

DESIGN AND FABRICATION OF MULTIFACETED AUTOMATION SYSTEM FOR BUCKET EXCAVATOR MANUFACTURING

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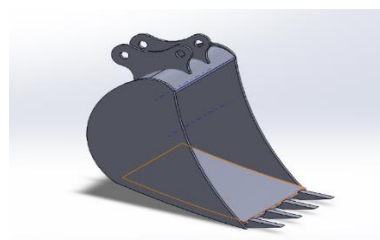
Abstract –

The project presents a comprehensive approach to automate bucket excavator manufacturing processes through the integration of CNC machining, robotic arm, roll bending technology and Arduino UNO based control unit innovatively designed in the solid works in 3D modeling animator. Each components play a vital role in Stream lining production, improving precision and reducing manual intervention, Automation required in many industries. The CNC system provides precise control over machining operation, ensuring accuracy and repeatability in the fabrication of components. The robotic arm is employed for material handling tasks, such as picking and placing work piece during the manufacturing process, thereby enhancing efficiency and reducing manual labor requirements. Furthermore, the roll bending mechanism is used to formation of curved components essential for bucket excavator structure. The integration of these machines facilitated by the Arduino UNO based control unit, which orchestrate the operation of individual components and ensure seamless coordination.

Key Words : CNC milling machine, Arduino UNO, Solid Works, Robotic Arm, Roll bending, Excavator Bucket

1. INTRODUCTION

In the ever-evolving landscape of manufacturing, efficiency and precision stand as the cornerstones of progress. Introducing an innovative paradigm in excavator bucket production: the integration of advanced technologies to streamline the design and fabrication process. This pioneering endeavour harnesses the capabilities of material containers, CNC milling machines, robotic arms with suction cups, roll bending machines, welding robotic arms, and specialized welding operation stands. Through this holistic approach, we propel excavator bucket manufacturing into a new era of automation and excellence.



Excavator bucket 3D model

WORKING PRINCIPLE

Here's a step-by-step explanation of the manufacturing process for an excavator bucket using the specified components:

Material Container: The material container, constructed from sheet metal itself, serves as the storage unit for the raw materials used in excavator bucket fabrication. With its body made of sheet metal, it seamlessly aligns with the manufacturing process. Equipped with a screw mechanism, it precisely delivers the sheet metal to the CNC milling machine. This controlled delivery ensures

an uninterrupted supply of material for the fabrication process.

CNC Milling Machine: Upon receiving the sheet metal from the material container, the CNC milling machine takes over the fabrication process. Using computer-aided design (CAD) data, it precisely mills the various components of the excavator bucket. The CNC milling machine's cutting tools carve out intricate shapes and features from the sheet metal, transforming it into the required parts with high precision and accuracy.

Robotic Arm: Once the parts are milled, a robotic arm with a suction cup is utilized to pick and place them. The suction cup securely grips the milled parts, transferring them to subsequent stages of the manufacturing process. In addition to transporting the parts to the roll bending machine and welding area, the robotic arm can also handle the movement of sheet metal within the material container.

Roll Bending Machine: The milled parts, including the back sheet of the excavator bucket, are transferred to the roll bending machine by the robotic arm. This machine, with its screw mechanism, bends the sheet metal into the required curvature. The sheet metal container's body made of sheet metal is a testament to the versatility of this material in fabrication processes.

Welding Robotic Arm: After the back sheet and other components are formed, they are assembled together using a welding robotic arm. This arm precisely welds the milled parts, ensuring strong and durable joints. The welding process is critical for the structural integrity of the excavator bucket, and the robotic arm's accuracy guarantees consistent weld quality.

Stand: Throughout the welding operation, a stand supports and holds the milled parts in place. It provides a stable platform for the welding robotic arm to work on, ensuring accurate positioning and alignment of the components during welding. The stand's construction

may also incorporate sheet metal, further highlighting its role in the manufacturing process.

TYPES OF MACHINERY

TYPES OF CNC

Milling CNC Machine: This machine is used for shaping with multi-point tools. It's used to make metal parts with high precision and accuracy. It has a movable bed and a spindle that moves up and down.

CNC Lathe Machines: These machines are used to make cylindrical parts, such as gears, shafts, and pistons. They rotate the work piece while the cutting tools remain stationary.

CNC Laser Cutting Machine: This machine uses a laser to cut materials, and it's commonly used in industrial manufacturing applications.

CNC Plasma Cutting Machine: This machine cuts through electrically conductive materials by utilizing an accelerated jet of hot plasma.

Drilling CNC Machine: This machine is used for drilling holes in various materials.

TYPES OF ROBOTIC ARM

Robotic arms are a significant part of the robotic machinery industry. They are programmable and are connected via joints or axes to allow rotational or linear movement. Here are some types of robotic arms:

Articulated Robots: These are the most common type of industrial robotic arms, characterized by multiple rotary joints resembling human arms. Articulated robots offer high flexibility and dexterity, making them suitable for a wide range of applications, including welding, material handling, assembly, and painting.

SCARA Robots (Selective Compliance Assembly Robot Arm): SCARA robots feature a rigid, vertical arm and a flexible horizontal arm, allowing them to move in a two-dimensional plane. They are well-suited for tasks that require fast and precise horizontal movement, such as assembly, pick-and-place operations, and packaging.

Delta Robots: Also known as parallel robots, delta robots feature three or more arms connected to a common base and end effector. These robots excel in high-speed pick-and-place applications, such as packaging, sorting, and assembly, due to their fast and precise movements.

Cartesian Robots (Gantry Robots): Cartesian robots utilize linear motion along three orthogonal axes (X, Y, Z) to maneuver the end effectors. They are commonly used in applications requiring heavy payloads and precise positioning, such as CNC machining, 3D printing, and material handling in large-scale manufacturing.

Cylindrical Robots: Cylindrical robots consist of a single rotary joint and a telescopic arm, allowing them to move in a cylindrical workspace. They are well-suited for applications requiring extended reach and rotation around a central axis, such as arc welding, machine tending, and palletizing.

Polar Robots: Polar robots feature a rotating base, a vertical arm, and a spherical wrist, allowing them to move in a polar coordinate system. These robots are suitable for applications requiring precise rotational movements, such as painting, polishing, and inspection in automotive and aerospace industries.

Collaborative Robots (Cobots): Collaborative robots are designed to work safely alongside humans without the need for protective barriers. They feature built-in sensors and safety mechanisms to detect and avoid collisions, making them suitable for tasks requiring close interaction with human operators, such as assembly, inspection, and packaging.

TYPES OF ROLL BENDING MACHINES

Roll bending machines, also known as plate bending machines or plate rolls, are used to bend sheet metal and

plates into various shapes and curves. They come in different types, each suited for specific bending applications. Here are some common types of roll bending machines:

Roll Bending Machine: Pyramid or Initial Pinch Type: This type of machine has three rolls, with the top roll being adjustable in height. The two bottom rolls are fixed in position. The sheet metal is passed through the machine and bent as it comes into contact with the top roll and the two bottom rolls. This design provides precise and accurate bending, especially for thicker materials.

4-Roll Bending Machine: Double-Pinch Type: A 4-roll bending machine has two bottom rolls and two top rolls, all of which are independently driven and adjustable. The sheet metal is fed between the bottom rolls, and the top rolls apply pressure to bend the material. This design offers greater bending flexibility and control, as both the top and bottom rolls can be adjusted to achieve various bending radii and shapes.

Angle Roll Bending Machine: Profile Bending Machine: This type of roll bending machine is specifically designed to bend profiles and sections, such as angles, bars, and beams, into curved shapes. It typically has three rolls, with two horizontal rolls and one vertical roll. The profile is positioned between the rolls and bent as they rotate. Profile bending machines are commonly used in industries such as construction, metalworking, and automotive.

Pyramid Roll Bending Machine: Ring Roll Bending Machine: This type of roll bending machine is specialized for bending cylindrical or conical shapes, such as rings and pipes. It consists of three or four rolls arranged in a pyramid configuration. The sheet metal or pipe is placed between the top roll and the two or three bottom rolls, and the bending process is achieved by adjusting the position of the rolls relative to each other.

Variable Geometry Roll Bending Machine: Variable Geometry Roll Benders offer the capability to adjust the geometry of the rolls, allowing for the bending of complex shapes and profiles with varying radii and curvatures. These machines are highly versatile and suitable for applications requiring precise and intricate bending operations.

COMPONENTS

MATERIAL CONTAINER

a) CONTAINER BODY

1. Sheet metal,
2. Rivets,
3. Nuts and bolts.

B) SCREW MECHANISM

1. 12V 500 RPM gear motor,
2. 200mm screw rod.

B) SCREW MECHANISM

1. 12V 500 RPM gear motor



1 12V, 500 RPM gear motor

Using a 12V, 500 RPM gear motor for a material container with a screw mechanism indicates a specific choice tailored to your application's requirements. The motor operates on a 12-volt DC power supply, which is common for many small to medium-sized electric motors. This voltage level is suitable for powering the motor efficiently while still providing enough torque for the intended application. As the gear motor rotates, it drives the screw mechanism, causing it to move the material along its length. The screw mechanism may have a helical design, which helps in pushing or pulling the material efficiently.

200mm Screw Rod

A 5mm diameter screw rod with a length of 200mm can be used in various mechanical applications, including linear motion systems, positioning mechanisms, and actuator assemblies

CNC MILLING MACHINE

1. FRAME

- a) Sheet metal, (all frame parts made by sheet metal)

- b) screws,

2. SPINDLE

- a) 775 dc motor,
- b) drill chuck,

- c) cutting tool,

3. ELECTRICAL COMPONENTS

- a) Arduino uno,
- b) A4988 stepper motor driver,
- c) stepper motor,
- d) limit switch,

4. MECHANICAL COMPONENTS

- a) pillow block bearing,
- b) pillow block
- c) lead screw,
- d) smooth rods.

