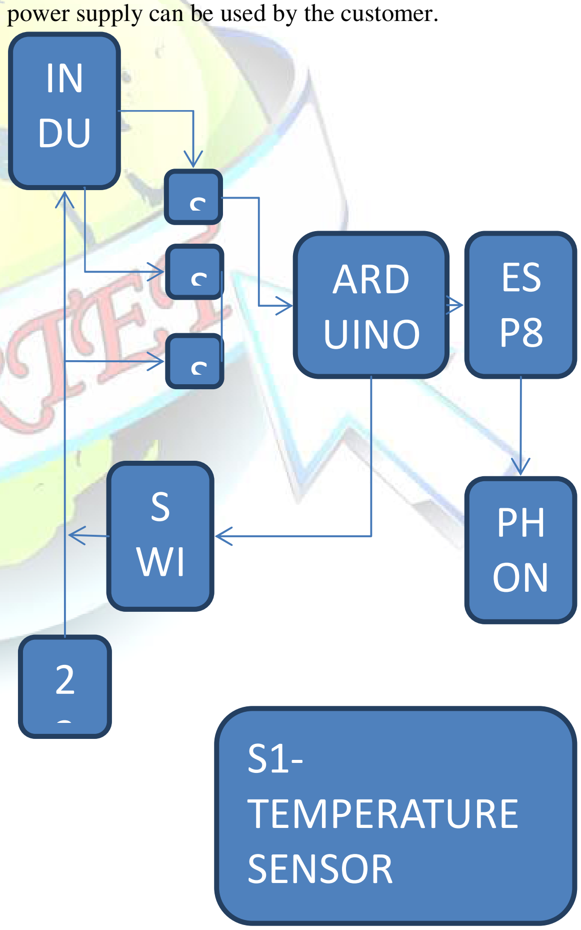

Fig 2. Block Diagram

In this Research a three phase industrial AC motor was used for experimental purpose. The motor rating is shown in Table 1 (Class A). Sensors (accelerometer and thermistor) are attached to the motor according to the description

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given in the previous section. Sensor data was collected and processed using Arduino and compared with the threshold value to trigger alarm if there is a prediction of failure.

Three phase industrial asynchronous induction motor ratings are shown in Table I.

TABLE I. INDUCTION MOTOR RATING.

Parameters	Unit	Value
Voltage	V	380-415
Frequency	Hz	50
Power	kW	0.55
Speed	RPM	1390
Current	Amps	1.42
Power factor	-	0.751
Efficiency	η	72.1

III. METHODOLOGY

A. Temperature Diagnostics

Temperature is a significant factor in determination of motor condition. Along with vibration and noise, motor temperature also increases as the motor condition gets worse.

TABLE II. MAX. ALLOWABLE TEMPERATURE VALUES FOR DIFFERENT MOTORS .

Insulation Hot Spot		Typical Surface
Class	Temp (°C)	Max Temp (°C)
A	105	80
B	130	105
F	155	130
H	180	155

Table II shows temperature data for different motor insulation classes. Typically there are four different insulation classes. Each of the four insulation classes must be able to withstand max temperature while also cater for any extra rise in temperature from normal operating conditions at full load [5]. Also, the letters for each classes of insulation holds its own importance as it relates to the type of working operation a motor is designed for. Table 2 relates to the maximum temperature that one might expect at the core of the stator that is also known as the Insulation Hot Spot and also contains the maximum temperature the surface of the motor would reach. These data will be used to determine the threshold value for motor failure.

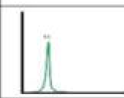
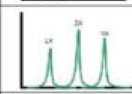
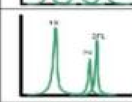
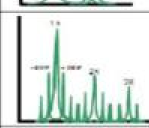
B. Vibration Diagnostics

Loose components, motor imbalance, resonance or the bearing failure are very common reasons for motor vibration, which in turn result the failure. The basic vibration measurements are usually done using an accelerator that works on the piezoelectric principle.

These acquired signals consist can further be analyzed using Cepstrum/Quefrency analysis, Short Time Fast Fourier analysis (STFF) and Power Density Spectrum analysis (PDS).

Table III shows the important aspects of Vibration Analysis Technique associated with the Electrical Signatures Analysis Technique. Different mechanical faults with their spectrum and vibration pattern are shown.

TABLE III. VIBRATION DIAGNOSTIC TABLE FOR INDUCTION MOTOR FAULTS .

