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# Automatic Coolant Nozzle Control in CNC Machine using Microcontroller

Chandrika H N [1] (4GW15EC404),
Priyanka L [2] (4GW15EC418),
Vinutha S [3] (4GW15EC422)
Department Of Electronics & Communication Engineering
GSSS Institute Of Engineering & Technology For Women

***Abstract*—The main objective of the project is to develop an automatic coolant nozzle control for CNC machines using Microcontrollers which avoids the manual intervention during a busy production work. The spindle or the job needs an external coolant to help bring it to the temperature, in the existing CNC machine based on the width of the job picked; a resource is required to adjust the coolant nozzle. Since, this is curbing the productivity rate at times; the same is being automated via this project without shutting down the machine. The automated nozzle control developed using Microcontrollers can be used for many CNC machines which adds onto its usefulness. The Microcontroller algorithm intended to be developed allows the user to adjust the nozzle position based on the physical feature such as width of the job using a joy stick.**

***Index Terms*—Atmega2560 Microcontroller, LCD Display, Motor Driver, Servo Motor and Joystick.**

## I. INTRODUCTION

CNC Stands for “Computer Numerical Control”. CNC machines are electro-mechanical devices that manipulate machine shop tools using computer programming inputs. The CNC machine comprises of the mini computer or the microcomputer that acts as the controller unit of the machine, the program of instructions is fed directly into the computer via a small board similar to the traditional keyboard. In CNC machine the program is stored in the memory of the computer. The programmer can easily write the codes, and edit the programs as per the requirements. These programs can be used for different parts, and they don’t have to be repeated again and again.

Presently, the coolant nozzle system of the BFW CNC machine used there requires a manual intervention to set up the nozzles with an explicit shutdown of the system which is directly affecting the productivity cycle based on the physical feature of the job. In order to optimize, automate, efficient utilization of the resources with respect to both the, increase the productivity without having to shut down the machine. The project aims at providing a Joystick to the user through which the nozzle can be re-positioned based on the next job’s physical feature without having to shut down the machine.

## II. PROBLEM STATEMENT

In a typical machining operation in CNC turning or CNC milling, two-thirds of the heat is generated as a by-product of shearing off the work piece material. The other one-third is created by the friction of the chip sliding over the cutting tool. High temperature in the tool results in rapid tool wear, and high temperature in the work piece can change its metallurgical characteristics and hardness, create unwanted thermal expansion, or lead to unwanted chemical reactions such as oxidation. This is why the tool and work piece must be kept cool by using a coolant.

80 % of the heat generated is carried away by chips and we use coolant to take away the rest. Coolant also acts as a lubricant, reducing the friction between the tool and work piece that generates heat. The lubrication also prevents built-up-edge.

There are various kinds of coolants: oil, oil-water emulsion, aerosols (mists), and air or other gases. They may be made from petroleum, plant oils, water, compressed air and compressed Carbon Dioxide.

The most popular coolant is an emulsion of water and mineral oil. Water is a good conductor of heat but cannot be used directly as a coolant because it boils quickly, promotes rusting of machine parts, and is not a great lubricant. Mineral oil is a great lubricant, but is poor at heat dissipation. When you mix water and mineral oil with other ingredients you get an optimal coolant. This mixture is designed to inhibit rust, tolerate water hardness, resist thermal breakdown, and be environmentally safe.

These coolant are manually controlled by human interface, this process may lead harm to the operator and inaccuracy in result.

## III. OBJECTIVE

- The main objective of the project is to develop an automatic coolant nozzle control for CNC machines using Microcontrollers which avoids the manual intervention during a busy production work.
- We also aim to optimize, automate, efficient utilization of the resources with respect to both the, increase the productivity without having to shut down the machine.
- This paper implementing a security and safety system which can deploy in secured zone where only authentic and well experienced person can operate.

## IV. LITERATURE SURVEY

Following sections explores different references that discuss about several topics related to collective behaviour

Takeshi Takaki at Al: [1] A manipulator which enables noncontact control of the position and attitude of an object on a plane by controlling a fluid field is proposed. The manipulator comprises 2 boards with grid pattern arrangements of holes and a parallel link robot which is capable of translational motion with 2 degrees of freedom and rotational motion with 1 degree of freedom in a plane. Air jets are discharged from the grid of holes. The direction of the air jets from the holes can be controlled by changing the positional relationship of the 2 boards by means of the parallel link robot. This makes it possible to form an air flow with a unidirectional fluid field or a vortex-like fluid field. When an object is placed in the fluid field, translational motion and rotational motion of the object are possible. If the position and attitude of the object are photographed and calculated using high speed camera and feedback control is performed, the position and attitude of the object can be controlled. The structure of the manipulator and the principle of control of the fluid field are described, and the possibility of controlling the translational motion and rotational motion of an object is demonstrated experimentally.