5. SOFTWARE

- a) IDE
- b) SolidCam
- c) UGS

SPINDLE

775 DC MOTOR



775 DC MOTOR

Using a 775 motor in a CNC (Computer Numerical Control) machine can offer several advantages, particularly in applications where moderate to high torque and speed are required. 775 motors are known for

their high-power output and torque capabilities. They can provide sufficient torque to drive the axes of a CNC machine, such as the X, Y, and Z axes, as well as the spindle or cutting tool. 775 motors typically have variable speed control capabilities, allowing for precise adjustment of the motor speed to accommodate different machining operations and materials. This feature is essential for achieving optimal cutting speeds and feeds in CNC machining. 775 motors are widely available and compatible with various motor controllers and driver circuits commonly used in CNC machines. They can be easily integrated into existing CNC systems or DIY projects without significant modifications.

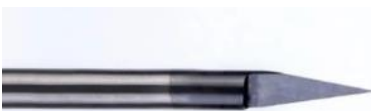
b) drill chuck



Drill chuck

A 3mm drill chuck is a tool holder designed to securely hold drill bits with a shank diameter of 3mm. It is commonly used in hand drills, power drills, drill presses, and other drilling machines to accurately and securely grip the drill bit during drilling operations.

c) cutting tool

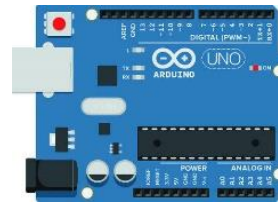


3mm shank V-bit

A 3mm shank V-bit with a 20-degree angle is a specialized cutting tool commonly used in CNC (Computer Numerical Control) routing and engraving machines. It features a V-shaped cutting edge with a 20-degree angle, making it ideal for creating precise and fine-detail cuts, V-grooves, and decorative engravings on various materials.

3. ELECTRICAL COMPONENTS

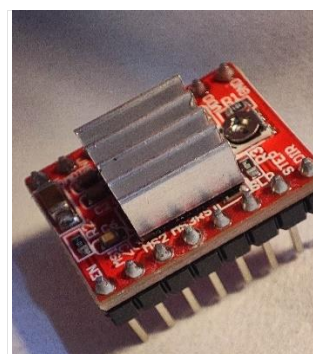
a) Arduino uno



Arduino uno

The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller chip. It is one of the most popular and widely used boards in the Arduino family due to its simplicity, versatility, and affordability. The Arduino Uno is powered by the ATmega328P microcontroller, which features 32KB of flash memory for storing code, 2KB of SRAM for variables, and 1KB of EEPROM for non-volatile data storage. The ATmega328P operates at a clock speed of 16 MHz, providing sufficient processing power for a wide range of projects and applications. The Arduino Uno has a total of 14 digital input/output pins, of which 6 can be used as PWM (Pulse Width Modulation) outputs. Additionally, it has 6 Analog input pins, allowing it to read Analog signals from sensors and other devices. The board can be powered via USB connection, a DC power jack, or an external power supply (7-12V DC). It also features a built-in voltage regulator, which regulates the input voltage to a stable 5V for powering the board and connected components. The Arduino Uno includes a USB interface, which allows it to be easily connected to a computer for programming and serial communication. It uses the standard USB Type-B connector.

b) A4988 stepper motor driver



A4988 Stepper motor driver

The A4988 Stepper Motor Driver is a popular and widely used integrated circuit (IC) designed for driving bipolar stepper motors in various applications, including CNC machines, 3D printers, robotics, and more. The A4988 driver is specifically designed to control bipolar stepper motors, which are commonly used in precision motion control applications due to their ability to provide precise positioning and control. The A4988 driver supports microstepping, a technique that allows for smoother motion and finer resolution by dividing each full step of the motor into smaller micro steps. Microstepping helps reduce vibrations, noise, and resonance in stepper motor systems, resulting in improved performance and accuracy. The driver includes a built-in adjustable current limit that allows users to set the maximum current delivered to the stepper motor coils. This feature helps optimize motor performance while preventing overheating and protecting the motor from damage due to excessive current. The A4988 driver receives step and direction signals from a microcontroller or CNC controller, such as an Arduino board. By toggling these signals, the driver accurately controls the rotation direction and step size of the stepper motor. The A4988 driver features a built-in translator that converts digital step and direction signals into the appropriate current levels for driving the stepper motor coils. This integrated translator simplifies the control interface and reduces the external circuitry required for stepper motor control. The A4988 driver includes various protection features, such as thermal shutdown and overcurrent protection, to safeguard the driver and motor against potential damage from excessive temperatures or currents. The A4988 driver is available in a compact and easy-to-use package, typically in the form of a surface-mount or through-hole IC. Its small form factor makes it suitable for integration into space-constrained applications and DIY projects.

c) STEPPER MOTOR



STEPPER MOTOR

The NEMA 17 stepper motor is one of the most commonly used stepper motors in DIY projects, robotics, and 3D printers. It derives its name from the standards set by the National Electrical Manufacturers Association (NEMA) for stepper motors. The NEMA 17 designation indicates the mounting face dimensions of the motor, which is 1.7 inches by 1.7 inches (43.18 mm x 43.18 mm). This standardized size allows for easy integration into various mechanical systems. The typical step angle for NEMA 17 motors is 1.8 degrees per step. This means that the motor rotates 1.8 degrees with each step, resulting in a total of 200 steps for a complete 360-degree rotation. NEMA 17 motors are available in various torque ratings, typically ranging from a few N-cm to tens of N-cm. Holding torque refers to the amount of torque the motor can exert to hold its position when energized but stationary. These motors are available in different voltage and current ratings, depending on the specific application requirements. They are often operated using stepper motor driver modules, which regulate the voltage and current supplied to the motor coils. NEMA 17 stepper motors commonly come in a bipolar configuration, which means they have two coils that are energized in alternating patterns to generate rotational motion. This configuration offers precise control over the motor's movement. Stepper motors like the NEMA 17 provide precise position control, making them suitable for applications requiring accurate positioning, such as 3D printing, CNC machining, and robotic systems. NEMA

17 motors are compatible with various microcontrollers, stepper motor drivers, and motion control systems. They can be easily interfaced with popular development platforms like Arduino and Raspberry Pi. The NEMA 17 stepper motor is widely favored for its reliability, versatility, and ease of use, making it a popular choice for a wide range of motion control applications.

d) LIMIT SWITCH



Limit switch

Limit switches are placed at the end of each axis's travel range to detect when the machine reaches its maximum travel limits. When the machine approaches the end of its travel range, the limit switch is triggered, signalling the control system to stop the axis motion, preventing overtravel and potential damage to the machine or workpiece.

MECHANICAL COMPONENTS

a) PILLOW BLOCK BEARING



pillow block bearing

Pillow block bearings are commonly used in CNC (Computer Numerical Control) machines to support rotating shafts or lead screws. These bearings provide support and smooth motion for the moving components of the CNC machine, such as the linear motion systems, lead screws, and drive shafts.

b) PILLOW BLOCK



Pillow block

The pillow block housing is a solid block with a flat base and mounting holes for easy attachment to machine frames or structures. It houses the bearing insert and provides support and alignment for the smooth rod.

LEAD SCREW



LEAD SCREW

Lead screws are threaded rods with a helical groove or thread wrapped around them. When a rotational force is applied to the lead screw, it translates this rotary motion into linear motion along its length. This linear motion is used to move various components of the CNC machine, such as the cutting tool, workpiece, or gantry, along the X, Y, and Z axes.

SMOOTH RODS

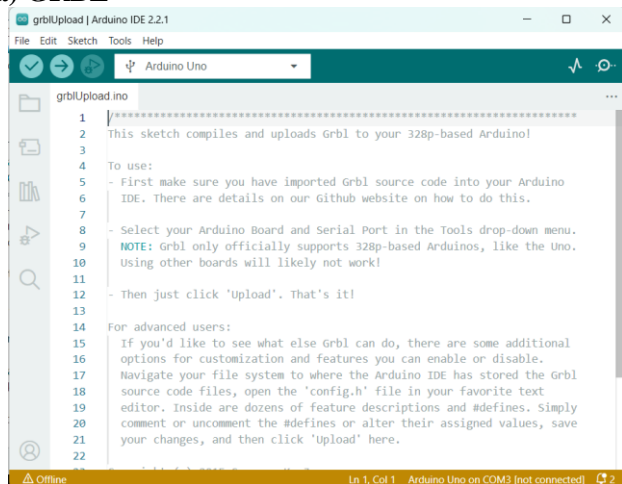


SMOOTH RODS

Smooth rods are precisely ground cylindrical rods made of hardened steel or other materials with a smooth and polished surface finish. They serve as guide rails for linear motion systems, providing a smooth and rigid surface for linear bearings or bushings to glide along.

5. SOFTWARE

a) GRBL



GRBL code upload

To download and upload GRBL (an open-source firmware used to control CNC machines) onto an Arduino Uno, we'll need the Arduino IDE and the GRBL source code. Here's a step-by-step guide:

Downloading GRBL:

Go to the GRBL GitHub repository: <https://github.com/grbl/grbl>

Click on the green "Code" button and select "Download ZIP" to download the GRBL source code to your computer.

