A Smart Temperature Monitoring System for Cutting Tools

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Abstract

In cutting tools nearly 70% of the heat is carried away by the chips which are formed during machining. Most of the remaining heat is transferred to the tool due to which the tool life suffers. It also affects the surface finish of the workpiece. Many research works have focused on analytical and numerical approaches to estimate the tool temperature. This paper presents Internet of Things enabled temperature monitoring of cutting tools. The system is built using Arduino microcontroller and MAX6675 Type K sensor. USB module is used to communicate the sensor readings to an android application named Blynk. The data obtained are monitored to observe any peak in temperature beyond a certain limit which intern turns on buzzer and light. Experiments were carried out on a center lathe and real time temperature data of tool was monitored on the Blynk android application.

Keywords: *Cutting tool temperature, Internet of Things, MAX6675 Type K, Tool Temperature, Blynk, Arduino*

1.0 Introduction

Wide ranges of cutting tools are used in lathes. Material of the cutting tool is selected based on the material to be machined and the machining process [1]. In metal cutting, heat generated on the cutting tool tip is important for the performance of the tool and quality of the finished workpiece. Effect of the cutting temperature, particularly when it is high, is detrimental to both the tool and the work piece [2-4]. The cutting tool temperature data can be analyzed and used in improving the machining quality and tool life. IoT is the state-of-the art technology for remote sensing and monitoring real time the industrial machines. Sensor data is acquired in real time and transferred to the cloud in order to access it through a smartphone application, which can be processed and presented in the required form [5, 6]. This paper focuses on development of an IoT enabled temperature monitoring for acquiring temperature data of cutting tool in a lathe in real time and compare the same with the preset threshold value to assess safe limits [7-10]. In case of temperature crosses the set limits, the user is alerted through an alarming system.

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2.0 System Development

2.1 Methodology Adopted

Existing tool temperature monitoring systems were studied for identifying improvements [11-13]. Functions related to sensing, sensitivity of the sensors, temperature measurement, fixing of threshold were studied. Suitable sensors were selected for the application and the circuitry was developed. A program developed using C++ was flashed into the microcontroller and the data obtained was forwarded to the cloud. The same data is monitored through smartphone Android application. The system gives alert in the form of a buzzing alarm if the temperature exceeds the preset safety limit and continuous monitoring of the tool temperature can be done in the mobile application.

2.2 Experimental Details

The block diagram, shown in the Fig. 1, depicts the major components and sequence of signal flow in IoT based temperature monitoring system.

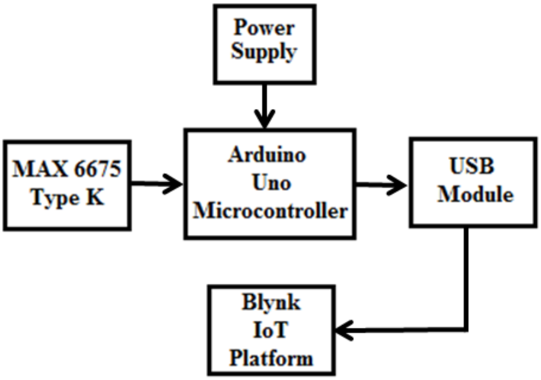

Fig. 1. Block Diagram of Arduino system

MAX6675 Type K sensor is connected to the Arduino as shown in Fig. 2. MAX6675 runs on 3.3V power supply. VCC and CH_PD are connected to 3.3V pin of Arduino and the network is completed as per fritzing diagram (Fig. 3). A controlling program is written and transferred it to Arduino Uno. The Arduino is connected to the Internet and the results are monitored on Blynk IoT platform. USB Serial communication module gives access to Internet. It is a very cost effective device and makes the system portable.

MAX6675 sensor senses the temperature of the tool through contact type. The Arduino connected to the sensor reads the temperature data, and provides the same data in degree Celsius or Fahrenheit. The temperature data in degrees is displayed on the serial monitor.