Mechanical faults	Typical vibration pattern	Typical Spectrum
Mass unbalance	1X	
Misalignment	2X, 3X	
Stator eccentricity	2XFL* *FL = Freq. line, e.g. 50/60 Hz	
Rotor eccentricity	PPF** sidebands around 1X, 2X, .. **PPF = Pole Pass Frequency	
Bearings wear	High freq. broadband vibrations	

IV.TEMPERATURE ANALYSIS

The temperature data from point A is been altered by motor fan. Hence, temperature sensor is placed close to the stator frame as shown in Fig. 6.

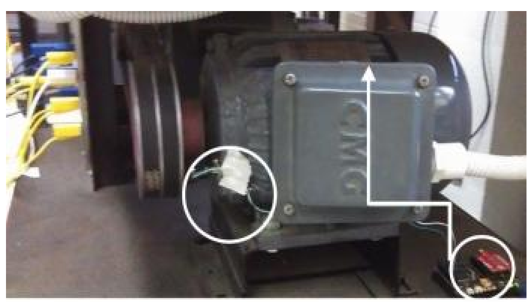


Fig. 3. Temperature Sensor in test bed.

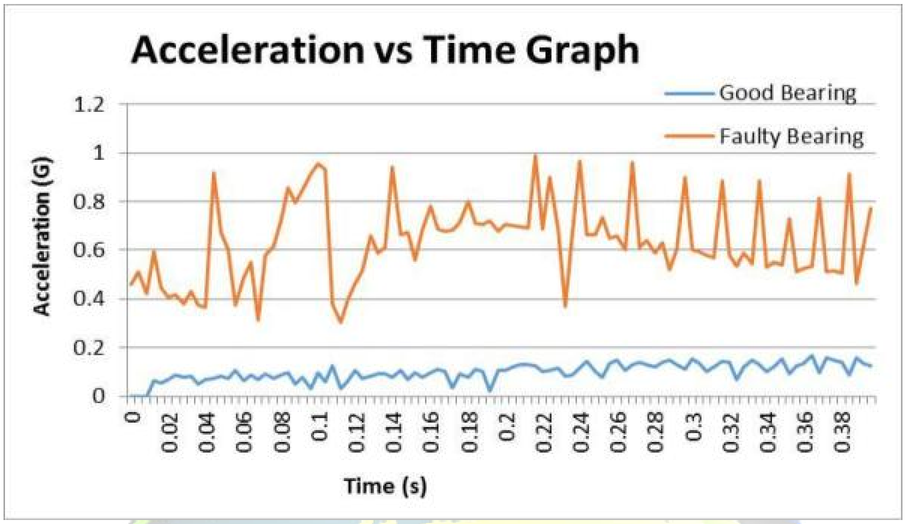


Fig. 4. Good and bad motor vibration plot in time domain.

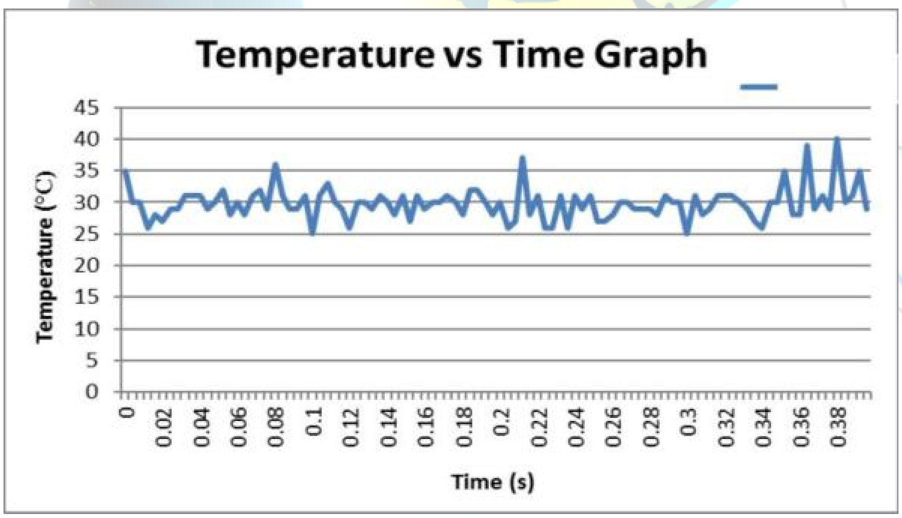


Fig. 5. Temperature sensor data over a period of time.