Uploading GRBL onto Arduino Uno:

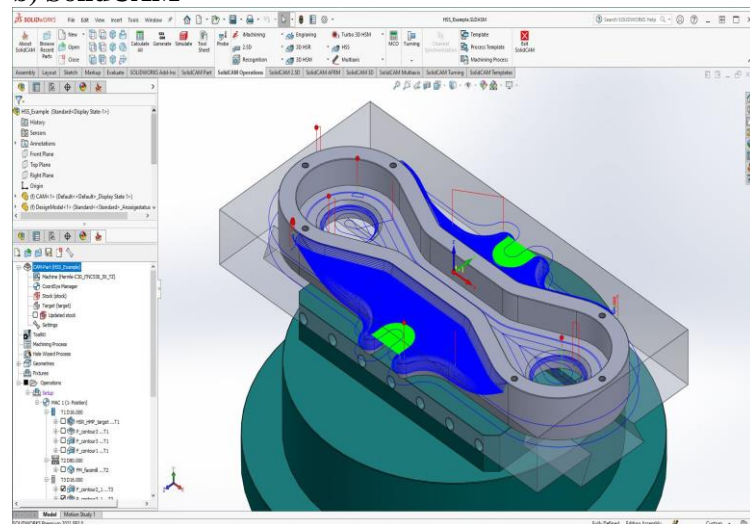
Extract the downloaded ZIP file containing the GRBL 1. source code to a folder on the computer. Open the Arduino IDE on computer. Connect Arduino Uno to the computer using a USB cable. In the Arduino IDE, go to "File" > "Open" and navigate to the folder where extracted the GRBL source code. Open the "grbl" folder and select the "grbl.ino" file. Once the GRBL code is open in the Arduino IDE, make sure to select the correct board and port. Go to "Tools" > "Board" and select "Arduino Uno." Then, go to "Tools" > "Port" and select the port to which your Arduino Uno is connected. Before uploading GRBL, you may need to modify some settings in the "config.h" file according to your CNC machine's specifications. Open the "config.h" file located in the "grbl" folder and adjust the settings as needed. After making any necessary

modifications, click the "Upload" button (the right-facing arrow icon) in the Arduino IDE to compile and upload the GRBL firmware to your Arduino Uno. Once the upload is complete, GRBL is installed on your Arduino Uno, and your Arduino Uno is ready to control your CNC machine.

Using GRBL:

After uploading GRBL to the Arduino Uno, we can communicate with it using a G-code sender software like Universal Gcode Sender (UGS) or CNC.js. Connect CNC machine to the computer, configure the communication settings in the G-code sender software, and start sending G-code commands to control your CNC machine.

b) SolidCAM



SolidCAMUSER INTERFACE

SolidCAM is indeed a robust CAM (Computer-Aided Manufacturing) software integrated directly into SolidWorks, which means it operates within the SolidWorks environment. It allows you to create G-code files directly from your SolidWorks models, streamlining the process of CNC machining.

Here's an overview of using SolidCAM to generate G-code files:

Integration with SolidWorks:

SolidCAM seamlessly integrates into SolidWorks, providing CAM functionality directly within the CAD environment. This integration allows for efficient transfer of CAD data to CAM operations without the need for exporting/importing files.

CAM Features:

SolidCAM offers a wide range of CAM features and machining strategies for milling, turning, and mill-turn operations. It supports 2.5D, 3D, and 5-axis milling, as well as multi-tasking machining with mill-turn capabilities.

Toolpath Generation:

SolidCAM generates toolpaths automatically based on your part geometry and machining requirements. It provides a variety of toolpath strategies for roughing, finishing, drilling, pocketing, profiling, and more.

Simulation and Verification:

Before generating G-code, SolidCAM allows you to simulate and verify your machining operations to ensure they are error-free and meet your expectations. The integrated simulation environment provides realistic visualization of toolpaths, material removal, and machine movements.

Post-Processing:

Once you're satisfied with the toolpaths and simulation results, SolidCAM generates G-code for your CNC machine. It supports customization of post-processors to generate G-code tailored to your specific machine's controller.

Optimization and Efficiency:

SolidCAM offers optimization features to improve machining efficiency, such as toolpath optimization, toolpath editing, and stock management. It includes advanced features for collision detection, toolpath smoothing, and adaptive machining to maximize productivity.

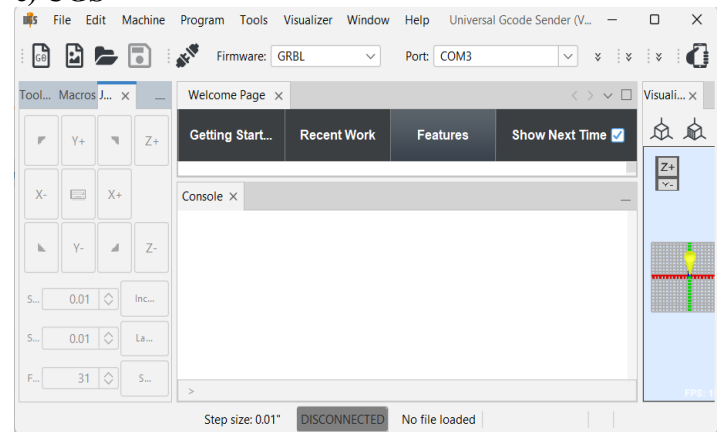
Documentation and Support:

SolidCAM provides comprehensive documentation, tutorials, and support resources to help users learn and utilize its features effectively. Training courses and certifications are available for users who want to deepen their understanding of the software.

Overall, SolidCAM is a powerful CAM solution that

leverages the capabilities of SolidWorks for seamless CAD/CAM integration. It enables users to generate high-quality G-code files for CNC machining with efficiency and precision.

c) UGS



Universal G-Code Sender user interface

Universal Gcode Sender (UGS) is a software application used to control CNC machines, including milling machines, routers, and 3D printers. It allows users to send G-code commands to the machine, which are then executed to perform various machining operations. Here's an overview of Universal Gcode Sender:

Features:

Cross-Platform Compatibility:

UGS is designed to work on multiple operating systems, including Windows, macOS, and Linux, making it accessible to a wide range of users.

G-code Visualization:

The software provides a graphical representation of the G-code program, allowing users to visualize the toolpath and verify machining operations before execution.

Real-Time Machine Control:

UGS enables users to control the CNC machine in real-time, including manual control of axis movements, spindle speed, and feed rate adjustments.

File Management:

Users can load G-code files directly into UGS for

execution, as well as manage and organize files for machining projects.

Macro Support:

The software supports the use of macros, allowing users to create custom commands or automate repetitive tasks.

Connection Options:

UGS supports various connection methods to communicate with the CNC machine, including USB, serial, and network connections.

Customization and Plugins:

Users can customize the software interface and functionality to suit their specific needs, as well as extend its capabilities through plugins.

Workflow

Setup:

Users connect their CNC machine to the computer running UGS using the appropriate connection method (USB, serial, etc.).

They configure the software settings to match their machine's specifications, including selecting the correct serial port and baud rate.

Loading G-code:

Users load the G-code file corresponding to their machining project into UGS.

They can preview the toolpath and make any necessary adjustments to the program parameters.

Execution:

Once the setup is complete, users can execute the G-code program using UGS.

The software sends the commands to the CNC machine, which performs the machining operations according to the specified instructions.

Monitoring and Control:

During execution, users can monitor the progress of the machining operation in real-time through the software interface.

They can pause, stop, or resume the program as needed, as well as adjust parameters such as feed rate and spindle

speed.

Overall, Universal Gcode Sender provides a user-friendly interface for controlling CNC machines and executing G-code programs, making it a valuable tool for hobbyists, makers, and professionals alike.

Robotic arm

- a) frame,
- b) servo motor,
- c) Arduino uno,
- d) bearing,

1. suction cup robotic arm.

- e) suction cup,
 - f) 12V vacuum pump,
 - g) pipe,
- #### 2. welding robotic arm
- h) 3D pen.

a) FRAME

sheet metal: Using sheet metal to construct the frame of a robotic arm offers several advantages, including flexibility in design, ease of fabrication, and structural integrity. Here's how sheet metal can be utilized effectively in building the frame of a robotic arm.

2.LITERATURE REVIEW

1.Dr. K. Srinivas Dr. D.V. Siva Reddy, et al. (2023) [1]:

DESIGNING AND ANALYSIS OF EXCAVATOR BUCKETA This paper delves into the design and analysis of the **excavator bucket**, a vital component in mining, using SolidWorks and ANSYS Workbench. The process involves 3D modeling, structural examination, and finite element analysis (FEA) to evaluate its performance under different load conditions. The insights gained are used to improve the bucket's design, ensuring its safety and reliability.

2.Yi gang Jin gets al. (2023) [2]:

DESIGN AND DEVELOPMENT OF HIGH PRECISION FOUR ROLL CNC ROLL BENDING

MACHINE AND AUTOMATIC CONTROL MODEL In investigation of the aerospace and automobile industries' increasing demand for bent components revealed the limitations of traditional hydraulic cylinders. To address this, hydraulic cylinders were replaced with servo electric ones, and the structure of four-roll bending machines was redesigned. This improved control precision and response times. An automatic control model was also created using actual profile curvature and feed values, enhancing the machine's universality and precision.³

3.J. Sai Dilip,K. Srinivas Rao et al. (2022) [3]:

DESIGN AND FABRICATION OF ARDUINO BASED ROBOTIC ARM,the report presents a robotic arm designed to increase efficiency and simplify tasks. The arm, mimicking human movements, is constructed with beams and hinges, and uses accelerometers for data collection. It operates on the Atmega32 and Atmega640 platform with Arduino UNO or MEGA and a PC. The arm can be operated manually or remotely, and is intended for handling hazardous materials, moving heavy items, and automating industrial tasks.

4.Hussein Mohammed Ali, Yasir Hashim et.al (2022) [4]:

DESIGN AND IMPLEMENTATION OF ARDUINO BASED ROBOTIC ARM The study discusses the creation of a six-degree freedom robotic arm controlled by an Arduino platform and a mobile application. The arm, consisting of five rotary joints and an end effector, is moved by servomotors. Each part was designed using SolidWorks and 3D printed. The Arduino is programmed to rotate each servo motor corresponding to sliders in the mobile application, enabling remote operation.

