

# Design and Development of Semi Automatic Wire Bending Machine

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**Abstract:-** The following is a synopsis of the design, construction, and testing of a semi-automatic wire bending machine that was specifically designed to improve production efficiency while reducing the cost of labor. The machine was specifically designed to include electromechanical parts as well as a simplified hydraulic system to improve the accuracy of the bending process compared to traditional manual processes.

The project was specifically designed to address the need to improve the accuracy of the material forming process by creating a semi-automatic bending machine. The following is a synopsis of the implementation of a microcontroller-based control system to improve the accuracy of the bending process, thus reducing the amount of waste compared to traditional manual processes.

## Keywords:-

Semi-automatic wire bending machine, Arduino Uno, stepper motor control, OLED display, embedded system, programmable bending, low-cost automation, microcontroller-based control, bending angle control, manufacturing automation.

## 1.INTRODUCTION:-

Wire bending is a fundamental metal forming operation commonly used by the manufacturing industry to produce precise components such as hooks, clips, rings, brackets, frames, springs, cages, stirrups, fasteners, and structural wire supports. Wire-bent components are critical in electrical panels, furniture manufacturing, automobile parts, agricultural equipment, building construction, material handling equipment, retail store display units, and household appliances. The wire bending process consists of plastic deformation of a metallic wire beyond the proportional limit to attain a desired shape and angle. The precision, precision, and consistency of the wire bending operation are critical factors that directly affect the dimensional accuracy, structural integrity, and reliability of the wire-bent components. Wire bending operations are typically performed manually by utilizing hand tools, bending fixtures, and mechanical jigs. Though the process is economical, it is highly sensitive to the manual skills and experience of the operator. Manual wire bending operations often result in deviations of bending angles, irregularity of the bent wire, and low production

rates. Moreover, the time-consuming wire bending operations often lead to operator fatigue, the resulting discomfort, and low productivity. In addition, the increasing rate of development in the areas of industrial automation, mechatronics, and embedded systems has resulted in the need for small-scale wire bending machines that are programmable and cost-effective while ensuring the required degree of accuracy, repeatability, and productivity. Though automatic wire bending machines based on the CNC process are available in the market, these systems are highly capital-intensive and not economically viable for small-scale industries, training institutions, and research laboratories. Therefore, the semi-automatic wire bending machine based on the stepper motor drive and the microcontroller-based embedded system can be the most suitable solution for the wire bending process while ensuring the required degree of performance, flexibility, and cost-effectiveness. The stepper motors can offer the required degree of angular positioning and speed control while ensuring the required degree of accuracy and repeatability in the wire bending process. The integration of Arduino Uno microcontroller also allows for programmable angle input, speed regulation, and real-time monitoring. The objective of the project is to design, develop, and fabricate a semi-automatic 3mm wire bending machine using advanced electromechanical devices and embedded system technology

The proposed system consists of:

- Stepper motor with gearbox to provide high torque and accurate angular rotation
- Arduino Uno microcontroller to provide logical and controlling capabilities
- SMPS power supply to ensure reliable and consistent electric power
- Buck converter to regulate voltage
- LCD display to facilitate visualization of parameters
- Keypad to facilitate angle input
- Push button to activate machine operation
- Potentiometer to regulate speed

- Rigid mechanical frame of 2 ft x 2 ft x 3 ft to ensure stability

The proposed system is expected to provide accurate bending angles, consistent product quality, minimal dependence on human effort, and improved productivity while keeping costs low and dimensions compact.

### 1.1 Literature Review:-

Wire bending is a significant metalworking operation used in various manufacturing industries to fabricate parts such as hooks, clips, brackets, springs, and frames from wire materials. Wire bending operations are traditionally performed using manual techniques and mechanical aids such as hand tools and mechanical jigs. Although manual wire bending techniques are inexpensive for performing operations in small production volumes, some of the disadvantages of using manual techniques include reduced precision and reproducibility, increased operator fatigue, and the requirement of skilled manpower. As a result, the use of manual techniques is not appropriate for automated industries.

