Sensor Fusion and Performance Monitoring System for Domestic Pump Application

Mane Prithviraj Jayendra[1] Jagtap Juili Dilip[2] Patil Rahul Arvind[3] Magar Gajanan Sudhakar[4] Chandan M.N.[5]

[1,2,3,4]Department of Mechanical Engineering

[1,2,3,4,5]Savitribai Phule Pune University, Pune, India

Abstract— This report presents a performance monitoring system for a domestic pump for monitoring and controlling the various parameters using sensors. A module of transducers and sensors monitors the parameters like temperature, speed, vibrations, flow rate and send to the processing unit (Node McU) for taking corrective action, also predictive maintenance can be scheduled for the same. Condi-tion monitoring technique can be used in manufacturing industries for on-line monitoring of the processes and equipment for diag-nosing the fault which can be addressed before they develop into a major failure. Also this system will increase the reliability of the pump and it will detect which parameter affects the pump performance. In this project we are interfacing various sensors with the Node MCU which act as a controller. To measure various parameters such as vibration, sound, temperature, flow rate various sen-sors like accelerometer ADXL335, sound sensor, temperature sensor DS18B20, flow sensor YF-S201 are selected respectively. Sen-sors are connected to Node MCU, the Node MCU collect all the data from sensor and it send to the PC/Mobile. Pump will be moni-tored continuously for any abrupt changes based on the condition monitoring for identifying the fault, so that maintenance can be scheduled accordingly.

Keywords: Accelerometer ADXL335, Sound Sensor, Temperature Sensor DS18B20, Flow Sensor YF-S201, Node MCU

I. INTRODUCTION

Condition monitoring is the process of monitoring a parameter of condition in Rotating Equipment, auxiliary systems and other machinery (compressors, pumps, and electric motors, internal combustion engines) in order to identify a significant change which is indicative of a developing fault. The use of condition monitoring allows maintenance to be scheduled, or other actions to be taken to prevent consequential damages and avoid its consequences. (The various parameters of the pump are analyzed in order to gather specific information that can predict pump's failure.) Machine condition monitoring is important because it provides information about the health of a machine. On the other hand, condition monitoring will provide information on not only pump status and performance but also the type of maintenance required. You can use this information to detect warning signs early and help your organization to stop unscheduled outages, optimize machine performance, and reduce repair time and maintenance costs. If the failure mode does not have a measurable symptom, alternative maintenance strategies may have to be applied. The monitoring system for predicting the condition of pump become a high priority task.

IoT (Internet of Things) is defined as a system where physical objects can become active participants and services are available to interact with these objects over the internet. It enables the devices that can communicate and network with each other and with the environment by exchanging information via the internet with or without human intervention.

II. OBJECTIVE

1) To design and develop performance monitoring and control system using various sensors for domestic pump application.
2) To measure various parameters using sensors.
3) To interface sensors with DAQ.
4) To monitor and control the various parameters in real time.
5) To classify various faults based on the parameters like temperature, vibration, sound, flow rate for pump.
6) To monitor the parameters for predictive maintenance.

III. METHODOLOGY

In practical, to envisage the problem rising in motor through visual inspection always may not be possible. In such cases a system using MEMS sensors and Node MCU to measure various parameters of motor. With this need, various methodologies have been studied to obtain a novel solution with the use of MEMS accelerometer and Node MCU which is easy to monitor, low cost and has a good accuracy during its life cycle.

It is observe that due to various reasons of motor failure like excessive vibration, velocity of fluid flow, volumetric fluid flow rate, excessive heat, power supply the life span of the motor may reduce. In order to pre-determine the life span of the motor or predict the occurring failure of motor we need to prepare a device which will give us live readings and based on those readings a predictive maintenance schedule is planned.

1) Identification of problem
2) Conceptualization based on literature review
3) Development of DAQ system for conditioning monitoring of pump.
4) Designing algorithm to analyze vibration, flow rate, temperature, and sound rate respectively.
5) Development of mechatronics interface and control system design for domestic pump application
6) Testing and validation of the performance monitoring system

IV. MECHATRONIC INTERFACING

The sensors used in Condition Monitoring System of a motor are as follows:

1) Node MCU

2) Accelerometer ADXL335
3) Temperature sensor DS18B20
4) Sound Sensor Module
5) Flow Sensor YF-S201

A. Node MCU

The Node MCU development board is one of the type of microcontroller, which is a part of the Internet of Things (IoT). Node MCU consist of an integrated Wi-Fi receiver, and transmitter. Node MCU supports several programing languages; hence, it is very easy to upload programs from any computer over a micro-USB port. When it comes to prototyping — just another perfect, relatively cheap, easy-to-learn, and user-friendly minuscule magic module.