5.Sharath Surati, Shaunak Hedro et.al (2022) [5]:

PICK AND PLACE ROBOTIC ARM: A REVIEW PAPER This review emphasizes the use of robotic arms in industries to enhance efficiency, productivity, and precision while reducing human errors. Robotic arms can operate under harsh conditions, making them advantageous over human labor. They fall under Flexible Automation, allowing for easy updates and modifications. The study of various research papers has provided insights into the different controllers and methodologies used in manipulator design, aiding in the design of a robotic arm.

6.Abd Rahman Z,Mohamed S.B et al. (2021) [6]:

DESIGN AND FABRICATION OF A PC-BASED 3 AXIS CNC MILLING MACHINEThe paper discusses a cost-effective, small-scale 3-axis CNC milling machine. Assembled with aluminum for rigidity and using off-the-shelf hardware to cut costs, it's controlled by Mach4 software. While not for mass production or precision machining, it provides efficiency and flexibility, serving as an alternative to costly commercial CNC machines.

7.Vakada Lokesh Reddy, Kalluri Bhavani Shankar et.al (2021) [7]:

DESIGN & CNC MACHINING In investigation of CNC is essential for manufacturing, offering benefits like efficiency, accuracy, and fabrication. The project aims to manufacture a design profile using CNC, overcoming drawbacks like complicated shapes, lack of skilled labor, and wastage. After a 3-month training on CNC programming, a profile was planned for a B. TECH final year project. The profile, difficult to achieve by conventional methods, was designed using aluminum. After programming and simulation, the profile was manufactured using CNC, resulting in a smooth finish, high accuracy, increased productivity, and cost-effectiveness.

8.Akshay R Sonawane, Arun Bhiva Rane et.al (2019) [8]:

DEVELOPMENT OF A3-AXIS CNC MILLING MACHINE WITH AN OPEN-SOURCE CONTROLLER This paper discusses the use of Arduino Uno with a GRBL shield for CNC control. A file (.jpeg, .png, or .pdf) is imported into Aspire software, converted into a .txt or .prt file, and then modeled and manufactured. The G-code file, generated post-processing, is saved with a .txt extension. This file is then visualized in Universal G-code sender software, coupled with the GRBL shield and Arduino board, making the CNC machine user-friendly.

9.Patrick Ejebeheare Amiolemhen, Joseph Konas Abiegbe et.al (2019) [9]:

DESIGN AND FABRICATION OF A THREE - ROLLS PLATE BENDING MACHINE This paper presents the design and fabrication of a cost-effective, motorized 3-rolls plate bending machine capable of bending up to 6mm thick mild steel plates. The machine, composed of components like rolls shaft diameters, chain drive, spur gears drive, and a framework, was built using various machining processes.

10.Prafull S. Thakare, Sandip M. Salodkar et.al (2019) [10]:

EXPERIMENTAL INVESTIGATION OF THREE-ROLLER BENDING OPERATION FOR MULTI-PASS CYLINDRICAL FORMING OF PLATES This paper proposes a methodology for accurately predicting the number of passes required for cylindrical bending on a three-roller bending machine. The method combines dimensional analysis and modern design of experimentation techniques, considering geometrical, operational, and material parameters. The model's results, validated against experimental data, show an

average RMSE of less than 10%, indicating the effectiveness of the proposed methodology.

11.Yagna Jadeja, Bhavesh Pandya et.al (2019) [11]:

DESIGN AND DEVELOPMENT OF 5-DOF ROBOTIC ARM MANIPULATORS This paper presents a robotic arm controlled by a Cortex ARM M3 LPC1768 Microcontroller, designed to perform tasks in non-human situations. The arm has 5 Degrees of Freedom (DOF), with a Servo motor at each joint for precise positioning. The system uses a rotary-encoder for angle feedback. The robotic arm can operate in hazardous conditions, reducing human errors and enhancing production quality and speed. The design has been experimentally verified, with simulation results discussed.

12.Ali Roshanianfard, Noboru Noguchi et.al (2019) [12]:

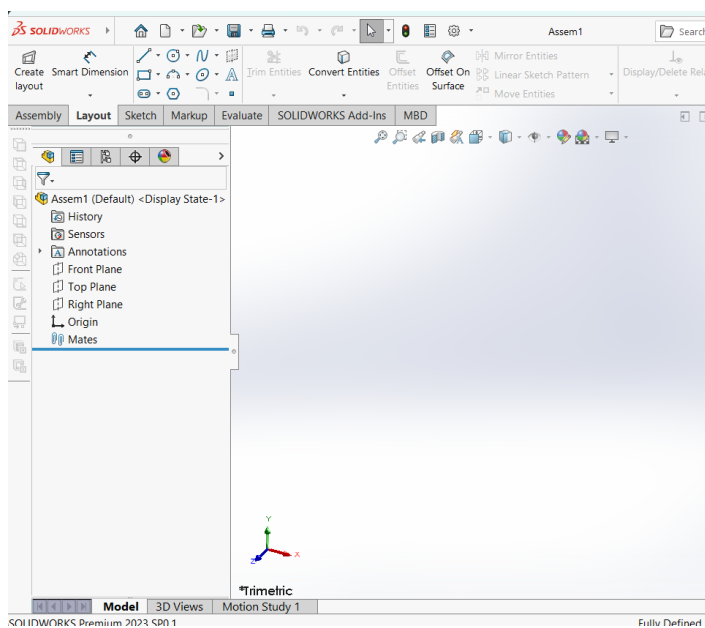
DESIGN AND PERFORMANCE OF A ROBOTIC ARM FOR FARM USE This study presents a 4-degrees-of-freedom robotic arm, designed as a smart harvesting system for heavy crops like pumpkins and watermelons. Developed to address labor shortages in Japan, the arm is part of a robot tractor optimized for outdoor agricultural environments. The system's control algorithm considers real-world kinematic and dynamic conditions. Performance metrics include a payload per weight of 0.21, an overall average accuracy of 1.85 mm, and a repeatability of ± 0.51 mm. The system can be easily modified for use in various industries.

3.METHODOLOGY

The methodology's that we have used, references from literature reviews by studying them every process for fabricating the parts of every involved multifaceted automated machinery. Our project shows the different types of multiple working principals. We have used lathe operations like facing, turning, drilling, boring for the

making of pillow blocks, pillow bearing block, couplers are the respective parts necessary for CNC milling machine Roll bending machine parts such as the rollers, supporting elements of the rollers are also have been processed using lathe Apart from that we have used the solid works for designing these parts.

SolidWorks software



SolidWorks Interface

SolidWorks is an excellent choice for designing and modeling components for your project, especially for mechanical and engineering applications like CNC machines. Here's how you can use SolidWorks for your project:

Modeling Components: You can use SolidWorks to create 3D models of the various components of your CNC machine, including the frame, rollers, motors, lead screws, limit switches, and other mechanical parts. SolidWorks offers powerful modeling tools that allow you to accurately represent the geometry and dimensions of each component.

Assembly Design: SolidWorks enables you to assemble the individual components into a complete 3D assembly

of your CNC machine. You can use mate features to define relationships between parts, such as coincident, concentric, parallel, or tangent relationships, ensuring proper alignment and fitment of components within the assembly.

DESIGN IN SOLIDWORKS

PREPARATION

Initial Planning and Research:

Define the specifications and requirements for each component, including dimensions, materials, functionality, and performance criteria. Research existing designs, standards, and best practices relevant to material containers, CNC machines, robotic arms, and roll bending machines. Identify key design considerations, such as load capacity, precision, safety features, and compatibility with other components.

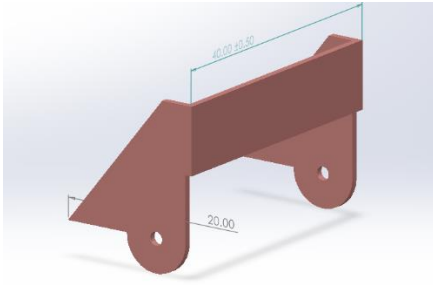
Conceptual Design:

Generate conceptual sketches and rough drawings to visualize the overall layout and arrangement of components for each machine. Explore alternative design concepts and configurations to evaluate their feasibility and potential advantages or limitations. Consider ergonomic factors, accessibility, and ease of maintenance in the design of each component.

DETAILED DESIGN IN SOLIDWORKS:

1. MATERIAL CONTAINER:

a) PIN



Pin design in solid works

- First Draw a rectangle 40*10 using rectangle tool,
- Now extrude 1mm of the rectangle using the extrude option,
- Now select face of a rectangle
- Draw a rectangle 1*25 on the edge of the selected face,
- Now extrude the rectangle for 20 mm,
- Draw the profile by using lines and circles has shown in the finger,
- Now use the extruded cut tool to remove the external part and inside circle,
- Now mirror the side part to the other side by using mirror entities and selecting center line of the main rectangle for the mirror about

b)MOVING BASE

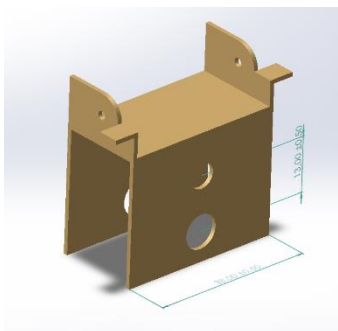


Fig 3.2.2 Moving base design in solid works

- Draw a rectangle of 38*20 and extrude 1mm,
- Now select face of the rectangle and draw two rectangles to and bottom 1mm,
- Now select two rectangles and extrude for 39mm,
- Select extruded one of the face,

