# Implementation of Condition Monitoring System and Its Implications

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*Abstract*— In earlier time the machine condition has not been monitored. This leads to the breakdown of machines/machine parts at the early stages. It resulted in unpredicted plant breakdown that cause production loss. The maintenance scope was restricted to electricity, mechanics or greasing. The prediction or prevention does not exist. The gradual development of condition monitoring system (CMS) helps in monitoring the machine condition periodically with the help of preventive and predictive maintenance. The evaluation of modern industrial revolution results to the automation. In industrial revolution 4.0, the machines are completely automated, reliable with machine safety and provides workers education and skills with social economic factors.

***Key words:*** Condition Monitoring System (CMS)

## I. Introduction

Condition monitoring system (CMS) is the process of monitoring a parameter of condition in machinery (vibration, temperature, pressure, lubrication, current, flow etc.) in order to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. The use of condition monitoring allows maintenance to be scheduled or other actions to be taken to prevent consequential damages and avoid its consequences. Condition monitoring has a unique benefit in that conditions that would shorten normal lifespan can be addressed before they develop into a major failure.

## II. Need for CMS

In modern industries environment require high degree of automation.

- Predict the need of maintenance.
- Avoid failure and minimize downtime with reliable conditional monitoring system the machines can be utilized in a more optimized manner.
- Gives information about the nature of failure.
- It evaluates corrective action.

## III. Process Involved

- Data collection
- Signal processing
- Analysis

## IV. Devices & Components Used

### A. *Sensor*

1) Temperature (LM 35)
2) Pressure (PX2)
3) Voltage
4) Current
5) Flow

### B. *Arduino mega 2560*

### C. *Raspberry pi3*

## V. Sensors

### A. *Temperature sensor (LM35)*

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling.

The LM35 device does not require any external calibration or trimming. They have special features such as,

1) *Calibrated Directly in Celsius(Centigrade )*
   - Linear+10-mV/°C Scale Factor
   - 0.5°C Ensured Accuracy (at 25°C)
   - Rated for Full −55°C to 150°C Range
2) *Suitable for Remote Applications*

### B. *Pressure sensor (PX 2)*

The PX2 Series is available in three pressure ranges:

1) bar to 70 bar
2) 100 Kpa to 7 Mpa
3) 15 psi to 1000 psi

DC 5 volt operating voltage is given from the arduino to pressure transducer and the proportional output from the pressure transducer is connected to the analog pin of the arduino and the program is developed accordingly.

### C. *Voltage sensor*

The Voltage Sensor block represents an ideal voltage sensor.It converts voltage measured between two points of an electrical circuit into a physical signal proportional to the voltage. Connections + and – are electrical conserving ports through which the sensor is connected to the circuit. Connection V is a physical signal port that outputs the measurement result.

### D. *Current sensor*

In current sensor, the magnetic flux created by the primary current (If) is concentrated in a magnetic circuit and measured using a hall device.

The output from the hall device is then signal conditioned to provide an exact (instantaneous) representation of the primary current. DC 5 volt operating voltage is given from the arduino to Current sensor and the proportional output from the Current sensor is connected to the analog pin of the arduino and the program is developed accordingly.

### E. *Flow sensor*

A flow meter works by measuring the amount of a liquid, gas, or steam flowing through or around the flow meter sensors. The Arduino code uses the external interrupt (int 0) on

Arduino’s digital pin. This is used to read the output pulses coming from the flow sensor. When Arduino detects the pulse, it immediately triggers the pulse counter() function. This function then counts the total number of pulses detected, Flow is calculated based on the counted pulses per minute.

### F. *ARDUINO Mega2560*

It has 54 digital I/O pins (15 can be used as PWM outputs), 16 analog inputs, 4 UART’s (hardware serial ports) a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It supports the micro controller and it connected to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

### G. *Raspberry pi3*

Arduino and Raspberry Pi are connected by USB interface. Actual serial output from the arduino is transferred to the server through Raspberry Pi USB interface in a fixed interval of 5 Sec. Raspberry Pi collects the data from the arduino by requests in a fixed intervals developed by necessary scripts. Raspberry Pi is connected to the server through Wi-Fi network for necessary storage and analysis. Data stored in the server are used for User screen and alert development. From the user screen trend of each parameter and its abnormality alerts can be viewed.

