# Experimental Setup for Hot Turning Using K-Type Thermocouple Interface with Arduino

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*Abstract*— Hot turning methodology for cutting of hard to cut material is one of the alternative to get good surface finish of work, better tool life, reduction of tool wear and power consumption. To develop a setup for this type of machining is one of the major task for the experimental investigation. This research focuses on the experimental setup for hot turning machining. The setup is divided into 3 parts that is Mechanical components like lathe machine and torch flame setup, Electronics components like K-type thermocouple temperature sensor, buzzer for alarm system & Arduino board for interfacing sensors and Heating application apparatus like LPG cylinder, Air/acetylene inlet and torch mechanism support.

***Keywords:*** Hot Turning, Hard to Cut Material, K-Type Thermocouple, Arduino

## I. INTRODUCTION

Dealing with materials having very high hardness and shear strength, Hot Machining can be used to decrease tool wear, power consumed and increase surface finish. In Hot Machining the temperature of the work piece is raised to several hundred Celsius above ambient, which causes reduction in the shear strength of the material [1]. That will help the cutting tool to remove material with less efforts which results into less power consumption. The torch flame method is used widely to provide heat to the workpiece but to measure the temperature of the workpiece and maintain the same is little bit tricky. Various heating methods were tried to make use of hot machining in industries. But all had limited applicability and were not suitable in all the circumstances. For example, laser beam heating has low gross efficiency and extremely expensive as very high power lasers are required. Electron beam heating required working under vacuum and was again found to be expensive. The breakthrough has been achieved by plasma arc hot machining process [2]. There are other setup like oxy-acetylene heating method, induction heating method, resistive heating method and ultrasonically assisted heating setups.

By considering the costing and feasibility this research has focused on the oxy-acetelyne flame heating which included the LPG + Compressed air supply for smooth carbon less flame heating process.

## II. FLOW OF WORK

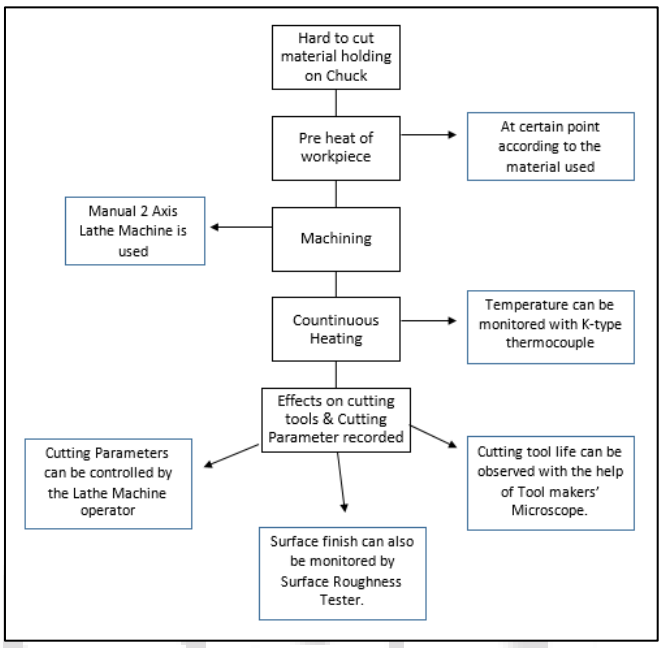


Fig. 1: Flow chart of Heat Application Setup Working

The Flow of the work will be as shown in upper flow chart. The hard to cut material is being clamped on the 3 jaw self-centred chuck on the manual lathe machine. The torch, cutting tool and a temperature sensor is kept at right angle to get proper results. The material is first pre heated at some point of time so the bond between the molecules of the upper surface will become weak. The temperature is recorded by the temperature sensors. On achieving the proper heating to the work piece the cutting has been carried out by means of cutting tool. With constant cutting speed & feed and at constant temperature the cutting has been carried out at constant RPM of the spindle. A closed loop feedback system is also attached with the electrical circuit to monitor the temperature and the get the alarm when the temperature goes beyond the set temperature as per the design of experiments. After cutting the tool & workpiece can be monitored for the analysis of tool life, surface finish accordingly for the different cutting parameters set by the engineers.