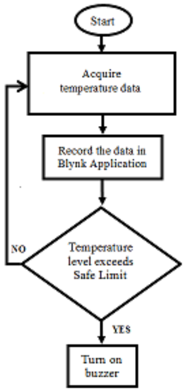

Fig. 2. Process Flowchart of temperature measurement

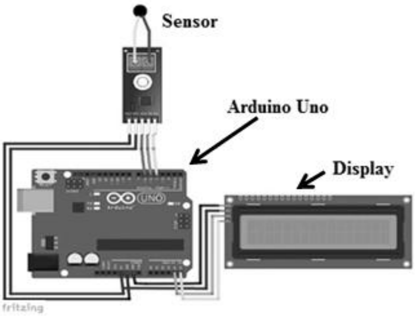

Fig. 3. Fritzing Diagram

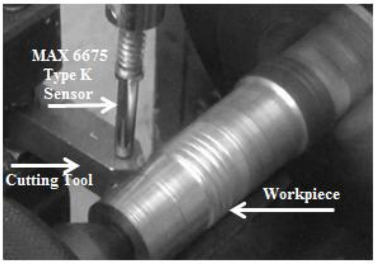

Fig. 4. Max 6675 sensor in contact with tool

Sensor provides the temperature value of 27°C (or room temperature) when it is not in contact with the cutting tool and provides the instantaneous temperature data as the sensor makes contact with the workpiece (Fig. 4).

3.0 Results and Discussion

The C++ code is compiled and flashed to the Arduino Uno. The temperature data are acquired on the serial monitor and the same is reflected on Blynk Android application.

1. The temperature of the tool is observed in the Serial Monitor and change in the temperature is monitored in the mobile application (Fig. 5).
2. The buzzer and LED are ON if the temperature is above is 50°C and below the range of 50°C the buzzer and LED are OFF (Fig. 6).

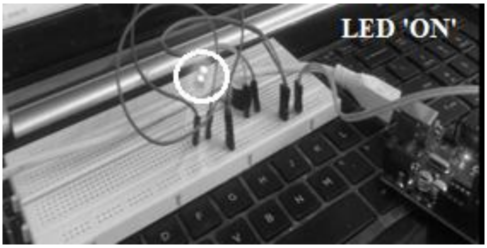

Fig. 5. Buzzer and LED light ON during temperature exceeding limit

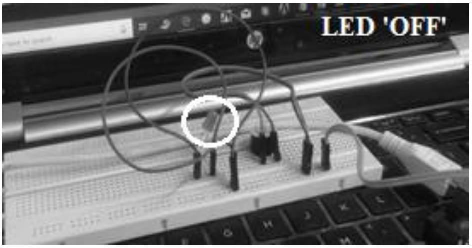

Fig. 6. Buzzer and LED light OFF during temperature within limit

The modelled Arduino system for tool temperature measurement finds its application in tool industries where machining is performed for long hours due to which the temperature of the tool increases which affects tool life and surface finish of the workpiece. The real time monitored data is shown in Fig. 7. It is wireless device and hence the data can be accessed from anywhere with the help of Blynk android application (Fig. 8).

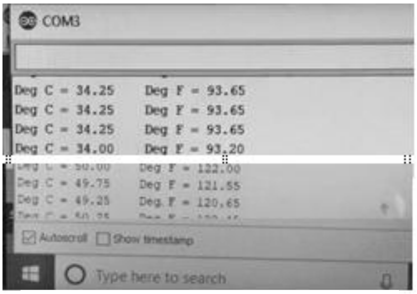

Fig. 7. Temperature output on serial monitor of Arduino IDE

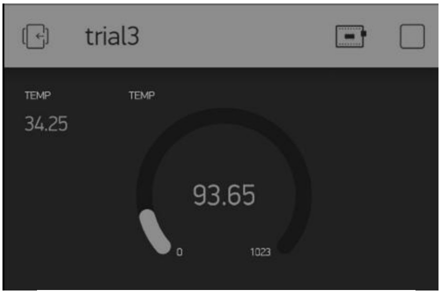

Fig. 8. Temperature output on Blynk application

4.0 Conclusions

The tool temperature monitoring using IoT is successfully developed. The smart temperature monitoring in the model shows the complete architecture with configuration of contact type temperature sensors and the Android application for showing the change in temperature. The proposed IoT based methodology can easily provide the information and the proposed hardware can serve the purpose for all tool types. The technology is robust, cost effective and easy to use. The following conclusions are arrived at based on the experimental results:

Temperature monitoring system is developed using Arduino Uno microcontroller and MAX6675 Type K contact sensor. Real-time temperature data of cutting tool tip is obtained by connecting the set up to internet using USB module and recording on Blynk android application. The system signals through buzzer and light whenever the temperature exceeds the permissible value for the machining speed of cutting tool. In case of centre lathe, initial temperature is below 50℃ which is the user specified limit of temperature. Hence, no signal mechanism is activated. As the temperature increases beyond 50℃, the developed IoT based system successfully activates the buzzer with a light as an alert notification indicating temperature exceeding limit.

Although an alert is given to the user through internet, the temperature is monitored by contact type. But, temperature measurement can be optimized using non-contact type sensor. Also, if a fixture is used to hold the sensor in place, a more sophisticated temperature monitoring system can be achieved. If Artificial Intelligence is used with the developed set-up, corrective actions such as change of tool and turning on coolant may be incorporated.

References

1. R Mark Miller, George Mulholland, Charles Anderson, Experimental Cutting Tool Temperature Distributions, *Journal of manufacturing science and engineering*, 125 (4), 667-673, 2003
2. Rui Li, A J Shih, Tool Temperature in Titanium Drilling, *Journal of Manufacturing Science and Engineering*, 129 (4), 740-749, 2007
3. N Trajcevski, M Kuzinovski, P Cichosz, Investigation of Temperature During Machining Process by High Speed Turning, *A tutorial review: 10th International Scientific Conference on Flexible Technologies*, 12 (1), 86-103, 2009
4. J Ratnasingam, T Pew Ma, G Ramasamy, Tool Temperature and Cutting Forces during the Machining of Particle board and Solid Wood, *Journal of Applied Sciences*, 10 (22), 2881-2886, 2010
5. L B Abhang, M Hameedullah, Chip-Tool Interface Temperature Prediction Model for Turning Process, *International Journal of Engineering Science and Technology*, 2 (4), 382-393, 2010
6. S D Ghodam, Temperature Measurement of A Cutting Benzhen Guo1 Tool in Turning Process By Using Tool Work Thermocouple, *International Journal of Research in Engineering and Technology*, 3 (4), 831-835, 2014
7. Abdil Kus, Yahya Isik, M CemalCakir, Salih Coşkun, Kadir Ozdemir, Thermocouple and Infrared Sensor-Based Measurement of temperature Distribution in Metal Cutting, *Sensors*, 15, 1274-1291, 2014
8. C S Akhil, M H Ananthavishnu, C K Akhil, P M Afeez, R Akhilesh, Rahul Rajan, Measurement of Cutting Temperature during Machining, *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 13 (2), 102-116, 2016
9. Wu Baohai, Cui Di He, Xiaodong Zhang Dinghua, Tang Kai, Cutting tool temperature prediction method using analytical model for end milling, *Chinese Journal of Aeronautics*, 29(6), 1788–1794, 2016
10. Gyanendra Singh Goindi, Karanvir Saini, Thermal Modelling of Heat Flux and Tool-chip Interfacial Temperature Distribution in Orthogonal Machining, *Indian Journal of Science and Technology*, 9(36), 97-102, 2016
11. Yuan Gao, James B Mann, Srinivasan Chandrasekar, Ronglei Suna ,Jürgen Leopold, Modelling of Tool Temperature in Modulation-assisted Machining, *16th CIRP Conference on Modelling of Machining Operations*, 58, 204-209, 2017
12. Denis O'Sullivan, Matthew Cotterell, Temperature measurement in single point turning, *Journal of Materials Processing Technology*, 118(1), 301-308, 2018

13. Sobron M Lubis, Steven Darmawan, Adianto, Ericsen, Effect of cutting speed on temperature cutting tools and surface roughness of AISI 4340 steel, *TICATE 2018*, *IOP Conference Series: Materials Science and Engineering*, 508, 102059, 2018