Development of Semi-Automatic Lathe by using Intelligent Soft Computing Technique

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Abstract: This paper discusses the enhancement of conventional lathe machine to semi-automated lathe machine by implementing a soft computing method. In the present scenario, lathe machine plays a vital role in the engineering division of manufacturing industry. While the manual lathe machines are economical, the accuracy and efficiency are not up to the mark. On the other hand, CNC machine provide the desired accuracy and efficiency, but requires a huge capital. In order to overcome this situation, a semi-automated approach towards the conventional lathe machine is developed by employing stepper motors to the horizontal and vertical drive, that can be controlled by Arduino UNO -microcontroller. Based on the input parameters of the lathe operation the arduino coding is been generated and transferred to the UNO board. Thus upgrading from manual to semi-automatic lathe machines can significantly increase the accuracy and efficiency while, at the same time, keeping a check on investment cost and consequently provide a much needed escalation to the manufacturing industry.

1. Introduction
Lathe is a machine tool used principally for shaping articles of metal by causing the work piece to be held and rotated by the chuck while a tool bit is advanced into the work causing the cutting action[1]. The basic lathe that was designed to cut cylindrical metal stock has been developed further to produce screw threads, tapered work, drilled holes, knurled surfaces, and crankshafts as shown in Figure 1. The typical lathe provides a variety of rotating speeds and a means to manually and automatically move the cutting tool into the work piece. Some of the operations done by a lathe machines are tabulated below in Table 1.

Figure 1. Conventional Lathe Machine [1]
Table 1. Operations done by Lathe Machine\[6\]

| Operation | Description |
|-----------|-------------|
| Turning   | To produce straight, conical, curved, or grooved work pieces. |
| Facing    | To produce a flat surface at the end of the part or for making face grooves. |
| Boring    | To enlarge a hole or cylindrical cavity made by a previous process or to produce circular internal grooves. |
| Drilling  | To produce a hole by fixing a drill in the tailstock |
| Threading | To produce external or internal threads |
| Knurling  | To produce a regularly shaped roughness on cylindrical surfaces |

2. Soft-Computing Technique used
Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor or a finger on a button, and turn it into an output - activating a motor, turning on an LED. The user can tell the board what to do by sending a set of instructions to the microcontroller \[4\]. To do so the user should use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. The Uno is a microcontroller board based on the ATmega328P \[3\].

2.1. Arduino UNO
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The Uno has a resettable poly-fuse that protects your computer's USB ports from shorts and overcurrent \[2\]. Arduino board is shown in the Figure 2.

![Figure 2. Arduino UNO\[4\]](image)

3. Input Parameters
The specifications of micro-controller(Arduino UNO) & the lathe machine is tabulated in Table 2 & Table 3.
**Table 2. Arduino UNO- specifications**\(^4\)

| Microcontroller-Specification |  |
|-------------------------------|---|
| Microcontroller               | ATmega328P |
| Operating Voltage             | 5V |
| Input Voltage                 | 7-12V |
| PWM Digital I/O Pins          | 6 |
| Analog Input Pins             | 6 |
| DC Current per I/O Pin        | 20 mA |
| DC Current for 3.3V Pin       | 50 mA |
| Flash Memory                  | 32 KB(ATmega328P) |
| SRAM                          | 2 KB(ATmega328P) |
| EEPROM                        | 1KB(ATmega328P) |

**Table 3. Lathe Machine-Parameters**\(^5\)

| Lathe Machine                      |  |
|------------------------------------|---|
| Swing over machine bed             | Min. 350mm |
| Swing over cross slide             | Min. 190mm |
| Distance between centers           | 750-800mm |
| Turning Length                     | 700-750mm |
| Width of bed                       | Mini.260mm |
| Normal Chuck diameter              | 160mm |
| Guide Length of carriage           | 350-365 |
| Cross-slide travel                 | 175-190 |
| Width of cross-slide               | 140mm |
| Cross Travel                       | += 10mm |

4. Experimental Details

4.1 Principle Of Arduino Lathe:

Embedded System - is one that has hardware with software embedded in it as one of its important components.

4.2 Construction Of Arduino Lathe

The essential electronics used in the construction of arduino lathe is tabulate in Table 4.