## III. EXPERIMENTAL SETUP

The experimental setup for the hot turning process can be divided in 3 sections accordingly the functionality of the parts.

1) Mechanical Parts
2) Electrical & Electronics Parts
3) Other Supporting Parts and Accessories.

*1) Selection criteria of Mechanical Parts*

The mechanical parts or machines used for the setup are

 

- Lathe machine
- Cutting Tool
- Flame Torch

Fig. 2: Lathe Machine. Photo taken at TeamLease Skills University, Vadodara

Lathe Machine is selected by the requirement of the machining speed, Work holding size, 3 Jaw chuck with different diameters, 4 Jaw chuck with different diameters, Length of lathe bed and cutting speed variables.

Fig. 3: Cutting Tool - Photo taken at TeamLease Skills University, Vadodara

Cutting tool is selected according to the material required to cut, according to cutting angle, cutting force and process required.

Fig. 4: Flame Torch, Photo taken at TeamLease Skills University, Vadodara.

Flame torch is selected according to the size of the workpiece, length of the workpiece, available flammable gas and requirement of the temperature. Here the flame torch is connected with the mechanism of bulb as the mechanism is travelling parallel to the carriage of the lathe.

*2) Selection criteria of Electrical Parts*

The electrical parts are used for the setup are

- Arduino MEGA
- Temperature Sensor
- Buzzer

Fig. 5: Arduino MEGA

The selection of Arduino Mega is required based on the requirement of I/O ports. This is used to interface between different sensors with the computer. We can get the output serially or parallel on the computer. For this experimental setup 3 analog and 3 digital I/O ports are required.

Fig. 6: K-type thermocouple with Max6675 Module.

Type K are the most widely used thermocouples in the Oil & Gas, and refining industries due to their wide range and low cost. They are occasionally referred to as Chromel-Alumel thermocouples. Note that above about 750°C oxidation leads to drift and the need for recalibration. K-type of thermocouple's temperature range is 0˚C to 1260˚C [3]. Max6675 module is compatible with Arduino Mega.

Fig. 7: Feedback sensor - Buzzer.

Buzzer – a feedback sensor for this setup is selected based on noise intensity required, type of buzzer, and compatibility with Arduino. For this experimental setup the buzzer is connected with thermocouple. If the temperature of workpiece goes beyond the set temperature then buzzer starts to function and give alarm to the researcher.

*3) Selection criteria of other supporting part.*

The Other supporting parts used for the setup are

- LPG Cylinder
- Oxygen Cylinder
- Torch Holding Mechanism

Fig. 8: LPG Cylinder

The selection of LPG cylinder is based on the Based on the pressure required for flammable gas. For replacement of LPG cylinder acetylene cylinders can also be used. For this experimental setup LPG Cylinder as shown in figure 8.

 

Fig. 10: Oxygen Cylinder

Oxygen cylinder is used for generating blue flame. For this experiment due to unavailability of oxygen cylinder we have used pressure regulated compressed air as a replacement of oxygen.

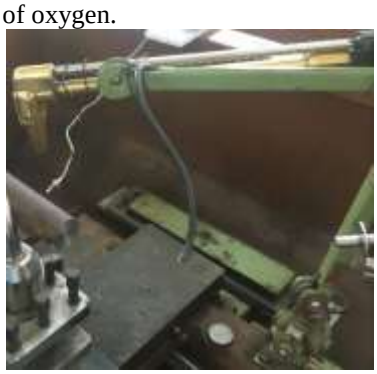

Fig. 11: Torch support mechanism

This mechanism must move with the movement of the carriage. Torch should remain at 90 degree angle with the cutting tool. For this experimental setup the bulb mechanism attached with the carriage is used to control the flame angle and stand of distance from the work piece. This mechanism must be flexible and should be able to adjust the angle and the distance from the tool.