- Now draw two circles and one arc of 6mm, 8mm and 30mm has shown in the finger ,
- Now use the extruded cut tool to remove the inside and out of the circle and arc part 20mm,
- Select first rectangle and draw two rectangles each side,
- Now extrude for 11mm of the two rectangles,
- Select the one of the face of the extruded rectangle,
- Now draw two circles of 2mm and 10mm at center of the extruded face,
- Now draw the profile by using 10mm circle and remove the part outside of the 10mm circle and inside of the 2mm circle and also other side,
- Now select the face of previously drawn face and draw a rectangle from the 10mm circle and 1mm length,
- Now extrude the rectangle 5mm and also other second extruded face.

c)CLAMP 1 (DC MOTOR)

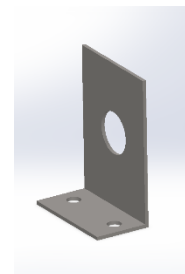


Fig 3.2.3 Clamp1 design in solid works

- Draw a rectangle of 30mm and 42mm and also draw a circle of 12mm from the height 22mm,
- Now select all the entities and extrude for 1mm,
- Select face and draw a rectangle at the bottom of height 1mm,
- Now extrude the rectangle for 15mm,
- Select the face of the extruded face and draw two circles at the center of the rectangle,
- Now select the extruded cut and remove the inside the circle.

d)CLAMP 2 FOR LEAD SCREW AND SMOOTH ROD

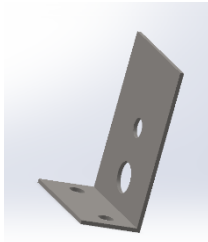


Fig 3.2.4 Clamp 2 design in solidworks

- Draw a rectangle of 30mm and 42mm and also draw two circles of 5mm and 8mm from the height 22mm and 9mm
- Now select all the entities and extrude for 1mm,
- Select face and draw a rectangle at the bottom of height 1mm,
- Now extrude the rectangle for 15mm,
- Select the face of the extruded face and draw two circles at the center of the rectangle,
- Now select the extruded cut and remove the inside the circle.

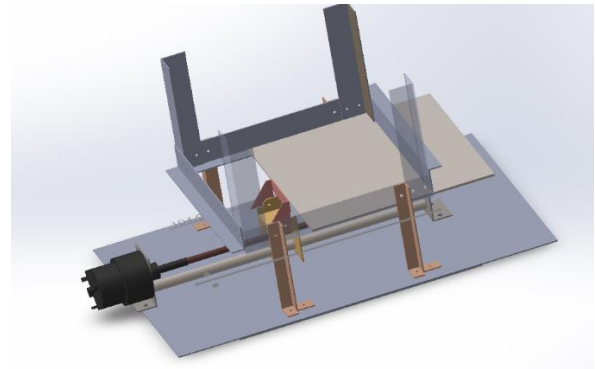


Fig 3.2.6 Material container assembly in solid works

2. CNC milling machine:

Design the frame and structure of the CNC milling machine, considering factors such as rigidity, stability, and vibration damping. Model individual components such as the gantry, spindle mount, tool holders, and linear motion systems using SolidWorks. Integrate features for motor mounts, guide rails, lead screws, and limit switches to facilitate accurate and repeatable machining operations.

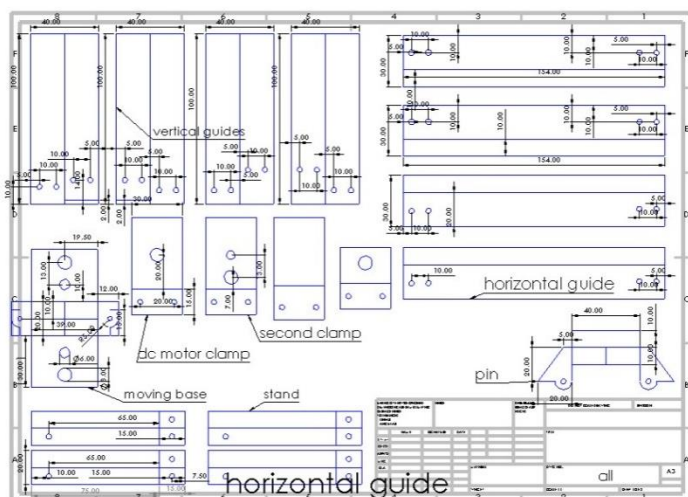


Fig 3.2.5 Engineering drawing of all parts in solid works

a)PILLOW BLOCK BEARING

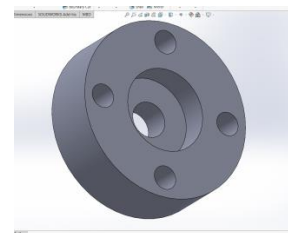


Fig 3.2.7 SolidWorks Pillow block bearing

Draw a circle of 30mm,

- Now extrude the circle for 10mm
- Select the face of the circle and draw a circle of 14mm,
- Now select the extruded cut and remove the part inside the circle for 5mm,

- Now select another side of the circle and draw a circle of 5mm,
- Now select the circle then select extruded cut for 5mm
- Select any side of the circle and draw a circle of 11mm,
- Draw 4 circles on the 11mm circle and remove the part with the help of the extruded cut

b) COUPLER

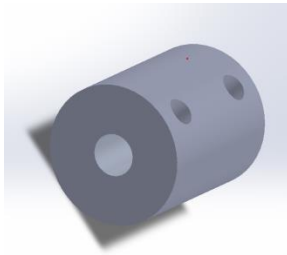


Fig 3.2.8 Coupler design in solid works

- Draw a circle of 20mm,
- Now extrude the circle for 25mm,
- Select circle one of the faces and draw a circle of 6mm,
- Now select the circle then select extruded cut and remove the whole coupler,
- Select top plane and draw two circle of distance 15mm from each other,
- Now select the two circles then select extruded cut for 10mm.

c) X axis

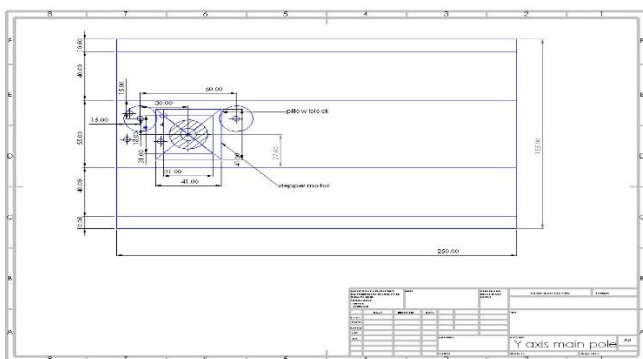


Fig 3.2.9 X axis main engineering drawing in solid works

d) Y axis with supports

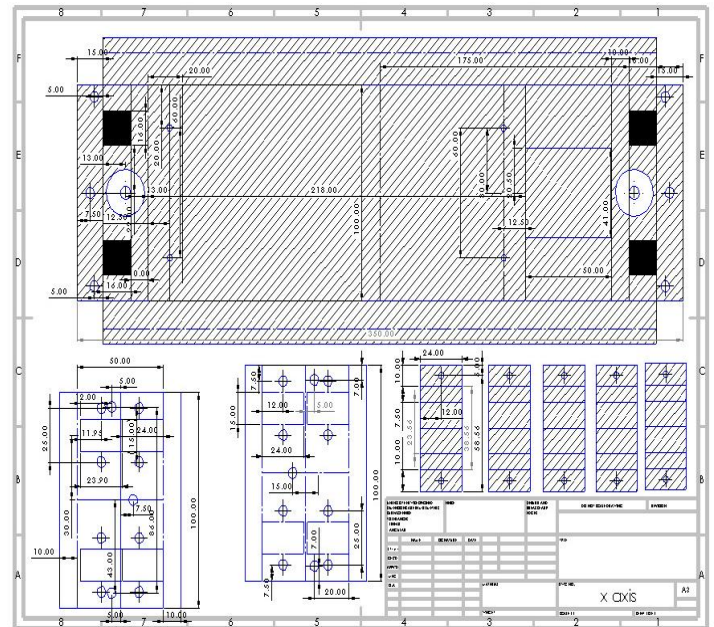


Fig 3.2.10 X axis framedrawing in SolidWorks

e) Z axis

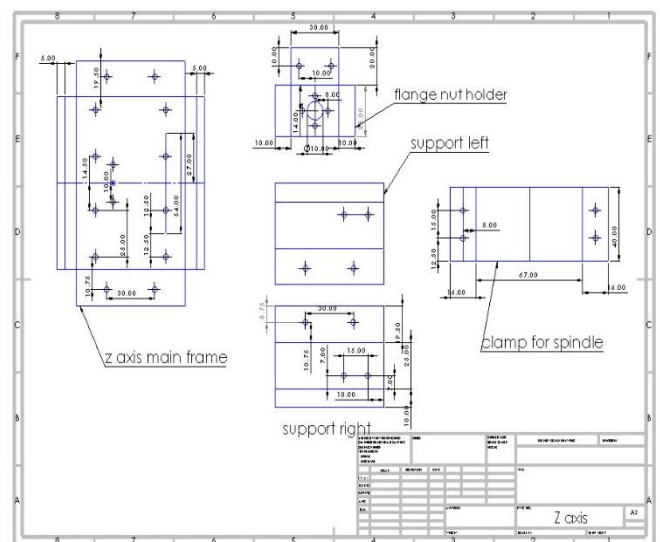


Fig 3.2.11 Z axis frame edrawing in solid works

3. ROBOTIC ARM

a) SERVO MOTOR

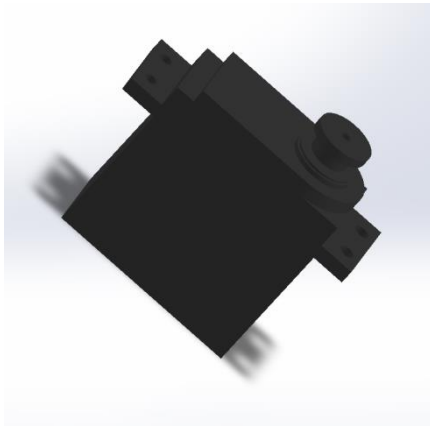


Fig 3.2.12 servo motor

- Draw a rectangle of 55*20mm with the rectangle tool,
- Now extrude the rectangle for 3mm,
- Select rectangle face and draw a rectangle at the center of the extruded face,
- Now select the rectangle then select extrude tool for 5mm,
- Draw a profile of the top side of the servo motor with the help of line and circle.
- Now extrude the profile for 3mm,
- Draw a circle on the extruded face at the center of the previous circle,
- Now extrude for 1mm,
- Draw a circle 6mm on the extruded face at the center of the previous circle,
- Now extrude for 0.5mm,
- Select circle face and draw a circle 8mm at the center of the extruded face,
- Now extrude for 3.5mm,
- Select circle face and draw a circle 12mm at the center of the extruded face,
- Now extrude for 2mm,
- Select circle face and draw a circle 2mm at the center of the extruded face,

- Now select the circle then select extruded cut tool for 5mm,
- Select longest part and draw 4 circles 1.5mm on the face of each side,
- Now select the circles then select extruded cut tool for 3mm,
- Select down side face and draw a rectangle of 40*20.50,
- Now extrude for 29mm.

