Industry 4.0 IIOT CNC Machine Automation and Health Monitoring

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Abstract— A reliable monitoring system is needed in a wide range of industries in order to detect the occurrence, so that to prevent machinery performance degradation, malfunction etc. This website helps by using a new intelligent system (sensors), IoT & for real-time machinery condition monitoring. The monitoring reliability is improved by integrating the predicted machinery condition to fault diagnosis, which can be displayed on the created website. By this the given parameters can be studied and the required actions can be taken to increase the efficiency of the machine.
Keywords: Coolant, Spindle, Pneumatic Pressure

I. Introduction

Advances in the information and communication technologies have led to the emergence of Internet of Things (IoT). IoT allows many physical devices to capture transmit data, through the internet, providing more data interoperability methods. Nowadays IoT plays an important role not only in communication, but also in monitoring, recording, storage and display. Hence the latest trend in Healthcare communication method using IoT is adapted. Monitored on a continual basis, aggregated and effectively analyzed - such information can bring about a massive positive transformation in the field of industrial production. Our matter of concern in this project is to focus on the development and implementation of an effec-tive healthcare monitoring system based on IoT in CNC ma-chines. In the proposed project the parameters are taken into account and their efficiency is monitored .In this project the parameters considered are coolant, spindle temperature, oil temperature and pneumatic pressure.

II. Problem Statement

A. Objectives

The main objective is to increase the efficiency of the machine which in turn increases its durability and lifespan.
This is done by continuously monitoring the real time data of the machine’s parameters, these parameters either have a threshold value above which it will harm the machine or an optimum range where the performance of the machine is recommended (eg. the pneumatic pressure must be in the range,4-5baratmospheric pressure). The objective also reflects the idea of ‘smart industries’ which is idea to reform mechanical industries by using IOT. The idea is to allow an operator at a remote location to work on the machine and acquire real-time data and do the necessary, like, switching on a cooler when the temperature exceeds a limiting value or fill the cool-ant tank when they are approaching 0%.

B. Existing System

Existing model is nothing but a CNC machine which is used for manufacturing process in which pre-programmed computer software dictates the movement of its tools and functions. This suctions can include drilling, milling etc. The process can be used to control a wide range of machinery. The given machine is not accessible through cloud and is impossible for operator at remote location to control the machine.

C. Proposed System

Proposed system is the one which is connected to the internet and has a number of sensors to read the parameter values during their runtime and store the observed data in a local data-base which can be used as and when required. The sensors not only collect and store the real time data but also controls the machine by looking into it that the parameter do not cross the specified range or value provided to it. If such travesty occurs then the sensors sends an alert message to the operator to do the needful. It a smart factory the sensor finds a solution and takes the necessary tasks to bring down the parameter value to the required range.

III. Methodology

A. Protocols & interface used:

1) I2C protocol:

I2C (Inter-Integrated Circuit), pronounced I-squared-C, is a synchronous, multi-master, multi-slave, packet switched, single-ended, Serial computer bus. It is widely used for attaching lower-speed peripheral ICs to processors and micro-controllers in short-distance, intra-board communication. I2C is popular for interfacing peripheral circuits to prototyping systems, such as the Arduino and Raspberry Pi. IÇC does not employ a standardized connector, however and board designers have created various wiring schemes for IÇC Interconnections.

To minimize the possible damage due to plugging 0.1-inch headers in backwards, some developers have suggested using alternating signal and power connections of the following wiring schemes: (GND, SCL, VCC, SDA) or (VCC, SDA, GND, SCL).

2) Serial Peripheral Interface:

The Serial Peripheral Interface (SPI) is a synchronous serial communication interface specification used for short distance communication, primarily in embedded systems
The SPI bus specifies four logic signals:

- SCLK: Serial Clock (output from master)
- MOSI: Master Output Slave Input.
- MISO: Master Input Slave Output.
- SS: Slave Select.