Mechanical and motorized wire bending machines were invented to improve the efficiency of wire bending operations. Mechanical and motorized machines use electric motors and mechanical aids such as cam mechanisms, crank-slider mechanisms, and rack-and-pinion drives to facilitate wire bending operations. Although mechanical and motorized machines minimize manual effort and time required for wire bending operations, they do not permit programmability and only allow a limited number of bending angles to be used. The advanced CNC wire bending machines are highly accurate and provide facilities to perform multiple axis bending. The machines use servo motors, computer programming, and automated wire feeding systems. The CNC machines are highly expensive, require programming, and require highly skilled operators. Hence, CNC machines are not suitable for small workshops, training centers, and small-scale industries. The recent advancements in the field of embedded systems and the use of microcontrollers have helped design cost-effective automated machines. The use of microcontrollers like Arduino has the capability to accurately control the stepper motors with programmable bending angles. The use of human-machine interfaces like OLED displays has the potential to provide clear visualizations of parameters like bending angle, speed, and other machine parameters. The recent advancements have the potential to design cost-effective semi-automatic wire bending machines with increased accuracy.

## 2. TECHNICAL SPECIFICATIONS:-

### 2.1 Stepper Motor (NEMA 18)

Instead of rotating continuously like a regular motor, a stepper motor is an electric motor that moves in tiny, precise steps. It operates by transforming electrical pulses into mechanical

motion, with the motor moving one set step with each pulse. In many situations, this eliminates the need for a feedback system and enables precise control of position, speed, and direction. Stepper motors come in permanent magnet, variable reluctance, and hybrid (the most popular) varieties. They usually have a fixed step angle, such as 1.8° per step. They are widely used in applications like printers, CNC machines, robotics, and 3D printers due to their high precision and dependability.



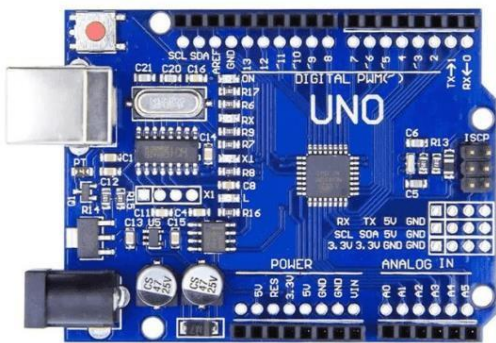
### 2.2 Stepper Motor Driver (DM 542)

A DM542 stepper motor driver is a digital device used for the control of the operation of a stepper motor, converting input signals into precise motor movement. It essentially acts as an interface between the controller, such as a microcontroller or a CNC controller, and the stepper motor. The DM542 stepper motor driver makes use of advanced technology in the form of digital control, allowing for smooth operation, minimal noise, and reduced heat compared with traditional drivers. It operates on an input voltage range of about 18-50V DC, with the capacity to deliver up to 4.2A current, allowing for the operation of 2-phase stepper motors, including NEMA17 and NEMA23 stepper motors. The DM542 drive allows for the operation of the stepper motor in the microstep mode, dividing the steps into smaller steps, allowing for increased accuracy in the operation of the motor, in addition to the availability of features such as over-voltage, over-current, and short-circuit protection.



### 2.3 Arduino Uno

Arduino uno is a popular electronic circuit board that is widely used for building electronic circuits and automation projects. It is based on an ATmega328P microcontroller and can be programmed using an Arduino IDE. This board is widely used for programming stepper motor drivers, such as the DM542, where it sends pulse and direction signals to control the movement of a stepper motor. This is because it is easy to use and can be purchased at a low cost. Arduino Uno is a popular board for building robotics, home automation, and CNC projects.