4. ROLL BENDING MACHINE

a) ENGINEERING DRAWING SHEET 1 IN SOLID WORKS

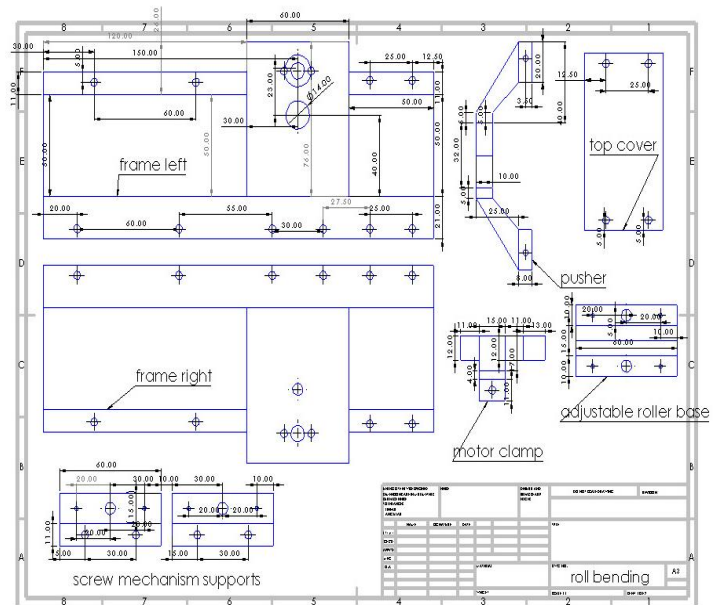


Fig 3.2.15 Engineering drawing sheet 1 in Solid Works

b) ENGINEERING DRAWING SHEET 2 IN SOLID WORKS

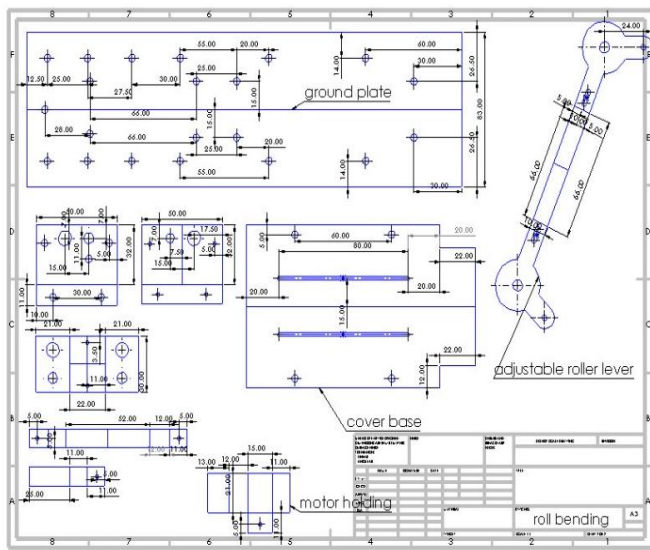


Fig 3.2.16 Engineering drawing sheet 2 in Solid Works

c) ROLL BENDING MACHINE ASSEMBLY IN SOLID WORKS

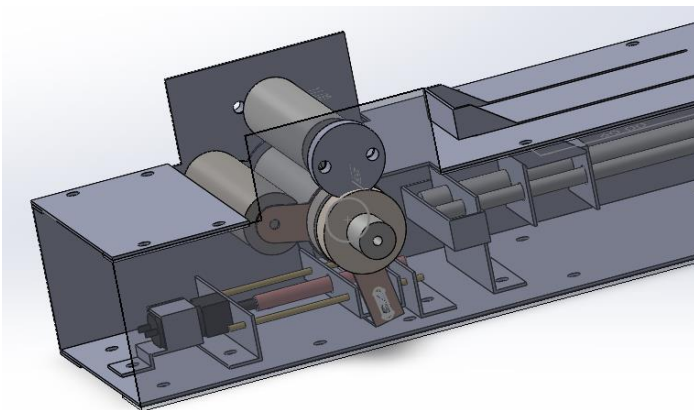


Fig 3.2.17 Roll bending machine assembly in solid works

4. FABRICATION

Material container

Fabrication steps:

1. stand,
2. horizontal guide,
3. vertical guide,
4. stand for 500 rpm dc motor,
5. Stand for lead screw and smooth rod support,
6. Moving base,
7. Pin.

8. Connecion

1. STAND

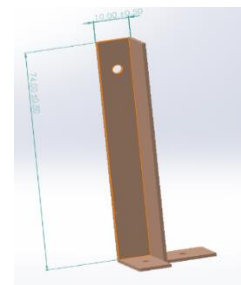


Fig 3.3.1 Stand

A stand is a supportive structure designed to hold. It serves as a stable platform for these PVC sheets, ensuring they are securely held in a place. The plywood base serves as a foundation for the stands and helps distribute the load of the PVC sheets and other parts. And its length is 74mm and width of two faces is 10mm and the bottom side is bended as shown in the fig, down side holes used to fasten (nuts and bolts) with plywood.

2. HORIZONTAL GUIDE

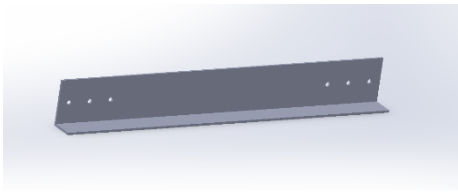
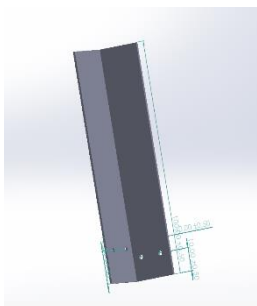


Fig 3.3.2 Horizontal guide

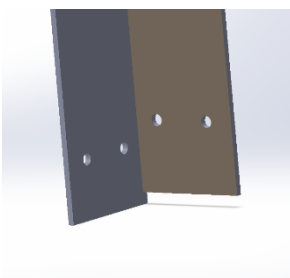
The four horizontal guides help to hold all parts together. The parts are the vertical guide and PVC sheets laid on the inner face of the guide. The horizontal guides are fitted to the stand by rivets. The total length is 154mm and height is 20mm and width is 15 mm to support PVC sheets on it.

3. VERTICAL GUIDE



vertical guide

guides are fastening to the horizontal guides. Four guide poles are used, for each horizontal guide have 2 guides. These guide poles prevent the horizontal movement of the PVC sheets. Total length = 100mm, Circles diameter = 2mm



Front vertical guide with clearance of 2mm

The front guide poles have a 2mm clearance to allow the PVC sheet to pass through the gap.

STAND FOR 500 RPM DC MOTOR

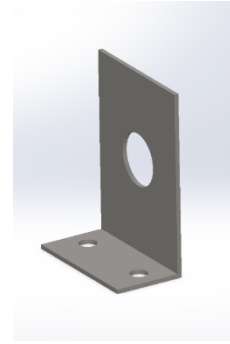


Fig 3.3.5 Stand for 500 rpm dc gear motor

a motor stand is used to support a 500 RPM DC gear motor, and the stand is fastened to a plywood base. we created a sturdy and functional platform for supporting and operating the 500 RPM DC gear motor, ensuring efficient performance and reliability in its intended application.

Upper hole supports lead screw of 5mm diameter, below the 5mm hole is used to support 8mm smooth rod and distance between is 13mm from the centers of the circles. One limit switch is fastened to the stand.

STAND FOR LEAD SCREW AND SMOOTH ROD SUPPORT

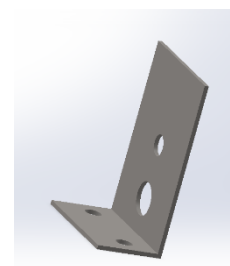
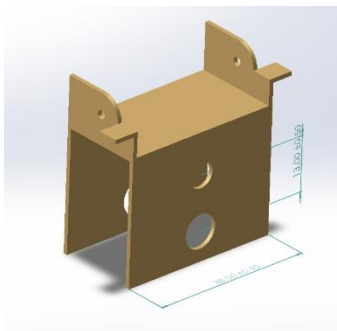


Fig 3.3.6 Stand for lead screw and smooth rod support

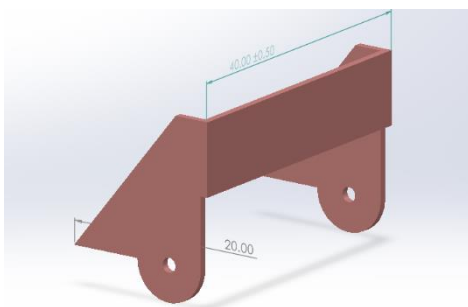
Stand is fastened on a plywood by using that bottom two holes. The stand is specifically designed to support and stabilize the lead screw and smooth rod assembly. It consists of sheet metal component configured in a manner that ensures proper alignment and support for the moving parts. One limit switch is fixed to the stand.