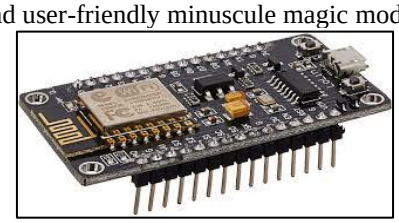

Fig. 1: Node MCU v1.0

A Node MCU has 10 bit ADC which means it scales an analog signal in a range of 0-1023.It has an inbuilt serial monitor that allow to take serial input and output from the Node MCU, while Node MCU is in action. It has inbuilt Wi-Fi. So that we can easily send sensed data through Wi-Fi module. Node MCU is cost effective.

B. Vibration Sensor ADXL335

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. An accelerometer is an electromechanical device used to measure acceleration forces. Such forces may be static, like the continuous force of gravity or, as is the case with many mobile devices, dynamic to sense movement or vibrations. Acceleration is the measurement of the change in velocity, or speed divided by time.

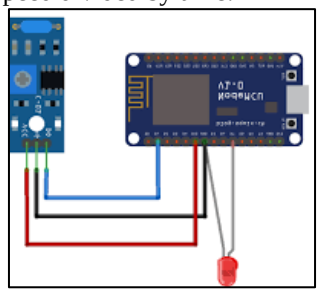

Fig. 2: ADXL Sensor Interfacing

Working Principle: MEMS inclinometers and accelerometers are low-cost, high precision inertial sensors that serve a wide variety of industrial applications. When tilt is applied to the sensor, the suspended mass creates a difference in electric potential which is measured as a change in capacitance. Vibration monitoring comprises of several emerging and promising hardware, software components that offer a flexible and yet reliable approach for diagnosing a new systems. Various researchers have analysed the presence and effects of the defects in a rotating system.

C. Temperature Sensor DS18B20

DS18B20 is 1-Wire interface Temperature sensor manufactured by Dallas Semiconductor Corp. The unique 1-Wire Interface requires only one digital pin for two way communication with a microcontroller. The sensor comes usually in two form factors. It can measure temperatures from -55°C to +125°C with ±0.5°C Accuracy. Here is DS18B20 Water Proof Temperature Probe – Black (1m) Original Chip which is based on the DS18B20 sensor. It is very handy for when you need to measure something far away, or in wet conditions. Because they are digital, you don't get any signal degradation even over long distance. These 1-wire digital temperature sensors are fairly precise (±0.5°C over much of the range) and can give up to 12 bits of precision from the onboard digital-to-analog converter. This feature can be a huge advantage when you want to control many DS18B20s distributed over a large area.

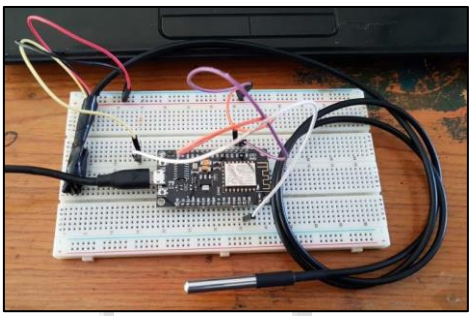

Fig. 3: DS18B2 Sensor Interfacing

This project uses ESP8266 Node MCU as the control device that easily connects to existing Wi-Fi network & creates a Web Server. When any connected device accesses this web server, ESP8266 reads in temperature from multiple DS18B20 Temperature sensors & sends it to the web of that device with a nice interface. Web page enlists the temperature readings of multiple DS18B20 temperature sensors. Web page also contains an update button. Pressing the update button will get the instance temperature readings from all DS18B20 sensors and display them on web page.

D. Sound Sensor Module

The sound sensor module provides an easy way to detect sound and is generally used for detecting sound intensity. This module can be used for security, switch, and monitoring applications. Its accuracy can be easily adjusted for the convenience of usage. It uses a microphone, which supplies the input to an amplifier, peak detector and buffer. When the sensor detects a sound, it processes an output signal voltage, which is sent to a microcontroller then performs necessary processing.