## VI. CMS ARCHITECTURE

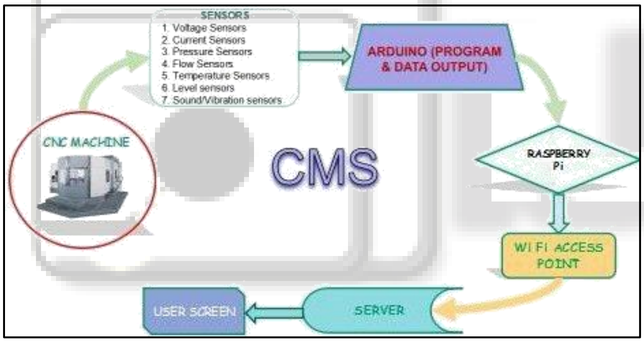

Fig. 4.1: CMS Architecture

Program's are developed in Arduino IDE platform to read the data from sensors and compile them with necessary calculations. Arduino and Raspberry Pi are connected by USB interface. The O/P is transferred to the server through Raspberry Pi USB interface in a fixed interval of 5 Sec. Raspberry Pi is connected to the server through Wi-Fi network for necessary storage and analysis. Data stored in the server are used for User screen and alert development. From the user screen each parameter and its abnormality alerts can be viewed.

## VII. PARAMETERS TO BE MONITORED

1) 3phase Input voltage
2) Electrical cabinet temperature
3) All axes/spindle motor temperature
4) All axes/spindle motor load current
5) All auxiliary (ATC, APC TURRET etc) axes motor temperature
6) All auxiliary (ATC, APC, TURRET etc) axes motor load current
7) Hydraulic motor current
8) Hydraulic motor temperature
9) Hydraulic oil temperature
10) Hydraulic pressure
11) Hydraulic oil level
12) All induction motor current
13) All induction motor temperature
14) Coolant flow/pressure
15) Lubrication pressure
16) Lubrication oil level
17) Cooling units oil temperature

## VIII. INTERFACING

A device or program that enables user to communicate to the computer. There are two types of interfacing,

- Hardware interface
- Software interface

### A. *Hardware Interfaing*

Interfacing different hardware’s with CNC machine to monitor various parameter consists of following sub categories

- Interfacing Arduino with its basic components
- Interfacing various sensors with Arduino
- Interfacing Arduino with Raspberry Pi3
- Establishing Wi-Fi network for Raspberry Pi3

#### *1) Interfacing Arduino with its Basic Components*

The Arduino has been connected to the CNC machines using interfacing of wire cables. For the flexible wiring of the Arduino with the sensors and for panel mounting purpose, Terminal board with screw type terminals developed. For the required input voltage, Power supply adapter with DC 12V, 1Amps output is connected with 1A(serial port), 2 pole MCB for necessary protection.

#### *2) Interfacing Various Sensors with Arduino*

Based on the list of parameters to be monitored, transducers relevant to the conditions are selected and they are placed in the measuring point and they are connected with the Arduino Mega 2560 through terminal board. Normally it is preferred to select transducers with 5V operating voltage to directly connect with Arduino.

#### *3) Interfacing Analog Sensors*

This shows the connection method for an analog output temperature sensor. Operating voltage (5V) from the Arduino is connected across 5V and Ground pin and Output from the sensor is connected to the analog pin A0 of the Arduino board. By the necessary programming, output voltage from the sensor in response to the temperature changes is read and its converted as temperature (℃) by the relevant calculations.

#### *4) Interfacing Digital Sensors*

This the connection method for an digital output (Eg. flow sensor). Operating voltage (5V) from the Arduino is connected across 5V and Ground pin and Output from the sensor is connected to the digital pin D2 of the Arduino board. By the necessary programming, output pulses from the sensor in response to the liquid flow is counted and its converted as flow (LPM) by the relevant calculations.

### B. *Software interfacing*

1) Arduino codes are developed for our application by using ARDUINO 1.7.10 IDE Complier. The open-source

Arduino Software (IDE) makes it easy to write code and upload it to the board.

2) Basic way is to work with Arduino Software and processing is used to load the program into Arduino.
3) Language which can be used is JAVA, Python, C , C++
4) A program for Arduino hardware may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their 8-bit
5) AVR (Alf and Vegard's RISC processor) and 32-bit ARM Cortex-M based micro controllers.

## IX. IDE

The Arduino IDE (Integrated Development Environment) is a cross- platform application (for Windows, mac OS, Linux) that is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDEdistribution.

## X. Conclusion

The machine 1078 is completely observed for a period of time and the values that are to be monitored are noted down. The causes for the abnormality when the values are beyond the standard limits are analyzed and the parameters are listed out. An update to the CMS have been suggested. This helps in giving an alert to the person about the machine abnormality through a message or an email which aids in predictive maintenance. This will decrease the production loss due to breakdown and ensures plant safety.

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