6. MOVING BASE



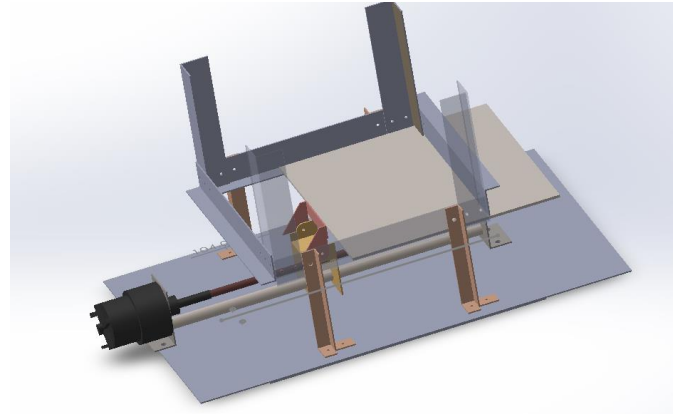
moving base is placed between the two stands and guided along a lead screw and smooth rod assembly, and a nut is fixed to the moving base to facilitate movement along the lead screw. The upper part of the base have two holes to give fastening facilities to the pin and it prevents over swing, swing angle is 90 degrees.

7. PIN



Pin

The two holes of the pin is fastened to the moving base, pin can swing for some angle as designed, the extended part of the pin prevent over back rotation. A spring is fixed to the pin and moving base.



8. CONNECTIONS

Connect limit switches to the arduino uno A0 and A1, connect motor1 to the L298N motor driver out1 and out2, connect L298N driver to the arduino uno like ENA to 13 pin, IN1 to 12, IN2 to 11

CNC Milling Machine

FABIRCATION STEPS:

a) Y axis

1. stepper motor pole (lift and right),
2. pillow block
3. pillow block bearing pole (lift and right),
4. pillow block bearing.

5.smooth rod

6. lead screw and coupler

b) x axis

7. x axis frame

11. z axis supports

c) z axis

12. main spindle frame

13. Left and right support

14. Clap for spandle motor

15. Bronze nut holder

d) Connection STEPPER MOTOR POLE (LIFT AND RIGHT)

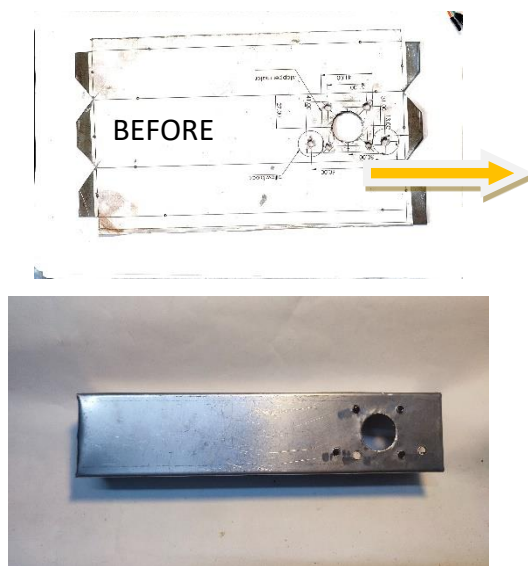


Fig 3.3.9 Y axis conversion

- **Export the Design:** In SolidWorks, export the design as a 2D drawing file format such as DXF or DWG. This file format can be opened in various software applications used for printing and fabrication.
- **Printing:** Open the exported file in a suitable software for printing. Ensure that the design is scaled correctly to match the desired dimensions on the sheet metal. Print the design onto a sheet of paper.
- **Transfer to Sheet Metal:** Use adhesive or other means to securely attach the printed design onto the sheet metal. Ensure that it is positioned accurately and firmly adhered to the surface.

- **Mark with Punch:** Use a punch tool to mark the locations on the sheet metal where holes or other features need to be drilled or cut. This can be done by aligning the punch with the printed design and applying pressure to mark the metal.
- **Cut Outer Lines and Inner Circles:** Use a drilling machine equipped with appropriate drill bits to cut the outer lines and drill the inner circles as indicated on the printed design. Ensure that the holes are drilled accurately and to the correct depth.
- **Bend the Sheet:** Follow the bending instructions provided on the printout. Use a bending machine or other tools to bend the sheet metal along the specified lines to achieve the desired shape.

The bottom side of the Y-axis pole should have holes to allow it to be securely fastened to a plywood base. Use appropriate fasteners, such as screws or bolts, to attach the pole to the plywood. This step ensures stability and support for the CNC machine.

Mount Stepper Motor: The Y-axis pole should have pre-drilled holes for mounting the stepper motor. Position the stepper motor on the pole and align it with the corresponding holes. Use screws or bolts to securely fasten the stepper motor to the pole. Ensure that the motor is mounted securely and aligned properly for smooth operation.

Install Pillow Block: Similarly, the Y-axis pole should have holes for mounting the pillow block, which supports the movement of the Y-axis. Position the pillow block on the pole and align it with the corresponding holes. Fasten the pillow block to the pole using screws or bolts. Ensure that the pillow block is securely attached and properly aligned to facilitate smooth movement of the Y-axis.

2. PILLOW BLOCK

- **Prepare MS Rod:** Place the MS rod securely in the lathe chuck,

- Turn on Lathe: Start the lathe at a medium RPM,
- Facing and Turning: Perform facing and turning operations on the MS rod to prepare its surface for further machining,
- Material Removal: Continue turning the rod until it reaches a diameter of 20mm, ensuring the outer diameter matches the required dimension,
- Mark Center for Hole: Mark the center of the shaft face where you intend to drill a hole for the pillow block,
- Drilling Hole: Fix the drill bit to the tailstock and adjust its position so that it aligns with the marked center. Drill into the rod to a depth of 10mm, creating the hole for the pillow block,
- Mark Length: Measure and mark a length of 14mm on the rod from one end. This mark indicates where the rod will be cut to achieve the desired final length for the pillow block,
- Cutting the Rod: Use an appropriate cutting tool, such as a parting tool or a hacksaw, to cut the rod at the marked length of 14mm.

or shafts that ensure the smooth and precise movement of the CNC machine along the Y-axis. Each pillow block bearing pole would have holes or slots to accommodate the mounting of the pillow block bearings at both ends. The smooth rods or shafts are inserted through the pillow block bearings, providing stable support and alignment for the Y-axis movement.

4. PILLOW BLOCK BEARING



Fig 3.3.11 pillow block bearing lathe operation

3. PILLOW BLOCK BEARING POLES

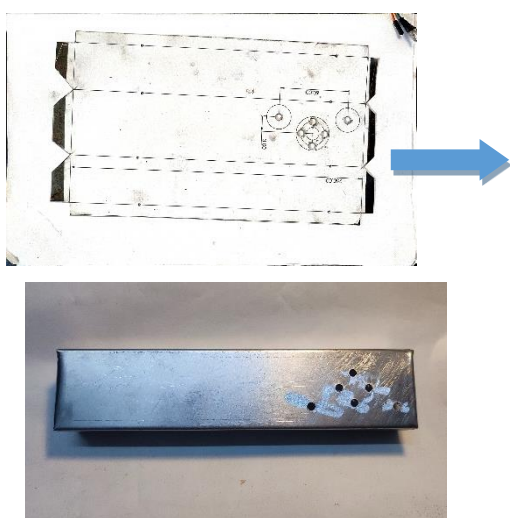


Fig 3.3.10 Other end Y-axis pole with pillow block bearing holes

These poles are specifically designed to mount pillow block bearings, which support and guide the smooth rods

- Prepare Aluminium Rod: Place the 30mm diameter aluminium rod securely into the lathe chuck. Ensure its properly centered and tightened to prevent any wobbling during machining.
- Turn on Lathe Machine: Start the lathe machine and set it to an appropriate RPM (revolutions per minute) for aluminium machining. A medium speed would typically suffice for facing and turning operations.
- Facing Operation: Use a facing tool to square off the end of the aluminium rod. This process ensures that the end is flat and perpendicular to the axis of the rod. Adjust the lathe tool's position and feed rate to achieve a smooth and even facing cut.
- Turning Operation: Once the facing operation is complete, switch to a turning tool. Begin removing material from the outer diameter of the aluminium rod to achieve the desired diameter. In this case, that the diameter remains the same, so the turning operation is mainly to ensure a smooth surface finish.

- Drilling Hole for Bearing: After completing the facing and turning operations, mark the center of the face to drill a hole for the bearing. Use a center punch to make a small indentation to guide the drill bit.
- Drilling Operation: Install a suitable drill bit in the lathe's tailstock chuck. Position the tailstock to align the drill bit with the marked center on the face of the aluminium rod. Drill a hole to the required depth for the bearing. Take care to use proper cutting fluid and appropriate feed rates to prevent overheating and ensure smooth drilling.
- Begin by placing the aluminium rod into the lathe chuck securely.
- Use lathe turning tools to remove material from the outer diameter of the rod until it reaches a diameter of 20mm.
- Ensure accuracy and a smooth finish. Using a boring tool, create a hole through the center of the rod with a diameter of 6mm.
- This will serve as the inside diameter of the coupler.



Fig 3.3.12 Final Pillow block bearing

5. SMOOTH RODS

Cut 4 rods to a length of 215mm each for the Y-axis, cut 2 rods to a length of 200mm each for the X-axis, Cut 2 rods to a length of 140mm each for the Z-axis.