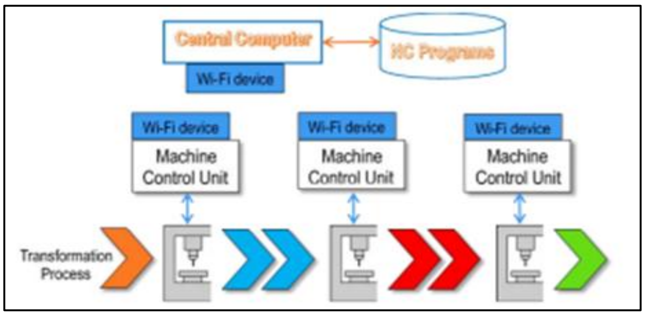


Fig. 1: Wireless Controller System

B. Communication Interface:

1) Ethernet:

Ethernet is the traditional technology for connecting wired local area networks (LANs), enabling devices to communicate with each other via a protocol -- a set of rules or common network language. As a data-link layer protocol in the TCP/IP stack, Ethernet describes how network devices can format and transmit data packets so other devices on the same local or campus area network segment can recognize and process them.

2) RS-232:

RS-232 is a standard introduced for serial communication transmission of data. It formally defines the signals connect-ing between a data terminal equipment such as a computer terminal, and a data circuit terminating equipment or data communication equipment, such as a modem. This standard had been commonly used in computer serial ports.

3) Modbus:

This enables communication among many devices connected to the same network. Modbus is often used to connect a supervisory computer with a remote terminal unit in supervisory control and data acquisition (SCADA) systems. PCMCIA card – normal & industrial grade: Stands for "Personal Computer Memory Card International Association". PCMCIA was an Organization that focused on creating expansion card standards for portable computers.

4) ETHERCAT:

ETHER-CAT (Ethernet for Control Automation Technology) is an Ethernet based field-bus system. It is suitable for both hard and soft real-time computing requirements in automation technology.

5) DNC – in CNC machine:

DCN stands for direct CNC networking. A DCN system enables much greater data flow in all directions from almost instantaneous part program loading, to the extraction of useful SPC or machine monitoring information right from the control while it is running.

6) Profibus, Profinet:

PROFIBUS is a standard for field bus communication in automation technology PROFINET is an industry technical standard for data communication over Industrial Ethernet, designed for collecting data from, and controlling, equipment in industrial systems, with a particular strength in delivering data under tight time constraints (on the order of 1ms or less).With cycle speed as fast as 31.25 µs, large quantity structures with up to 51 stations per network, fast start-up under 500 milliseconds, as well as the integration of safety and di-agnostics functions, you can set new standards with profinet.

7) TCP/IP:

TCP/IP, or the Transmission Control Protocol/Internet Protocol, is a suite of communication protocols used to interconnect network devices on the internet. The entire internet proto-col suite is commonly referred to as TCP/IP, though others are included in the suite.

C. Wireless Controller System:

This system consists from Central Computer and the wire-less devices that’s connected to Machine Control Unit (MCU) of the machine to make wireless network. Due to the variety machine types that exist in the workshop and commonly workshop machines had been limited with two types of connection (Ethernet RJ-45 or RS-232). In this case, to achieve our aims have to use a low-cost embedded UART-ETH-Wi-Fi module (Serial port, Ethernet and Wireless network) which offer Wi-Fi possibility to transfer data to different types of machines. The embedded UART-Wi-Fi modules (HLK-RM04) based on the universal serial interface network standard, built-in Transmission Control Protocol (TCP) / Internet protocol (IP) protocol stack, enabling the user serial port, Ethernet, wireless network (Wi-Fi) interface between the conversions. This module work with network standard: IEEE 802.11n, IEEE 802.11g, IEEE 802.11b. IEEE 802.3, IEEE 802.3u, as shown in figure (1). Any computer with wireless capability like (personal computer, laptop, Pad and Pendent) can connect to the CNC machine and become the device under Wi-Fi LAN and more of that was having the capability to become a part with other network connected to internet through WAN.WAN de-fault IP is dynamic IP address. LAN, Wi-Fi for the same local area network, enabled by default DHCP server.

D. Internet of Things for CNC Machine Monitoring:

In the process of machining work piece, the simulation and automation Centre needs a real time data information about vibration, temperature, humidity, noise level and object detection.