Jinsong Zhang at Al: [2] Electronic packaging industry widely uses a dispensing technology to deliver adhesive materials on substrates through a dispensing system. The cured adhesives can encapsulate and connect chips and substrates to provide mechanical, physical and chemical protections. For the high density packaging, a jet dispensing is regarded as the next generation adhesive delivery technology due to its features of non-contact, high precision and high efficiency. We developed a jet dispensing system including a jetting dispenser, a 3-axis movement platform, a substrate carrier, a power module, motion control hardware and software, supplementary modules, etc. The jetting dispenser is the most part since it affects the accuracy and quality during the dispensing process. Before its structure design and prototype manufacturing some important physical parameters can be determined by the fluid dynamics analysis. In the jetting dispenser, a piston drives a needle to move downwards and push the fluid flowing in the chamber and dispensing out of the nozzle. A simplified physical model has been set up to promote discussing the dynamic properties of the fluid. The results of dynamics analysis reveals that there are a back flow and a jetting flow existing in the chamber and an unsteady flow existing in the nozzle. The flow rate and volume are the most key parameters for the dispenser design. They are dependent on the nozzle length and diameter, the chamber length and diameter, the dynamic viscosity, the coefficient of the on-way resistance, the needle speed and the initial pressure on adhesive.

## V. PROPOSED SYSTEM

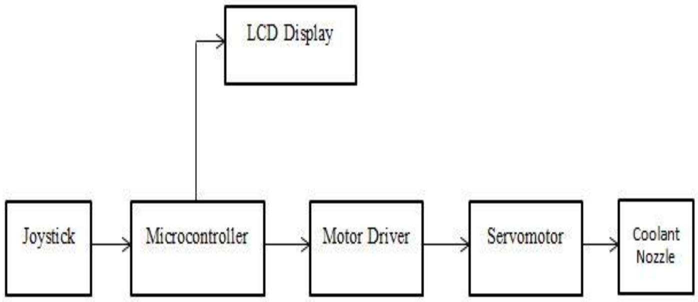


Figure 1.1

Figure 1.1 shows the complete block diagram of the module. The coolant nozzle plays a critical role in the proper supply of coolant. It must accurately direct an adequate flow with sufficient velocity directly at the Tool – Work piece interface and must resist vibration, swarf and inertial forces that could knock it out of alignment.

Most CNC machine tools have a coolant delivery system designed to handle a limited range of applications. In the real world, however, your setups can be extremely varied so you need lots of options for getting coolant to cutting edge. No single nozzle will work for all applications. That's why we have engineered a An automatic coolant nozzle control for CNC machines using Microcontrollers

An automatic coolant nozzle control for CNC machines using Microcontrollers is designed with servo motors which are controlled using joystick for better accuracy adjustment of water coolant nozzles on BFW CNC machine for different shapes and lengths.

## V.COMPONENTS

The main components required for the functioning of the above proposed solution are elucidated below.

### *A. MICROCONTROLLER*

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 . It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

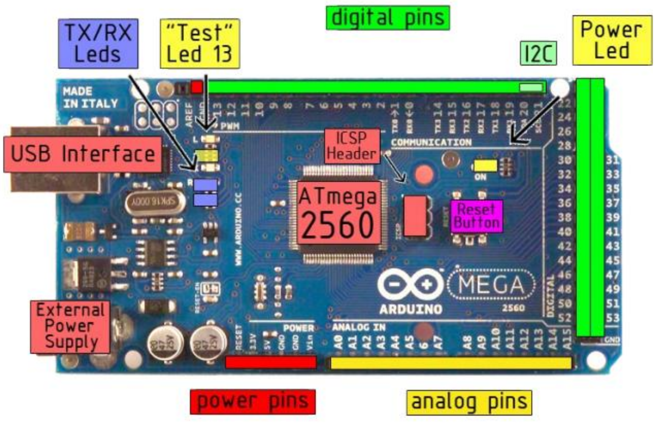


Figure 2: Microcontroller

***POWER SUPPLY***

The Arduino Mega2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

• **VIN:** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

• **5V:** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

• **3V3:** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

• **GND.** Ground pins.

**MEMORY:**

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the boot loader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

**INPUT and OUTPUT:**

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

• **Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .

• **External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2).** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a
change in value. See the attachInterrupt() function for details.

• **PWM: 0 to 13.** Provide 8-bit PWM output with the analogWrite() function.

• **SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also
broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.

• **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

• **I2C: 20 (SDA) and 21 (SCL).** Support IC (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I22C pin on the Duemilanove.The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference () function.

There are a couple of other pins on the board:

• **AREF.** Reference voltage for the analog inputs. Used with analogReference ().

• **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

COMMUNICATION:

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega's digital pins.

***B.SERVOMOTOR***

This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package. The MG996R is essentially an upgraded version of the famous MG995 servo, and features upgraded shock-proofing and a redesigned PCB and IC control system that make it much more accurate than its predecessor. The gearing and motor have also been upgraded to improve dead bandwith and centering. The unit comes complete with 30cm wire and 3 pin 'S' type female header connector that fits most receivers, including Futaba, JR, GWS, Cirrus, Blue Bird, Blue Arrow, Corona, Berg, Spektrum and Hitec.

This high-torque standard servo can rotate approximately 120 degrees (60 in each direction). You can use any servo code, hardware or library to control these servos, so it's great for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. The MG996R Metal Gear Servo also comes with a selection of arms and hardware to get you set up nice and fast!


Figure 3: MG996R SERVOMOTOR

SPECIFICATIONS:

- Weight: 55 g
- Dimension: 40.7 x 19.7 x 42.9 mm approx.
- Stall torque: 9.4 kgf·cm (4.8 V ), 11 kgf·cm (6 V)
- Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V)
- Operating voltage: 4.8 V a 7.2 V
- Running Current: 500 mA – 900 mA (6V)
- Dead band width: 5 µs
- Stable and shock proof double ball bearing design
- Temperature range: 0 ºC – 4.8 V a 7.2 V – 900 mA (6V) double ball bearing design 55 ºC.

*C. LCD DISPLAY*

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

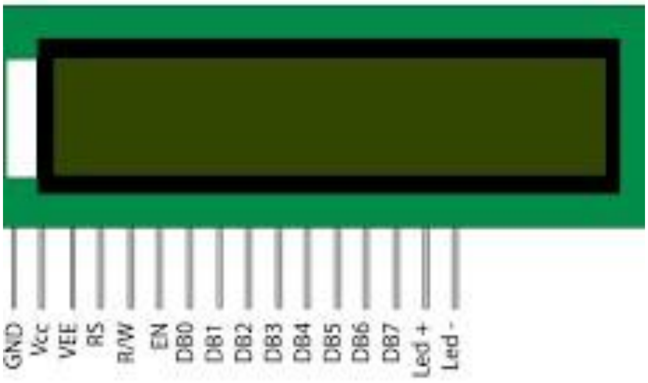


Figure 4: LCD DISPLAY

**LCD SPECIFICATIONS:**

- **Resolution** The resolution of an LCD is expressed by the number of columns and rows of pixels (e.g., 1024×768). Each pixel is usually composed 3 sub-pixels, a red, a green, and a blue one.
- **Spatial performance:** For a computer monitor or some other display that is being viewed from a very close distance, resolution is often expressed in terms of dot pitch or pixels per inch, which is consistent with the printing industry.
- **Temporal performance:** the temporal resolution of an LCD is how well it can display changing images, or the accuracy and the number of times per second the display draws the data it is being given.
- **Color performance**: There are multiple terms to describe different aspects of color performance of a display. Color gamut is the range of colors that can be displayed, and color depth, which is the fineness with which the color range is divided.
- **Brightness and contrast ratio:** Contrast ratio is the ratio of the brightness of a full-on pixel to a full-off pixel. Brightness is usually stated as the maximum light output of the LCD, which can vary greatly based on the transparency of the LCD and the brightness of the backlight.

*D.MOTORDRIVER*

The dual H-Bridge Motor Driver Shield, which based on H-Bridge driver chip L298N Motor Driver Integrated Circuit, is a useful Module for controlling of Robotics and Mechanics. It can drive two brushed DC motors or one 4-wire two-face stepper or servo motor. It is a high voltage, high current dual full-Bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC motors. Both motors can be driven simultaneously while set to a different speed and direction. All driver lines are diode protected from back EMF.