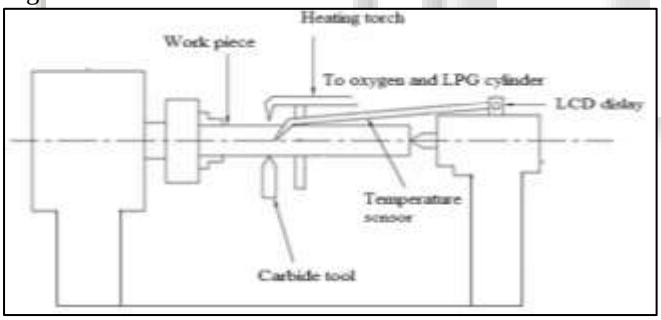


Fig. 12: Block diagram of the setup. [1]

## IV. ELECTRICAL CIRCUIT DIAGRAM AND ARDUINO PROGRAMME FLOW CHART

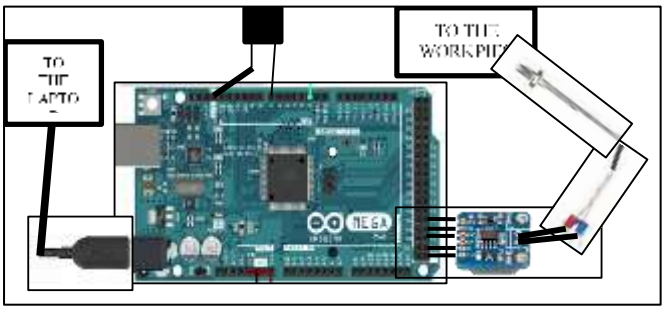

Fig. 9: Block Diagram for Electrical Circuit

Fig. 13: Output display for temperature readings

Arduino UNO/MEGA can be used as a microcontroller to interface K-type thermocouple having range up to 1200 ˚C. In above circuit diagram the Arduino is connected with Laptop/Computer, thermocouple is connected with Arduino digital pin 45,47,49,51,53 where 45 is used for ground, 47 is used for VCC, 53 is used for SO, 51 is used for CS and 49 is used for CSK. The buzzer is connected with pin 06 of digital pin and it is used to indicate us when the temperature will go above the desired temperature. For this experiment we have set 500˚C. The display of the temperature can be taken by the LCD interface and also on Laptop screen. As shown in figure 13, we have used laptop screen to display the temperature.

The working flow chart of the circuit diagram is as given below.

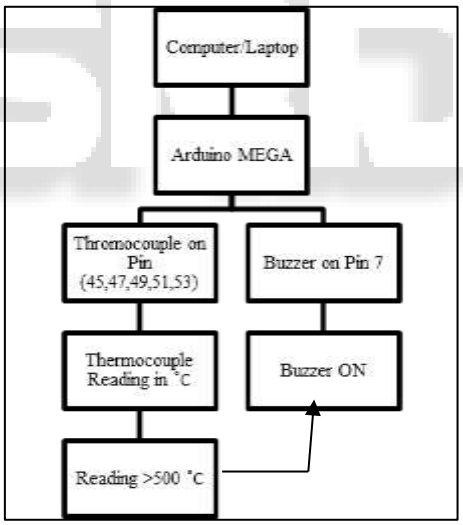


Fig. 14: Flow chart for programming

 

## V. WORKING

Fig. 14: Actual setup photo captured at TeamLease Skills University, Vadodara

Fig. 15: Actual Experimental Setup.

Fig. 16: Preheating Process.

The workpiece is held between the centres on the lathe machine as shown in figure 14. The torch can move with the movement of the tool as shown in figure 16.

The workpiece is preheated at desired temperature, after preheating the cutting operation can be carried out with the selection of proper process parameters like speed, feed, depth of cut and temperature. During that the temperature is constantly being measured by the temperature sensor and the result is being displayed on the computer.

## VI. CONCLUSION

Hot Machining is an efficient machining process for hard to cut materials. For this experiment the mounting of the heat application fixture was kept on to the lathe carriage, for flame the oxygen and LPG mixture was used. The main objective of this experimental setup was to cut the high strength hard to cut materials by carbide tools to increase tool life and to decrease the tool wear. The movement of the torch has been successfully done manually as well as with the help of connection with carriage.

An efficient temperature sensor K-type thermocouple was successfully interfaced with the Arduino mega board along with buzzer for efficient feedback of temperature and the alarm based of set values. The use of this sensor is one of the cheapest method to get the sensing of temperature.

## REFERENCES

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