### 2.4 SMPS (24V,10A)

A Switched Mode Power Supply (SMPS) 24V 10A is an electronic device that converts AC mains voltage to a steady 24V DC voltage at a maximum current of 10A. This device uses high-frequency switching, which makes it more efficient, compact, and lightweight compared to other linear voltage regulators. This SMPS can be used to drive devices such as stepper motor drives (DM542), CNC drives, LED strips, etc. This device gives a constant voltage to drive such devices, which is necessary to drive them smoothly. In other words, it provides a constant voltage required to drive devices such as motors smoothly.



### 2.4.OLED DISPLAY

An OLED (Organic Light-Emitting Diode) display is a modern screen technology where each pixel creates its own light using organic materials. This setup removes the need for a separate backlight. As a result, OLED displays can produce true black levels since individual pixels can turn off completely. This feature leads to high contrast and vibrant colors. OLED screens are thinner, lighter, and more flexible than traditional LCD displays. This makes them perfect for smartphones, televisions, and wearable devices. They also provide wide viewing angles and quick response times, which enhance the overall visual experience. However, OLED displays can be more expensive and may encounter problems like burn-in and gradual degradation over time, particularly with blue pixels.



### 2.6. 4X4MATRIX MEMBRANE KEYPAD

A 4×4 matrix membrane keypad is a small input device with 16 keys that are arranged in 4 rows and 4 columns. When you press a key, it connects a certain row and column, which lets a microcontroller read the input with fewer pins. It is light, cheap, and often used in devices like keypads, calculators, and security systems.



### 3. PROPOSED WORK:-

The proposed work is focused on the design and development of a semi-automatic wire bending machine, which can be used to bend the wire up to a size of 3 mm by incorporating a control system.

The machine will have a mechanical structure, electronic circuit, and motor drive to carry out the bending operation accurately.

The machine will have a microcontroller, i.e., Arduino Uno, which will act as the main controller of the machine. The angle of bending will be entered through a keypad, and the entered angle will be converted into a signal by the microcontroller, which will then be sent to the stepper motor driver.

A high-torque stepper motor will be used to rotate the bending arm, which will then bend the wire around a fixed bending pin to the desired shape.

An OLED display will be used instead of a normal LCD display to display the information, i.e., bending angle, speed setting, etc.

OLED displays are used because these displays have better visibility, high contrast, low power consumption, etc., when compared to normal LCD displays. The bending speed is maintained through a potentiometer, which is used to smoothly regulate the speed according to various wire materials, such as mild steel, aluminum, and copper. The machine is powered through an SMPS power supply and voltage regulation using a buck converter.

The main objective of developing a semi-automatic wire bending machine is to ensure higher accuracy, repeatability, lower manpower, and lower manufacturing costs, which can be used in various small industries, fabrication units, and engineering laboratories.

### 4. OUTPUT:-

The designed semi-automatic wire bending machine was successfully tested to bend wires with a diameter of up to 3 mm. The system incorporates an Arduino Uno microcontroller to drive a stepper motor with gearbox to achieve rotational motion. The input for the bending angle is provided through a keypad, and the motor rotates the bending arm to achieve accurate bending. The system also incorporates an OLED display to display real-time data such as bending angle, speed level, and machine status. The experimental results confirm that the designed system can achieve accurate bending with minimal error. The system reduces manual work and is a cost-effective solution.

### 5. Conclusion:-

The semi-automatic wire bending machine was successfully designed and developed to bend wires up to 3 mm diameter with good accuracy and repeatability. The system uses an Arduino Uno microcontroller, stepper motor, and gearbox to achieve precise control of the bending angle. The OLED display provides clear visualization of parameters such as bending angle, speed, and system status, improving user interaction. The developed machine reduces manual effort, improves productivity, and ensures consistent bending results. Due to its compact design, low manufacturing cost, and simple operation, the system is suitable for small-scale industries, fabrication workshops, engineering laboratories, and training institutes.

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