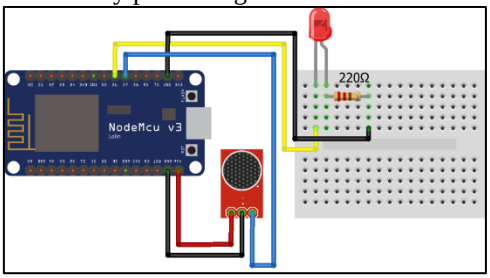

Fig. 4: Noise Sensor Interfacing

The working principle of this sensor is related to human ears. Because human eye includes a diaphragm and the main function of this diaphragm is, it uses the vibrations and changes into signals. Whereas in this sensor, it uses a microphone and the main function of this is, it uses the vibrations and changes into current otherwise voltage.While describing sound in terms of sound pressure (Pascal) is possible, a logarithmic conversion is usually applied and the sound pressure level is stated instead, with 0 dB SPL equal to 20 micropascals. In recent years, interest in MEMS microphones has expanded due to their versatile design, greater immunity to radio frequency interference (RFI) and electromagnetic interference (EMI), low cost and environmental resiliency.

E. Flow Sensor YF-S20

Flow can be measured in a variety of ways, the Flow Rate Sensor can be used for environmental or Earth science studies. The paper proposes a methodology to monitor and control the liquid flow in the pipeline through web server. The Water Flow Monitor Module has been built keeping in mind the (i) Cost Effectiveness, (ii) Ease of Usage, (iii) Efficiency, (iv) Ease of Availability and (v) Ease of Interpretation of Data. This water flow sensor module can be easily interfaced with Microcontrollers, Node MCU, Arduino Boards and Raspberry Pi. The circuitry basically consists of three components namely The Water Flow Sensor, the Micro-Controller Board and a Computer that is used for processing all the raw data that is obtained from the Micro-Controller Board. Water Flow Sensor used here is YF-S201. The sensor contains a pinwheel and sits in line with the water line such that water will pass through the sensor striking the pinwheel and rotating it to measure how much water has passed through it. An integrated magnetic Hall-Effect Sensor is used. The pinwheel rotor rotates when water / liquid flows through the valve and its speed will be directly proportional to the flow rate. The Hall Effect sensor will provide an electrical pulse with every revolution of the pinwheel rotor.

Fig. 5: Flow sensor Interfacing

The operating voltage of the YF-S201 lies anywhere in between5V-18V. The signal pin of the sensor is given to the Digital I/O pin of the Micro-Controller, which will produce a corresponding pulse for every value recorded by the sensor. The Micro-Controller is connected to the Computer via a USB cable that ensures a fast paced transmission of data between both the devices. The post processing is done on the Computer where raw values that have been obtained from the sensor is translated into corresponding litres of water that has flown though the sensor. The values that have been obtained after post processing are periodically dumped into a text file so as to maintain a database of values through which a graphical interpretation of data is possible in the future.

V. PROPOSED FLOW CHART

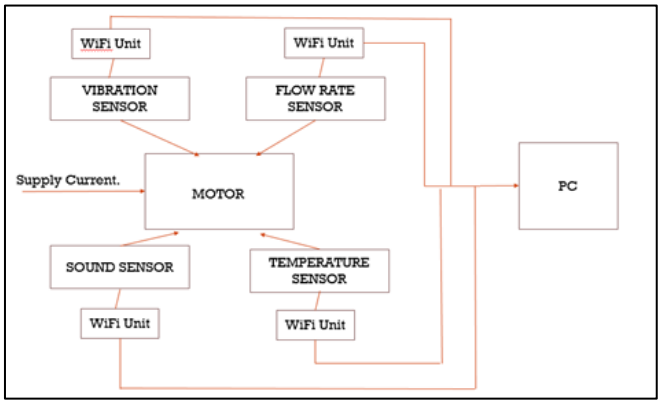

Fig. 6: Schematic Diagram

The proposed flow chart shows the various interfacing of different sensors like vibration sensor, flow rate sensor, sound sensor and temperature sensor with individual Wi-Fi units. These sensors are connected to a common micro-controller. The micro-controller used here is Raspberry Pi 3B+ which is further connected to PC through central Wi-Fi unit respectively.

VI. CONCLUSION

The development of a practical and reliable method to measure and collect data from the sensor, which connected to pump using Wi-Fi unit, is essential for condition monitoring and developing maintenance schedule. By studying various research papers related to Condition monitoring we should say that it is possible to prevent damage of motor by developing maintenance schedule. In this project, various sensors are connected to Node MCU, the sensor collect the data and it send to the controller, controller collect it and resend it to the Device which is connected to Node MCU. After getting sufficient readings we can schedule the maintenance program. The required methodology for this experiment study was gained and will be performed accordingly.

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