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VIII. ALERT SYSTEM

The monitoring system has been designed to monitor vibration and temperature data. To detect excess vibration or temperature readings on a particular motor, the system has been set to a threshold value close to 0.9 (acceleration value) and 70 degrees for temperature. Taking the failure mark as a threshold value would indeed lead to motor failure before maintenance work may begin. Therefore, after analysis the threshold value has been set to a point before motor failure phase and up till the extreme vibration level a motor is designed to endure.

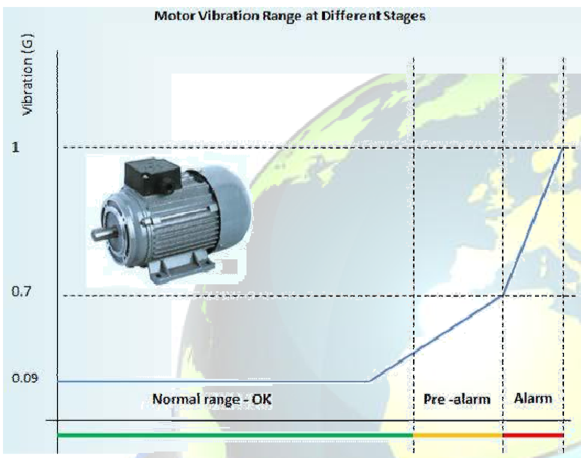

Fig 6. Alarming stages at different vibration level

Vibration on a new motor may increase up till 0.1443 to 0.2237 G. This level is permissible for a medium sized motor. If it exceeds this limit, the alarming system will alert the maintenance team. Fig. 11 shows the schematic diagram of how the alert system operates. Alarming technique works using the GPRS system (local network) interfaced to the microcontroller. The GPRS shield is a wireless interface for the microcontroller (Waspmote PRO). The microcontroller has been coded to send out alert messages/calls to the maintenance personal at remote location. This system immediately activates if set threshold value is triggered 5 times at a set interval of 15 minutes interval from the point of first trigger to avoid any false alarm.

Fig.6 displays alarming stages at different vibration level. The green line indicates that the motor is running normal without any problem, orange line indicates that the motor needs to be checked and red line shows that some action needs to be taken for motor maintenance or motor replacement.

Fig.7 is the overview of the system design hierarchy which shows the three important levels of this research on motor condition monitoring. Finally a proposed design is provided which is an overall idea of how this system can be implemented in industries.

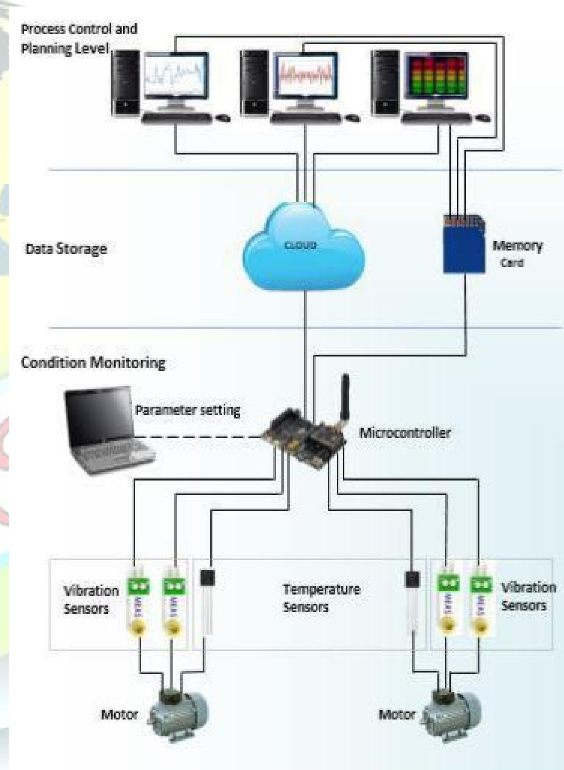

Fig.7.Overalldesign.

IX. CONCLUSION

The advancement of this research is the improvement of monitoring system for motor's real time condition. With the help of IoT, data storage, retrieval and access has been made user friendly. Any issue with motor failure due vibration,and temperature can easily be informed to the ultimate user through IoT. This research successfully designed and implemented a versatile motor condition monitoring system using the IoT technology which could reduce downtime for many industries and manufacturing companies.

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