**Table 4. Essential electronic parts used in the construction of Arduino Lathe**

| Components    | Description                                                                 |
|---------------|-----------------------------------------------------------------------------|
| Motor         | Motors are employed in both vertical & horizontal drive (i.e) Depth of cut & Lead Screw Movement/Rotation. |
| Rectifiers    | Rectifiers are used to convert the AC into DC voltage.                     |
| Transformer   | Transformers are used to rise or lower the voltage for motors & arduino board. Relay acts as a switch, that is controlled by a small electromagnet which can be activated by a small signal. In other words, the relay is used to power on -high powered devices such as large motors with a signal from the Arduino. |
| Relay Board   | Diodes acts like a low value resistor and allows the current flow.         |
| Diode         | Microcontrollers are used to control the motor employed in feed & depth drive. |

4.3 Working- Algorithm of Arduino lathe

The design phase of arduino lathe is developed using Solid Works software as shown in Figure 3. The coding is generated and compiled using Arduino IDE software as shown in Figure 4. The step by step working procedure of arduino lathe is tabulated in the Table 5.
Table 5. Working Algorithm for Arduino Lathe

| Steps | Function |
|-------|----------|
| Step 1 | The “Arduino Software IDE” is initialized as shown in Figure 4. |
| Step 2 | Based on the input parameters, the calculations are done for the required machining process. |
| Step 3 | With these results, the Arduino coding are generated for required profile/operation with specified definition, void setup and void loop. |
| Step 4 | Now the coding is compiled. So that, it ensures the coding generated is error free. |
| Step 5 | These coding are transmitted to the Arduino board by means of USB cable or accessed by means of its IP address. |
| Step 6 | Mean while, the work piece is mounted on the chuck of arduino lathe as shown in Figure 3. |
| Step 7 | Now, the arduino reads the program and based on the coding generated it initiate the manufacturing process/operation. |
| Step 8 | After the process gets over, if necessary the arduino can be reset for the new process/operation. |

5. Formula used for Calculation:
The optimum cutting conditions (i.e., speeds, feed, and depths of cut) depend upon the tool & work material for the required surface finish and the dimensional accuracy. The optimum cutting conditions used to determine the required spindle speeds for the proposed dimensional information about the work pieces to be machined. From the equation (1), (2), … (7), the formula required for calculation is achieved. So that these results can be incorporated while generating coding for desired lathe operation.

5.1 Determination of Power Requirements:
The drive power required for the cutting motion depends upon the cutting speed and the cutting force. The power needed for the feed drive is also dependent upon the feed force and the feed rate. The cutting forces mainly depend upon the work material, the size of cut, tool geometry, and cutting speed and to extend the tool material. From the analysis of the forces in turning, it was found that the cutting forces in turning could be resolved into three components namely:
The tangential component: $F_t$ is in the direction of the cutting velocity vector.

$$F_t = R_1(F^x)(d^y)_{1} \text{ kgf}$$  (1)

The radial component: $F_r$ is in the direction of the radius of the job.

$$F_r = R_2(F^x)(d^y)_{2} \text{ kgf}$$  (2)

The axial component: $F_a$ is in the direction of the longitudinal feed

$$F_a = R_3(F^x)(d^y)_{3} \text{ kgf}$$  (3)

Therefore the rate of work needed in turning approximately equals to the product of tangential force component and the cutting velocity.

$$P = (F_t \times V_{\text{max}})/4500 \text{ hp}$$  (4)

$$P_{RC} = P / \eta_c \text{ hp}$$  (5)

$$P_{RF} = (Q \times F) / \eta_f$$  (6)

$$Q = kF_a + \beta (F_c + F_r + W_d)$$  (7)

Where, $\eta_c$ is the mechanical efficiency, $\beta$ is the coefficient of friction between the carriage and the guide ways, $k$ is a recommended factor, $W_d$ is the weight of the parts being traversed, $F_a$, $F_c$ and $F_r$ are the components of the cutting force in the feed, cutting and radial directions respectively.

6. Conclusion

Therefore, the design of Semi-automatic lathe is successfully developed by the Solid Works Software. Which has the communion of both hardware(Arduino UNO) & software(Arduino IDE) resulting in the development of semi-automated approach towards the conventional lathe machine. As automation newly developed Arduino lathe is done by implementing some new features to the standard lathe, therefore the setup cost is increased, but when compared to the fully automated/CNC machine the setup cost is much low. The accuracy of the job manufactured in semi-automated lathe is high relatively, so the repeatability and dimensional stability of the manufactured part is achieved. Since the production rate is high, the semi-automated lathe machines will be very useful in mass production.

7. References

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