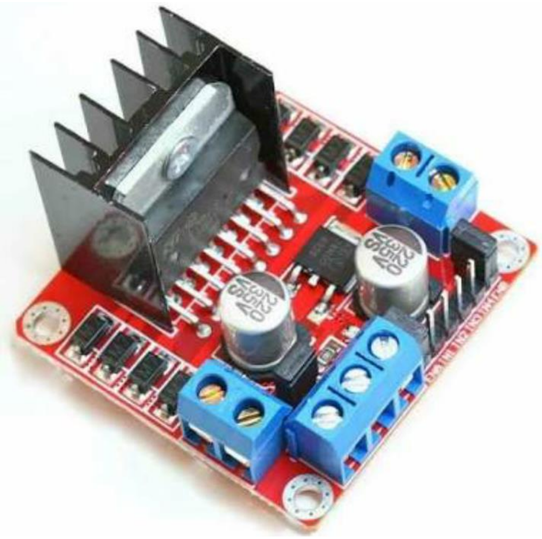

Figure 5:L298N Motordriver

*SPECIFICATION*

- Driver power supply: +5V~+46V
- Driver Io: 2A
- Logic power output Vss: +5~+7V (internal supply +5V)
- Logic current: 0~36mA
- Controlling level: Low -0.3V~1.5V, high: 2.3V~Vss
- Enable signal level: Low -0.3V~1.5V, high: 2.3V~Vss
- Max power: 25W (Temperature 75 cesus)
- Working temperature: -25C~+130C
- Dimension: 60mm*54mm
- Driver weight: ~48g
- Other extensions: current probe, controlling direction indicator, pull-up resistors switch, logic part power supply.

*E. JOYSTICK*

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. A joystick, also known as the control column, is the principal control device in the cockpit of many civilian and military aircraft, either as acenter stick or side-stick. It often has supplementary switches to control various aspects of the aircraft's flight. Joysticks are often used to control video games, and usually have one or more push-buttons whose state can also be read by the computer. A popular variation of the joystick used on modern video game consoles is the analog stick. Joysticks are also used for controlling machines such as cranes, trucks, underwater unmanned vehicles, wheelchairs, surveillance cameras, and zero turning radius lawn mowers. Miniature finger-operated joysticks have been adopted as input devices for smaller electronic equipment such as mobile phones.

The PS2 style joystick is a thumb operated device, that when put to creative use, offers a convenient way of getting operator input. Its fundamentally consists of two potentiometers and a push button switch. The two potentiometers indicate which direction the potentiometer is being pushed. The switch sends a low (or ground) when the joy stick knob is pressed.

Figure 6: Joystick Module PS2 Breakout Sensor

*SPECIFICATIONS*

- Directional movements are simply two potentiometers – one for each axis
- Compatible with Arduino interface
- Dimensions: 1.57 in x 1.02 in x 1.26 in (4.0 cm x 2.6 cm x 3.2 cm)
- 5 Pin
- Color: Black

*PIN CONFIGURATION*

1. GND: ground
2. +5V: 5V DC
3. VRx: voltage proportional to x position

*F. SOFTWARE DESCRIPTION*

The software used in our project is arduino IDE.


Figure 7: Arduino IDE Window

Arduino is an open-source electronics platform based on easy-to-use- hardware and software. The figure 4.1 shows the Arduino IDE window. Arduino boards are able to read inputs – light on a sensor, a finger on a button, or a Twitter message – and turn it into an output – activating a motor, turning on an LED. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software , too, is open-source. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced users and to get started with programming and robotics.It runs on Mac, Windows, and Linux.

Advantages of Arduino over other systems

- Inexpensive – Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and can be pre-assembled easily.
- Cross-platforms – an Arduino Software (IDE) runs on windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment.
- Open source and extensive software – an Arduino software is published as open source tools, available for extension by experienced programmers and the languages can be expanded through C++ libraries.
- Open source and extensible hardware – The plans of Arduino boards are published under a Creative Commons license, so experienced circuit designed can make their own version of the module, extending it and improving it . Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

*Power supply*

All the microcontroller based system requires maximum voltage of 5v DC. Some requires 12volt, in that systems 12v is regulated to 5v DC. So in our project we are using 12 volt supply to power up the system.

In most of our electronic products or projects we need a power supply for converting mains AC voltage to a regulated DC voltage.

*Electrical requirements.*

The power for an electromagnet lock is DC (Direct Current),around 5-6 W . The current is around 0.5 A when the voltage supply is 12VDC and .25A (varies between manufactures and if there are one or two coils in the block). It is also recommended to verify that the magnetic lock carriers the UL mark. Generally, the specification of the electromagnet lock is dual voltage of 12/24 VDC. If using a rectifier to convert AC power, a full wave bridge rectifier should be used.