Sensing Unit: Each sensing unit consisting from Bluetooth Low Energy chip, printed circuit board (PCB) and Li/ion coin cell battery. This unit consists of multiple sensors like:

1) Tp 240
2) DP15
3) DP15 TL
4) AP10
5) Fiber Bragg Grating (FBG) sensor
6) RTD sensor
7) P0196
8) P0197

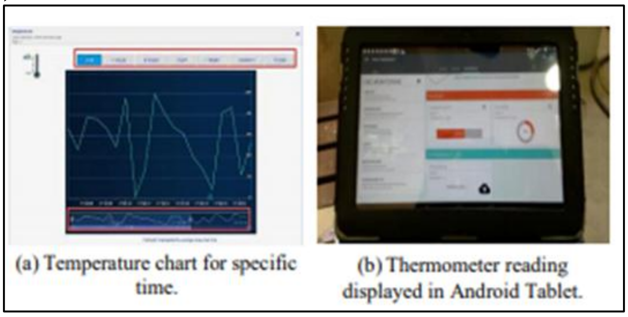


Fig. 2: Visualizing Device Data

The coolant level sensor is the electronic sensor that is responsible for measuring the coolant level of your engine. It is usually installed in the coolant reservoir or radiator, and measures the amount of coolant in the system to make sure that it is always at the proper level.

Symptoms of a Bad or Failing Oil Temperature Sensor. The oil temperature is a vital part to keeping your engine running smoothly. The oil temperature should be a few degrees warmer than the coolant. The oil temperature sensor is an important piece to know when your oil is warmed up when working properly.

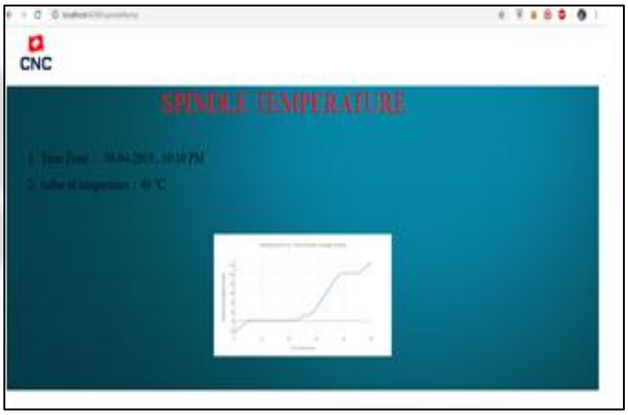
E. Internet Things System Implementation:

To implement this system, need some steps starting from connecting sensors with master unit to build a node in the machine. This node connected to the cloud server via wireless local area network. The data collected from the machine will be stored in cloud server and this gives the capability to reach and analyses data from different devices or location. The present work has created a CNC monitoring system that's allowed implementation rules and identify patterns. A. Sensor Unit Configuration The most important step in IoT system is to make unique identity for device, to do that there are two main parameters in sensor unit need to be configured before can connecting it to cloud server as shown in figure (8). At beginning configured the Readings, will need to set the following properties: Meaning: Description of device reading. Name: The name of the command or configuration. Path: An optional filter that lets to differentiate between multiple readings / commands / configurations with similar meanings / names After that will configure the model details and enter the following information for device model:
Device model name: The name of the model.
Description: A description for the model.
Website: URL of the website for the model.
Manufacturer details: Information about the manufacturer of this model.

At this point the device settings are completed and ready to connect to cloud server. Create Monitoring Rule Creating rule for devices to facilitate interaction between devices by sending a command or a configuration to the device when reading from another device matches a certain condition. In this work one rules have been used. 1) Machine tool temperature rule: One of the important monitoring parameter in CNC machine is machine tool temperature. A machine tool temperature alert has been created to accomplish this role must make some coding in JSON Schema. JSON Schema describes existing data format, clear for human and machine readable documentation. After device created will now setup the control step "Role" this role gives an alert when the temperature gets higher than 100°, the alert can be sound or signal send to device to do an action

IV. SNAPSHOTS

Snapshots of different parameter pages.



localhost:4200/dba

Sl	Date	Time	value
1	26-2-19	1:00:00	100
		3:00:00	95
		5:00:00	90
		7:00:00	85
		9:00:00	80
		11:00:00	75
		13:00:00	70
		15:00:00	65
		17:00:00	60
		19:00:00	55
		21:00:00	50
		24:00:00	20

V. CONCLUSION

Based on the results from experimental and implementation works, the following clarifications can be concluded: IOT for monitoring CNC machines provided:

1) Automated production data recording and this lead to eliminating paper work, assisted in decision making & overview, enhanced work efficiency.
2) Predictive maintenance for machine by using recorded data and rule feature.
3) Collected data used to enhancement occupational safety and health.

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