*G.FLOW CHART OF PROPOSED WORK*

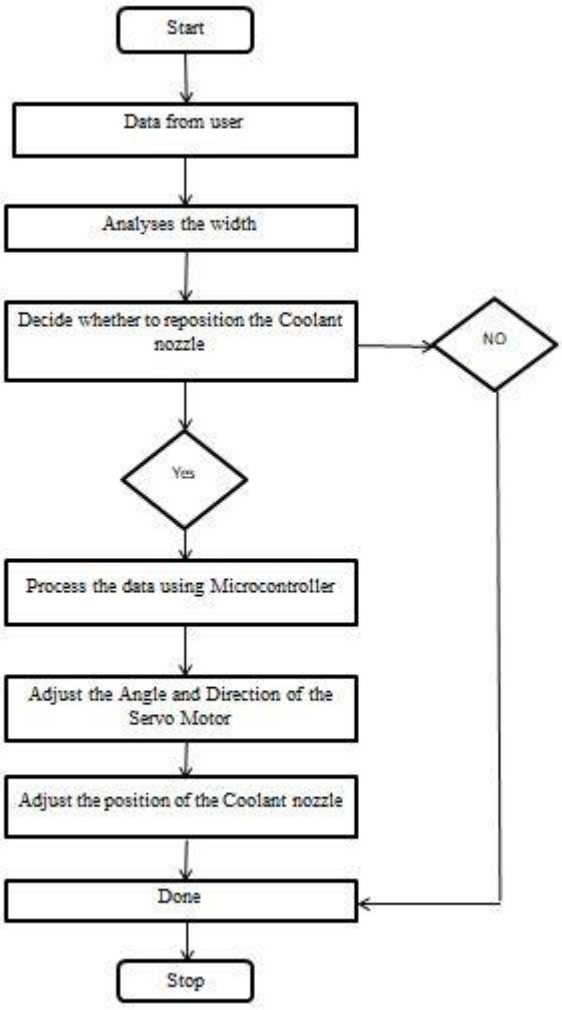


Figure 8: Flow Chart

*ADVANTAGES*

- The proposed system is cost effective
- It avoids the manual intervention during a busy production work.
- It can be used for many CNC machines which adds onto its usefulness.
- Increase the productivity without having to shut down the machine.

*LIMITATIONS*

- Replacing any Hardware Component, needs to shutdown the machine.

*APPLICATIONS*

- The system is more economical and effective method.
- The system can be placed on many CNC machines.
- The module can be deployed on the machine, which requires very high accurate positioning of coolant nozzle

### *H. RESULT*

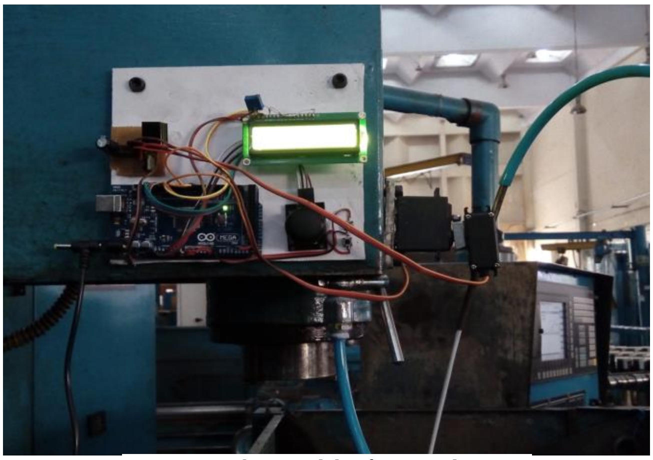

Figure 9: Working module of Proposed System.

This system is based on two main Components, Servomotor and Joystick. Servomotors are placed above the coolant nozzle, in which one servomotor drives the another motor. Joystick and LCD Display are placed externally on control panel of the CNC machine. Whenever the incharge person needs to reposition the coolant nozzle, he uses the externally placed joystick and adjust the direction and angle of servomotor. At the same time, details of angle adjusted and the position of the coolant nozzle is displayed on LCD.

## I. CONCLUSION

Automatic Coolant nozzle control in CNC machine is been successfully used in many industries, in which CNC machines are used for production work. The Various Production Work includes- manufacturing of different parts of heavy vehicles such as Trucks, JCB’s, underground mining equipments, earth moving equipments, railway equipments and high power diesel engines. It can be used on many machine to have effective, accurate and more précised control of the coolant nozzle with the flow of coolant to control the external temperature.

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