6. COUPLER



Fig 3.3.13 coupler lathe operation

7. X AXIS FRAME

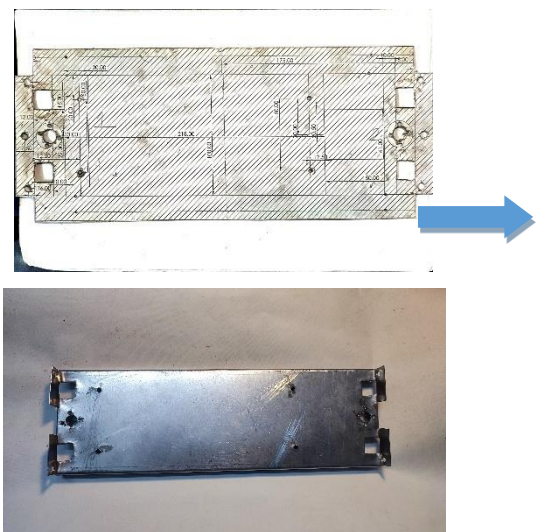


Fig 3.3.14 X axis frame

Connecting two bronze nuts to the X-axis frame of a CNC machine typically involves securing them to a lead screw. Bronze nuts are often used in CNC machines due to their low friction properties and durability. The four square holes are used for smooth rod passage.

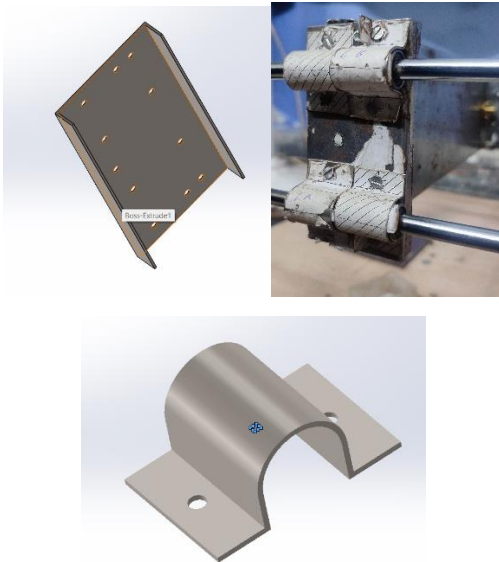


Fig 3.3.15 X axis side supports for linear bearings

The supports are the components that provide the structure for mounting the linear bearings. They are made of metal and designed to securely hold the bearings in place. The linear bearings are placed into the linear bearing holders, which are then positioned onto the supports. The number of linear bearings needed depends on the design and requirements of the CNC machine. In our case, requires a total of 8 linear bearings (4 per support). This is typically done using screws, With the linear bearings securely attached to the supports, the supports are then positioned onto the X-axis part of the CNC machine. The supports are aligned properly to ensure smooth movement along the X-axis. The supports are fastened to the X-axis frame using screws, fasteners. Typically, holes are provided in the X-axis frame for this purpose. In our case, 3 holes per support, for a total of 6 holes to attach both supports.

8. X AXIS SUPPORTS FOR Z AXIS

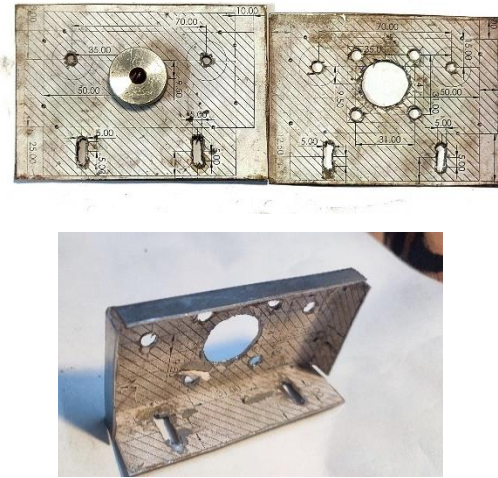


Fig 3.3.16 X axis supports for z axis frame

Each support is prepared to accommodate its respective component. The support for the stepper motor will have mounting points designed to securely hold the motor in place, while the support for the pillow block bearing will have provisions for mounting the bearing assembly. Ensure that the supports are aligned properly on the X-axis part to facilitate smooth movement and proper operation of the CNC machine. This involve aligning mounting holes with corresponding features on the X-axis part.



Fig 3.3.17 Xaxis supports one with stepper motor another with pillow block bearing

The stepper motor and pillow block bearing can now be mounted onto their respective supports. Now the supports are fastened to the X-axis part using screws. These fasteners should be tightened securely to ensure that the supports remain stable during operation.

9. Z Axis Frame

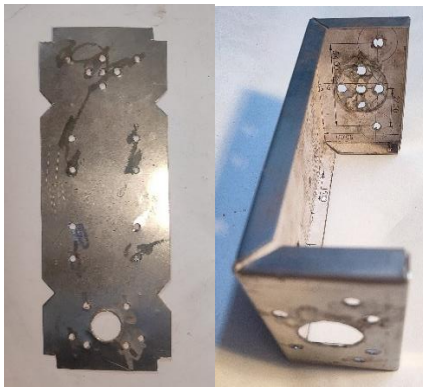


Fig 3.3.18 Z axis main frame

This part is typically a structural component designed to support the vertical movement of the cutting tool or workpiece. It should have provisions for mounting linear bearings, a stepper motor, pillow block bearings, and holders for smooth rods. Install holders for the linear bearings onto the Z-axis part. Ensure that the holders are positioned accurately and securely, as they will support the linear motion along the Z-axis. Install four linear bearings into the holders. On the top side of the Z-axis part, there should be holes to mount the stepper motor and pillow block for the smooth rods. Securely fasten the stepper motor and pillow block in place.

10. SPINDLE PART

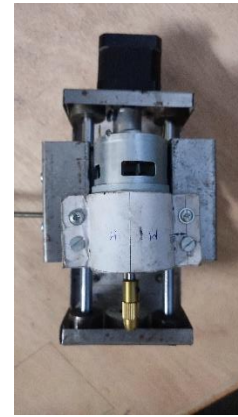


Fig 3.3.19 Spindle section

Total 5 parts are required for the z axis spindle.

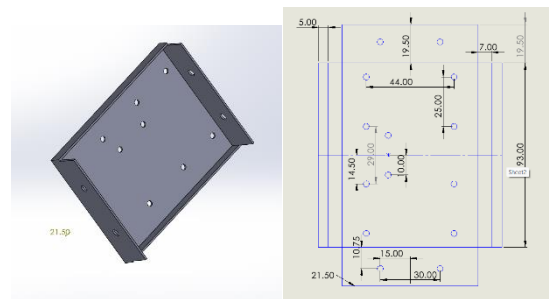


Fig 3.3.20 First main spindle frame

It holds all the 5 parts with 775 motor, Attach linear bearings to the backside of the spindle part. These bearings provide support and guidance for linear motion along the Z-axis. Secure the linear bearings firmly to the spindle part using appropriate fasteners to ensure stability and accuracy in motion.

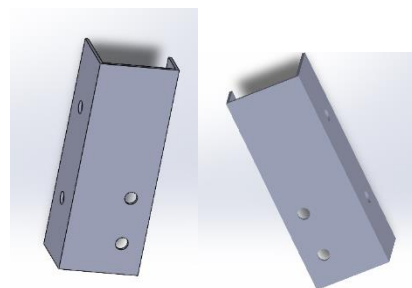


Fig 3.3.21 Left and right support parts

Fasten two additional parts to the left and right sides of the spindle part. These parts are designed to support and stabilize the 775 motor at the center. Position these support parts symmetrically around the spindle part and align them carefully to ensure balance and stability.

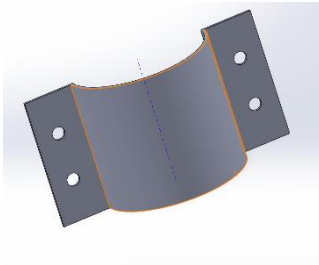


Fig 3.3.22 Clamp for spindle motor

Install a clamp that spans across the left and right support parts and secures them to the spindle part. The clamp ensures that the left and right support parts remain securely attached to the spindle part and that the 775 motor is held firmly in place. Fasten the clamp securely to the left and right support parts using appropriate fasteners. Ensure that all connections are tight and secure to prevent any movement or instability during operation.

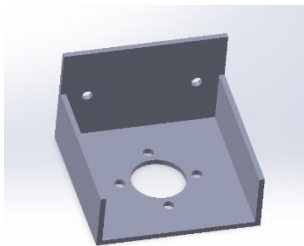


Fig 3.3.23 Bronze nut holder

Attach the bronze nut to a holder designed to hold it securely in place. Position the holder on the backside of the spindle part, aligning it with the desired axis of movement for the Z-axis. Securely fasten the holder, along with the bronze nut, to the backside of the spindle part using suitable fasteners. Ensure that all connections are tight and secure to prevent any play or movement during operation. Finally, fit the assembled spindle part onto the Z-axis part of the CNC machine. Ensure proper alignment and secure attachment to the Z-axis part to facilitate vertical movement along the Z-axis.

CONNECTIONS

Prepare the Arduino Uno:

Make sure your Arduino Uno is powered off and disconnected from any power source. Place the Arduino Uno on a stable surface of the plywood.

Place the CNC Shield:

Take the CNC shield and align it with the headers on top of the Arduino Uno. Gently press down on the CNC shield to seat it firmly onto the Arduino Uno's headers. Ensure that all the pins make proper contact.

Connect Stepper Motor Drivers:

Identify the stepper motor drivers A4988 that be using. Insert the stepper motor drivers into the designated slots on the CNC shield. Make sure to align the pins correctly and insert them firmly.

Connect Wires from Stepper Motors to CNC Shield:

Identify the wires coming from each of your stepper motors. These wires usually include pairs of colored wires. Connect the wires from each stepper motor to the corresponding terminal blocks on the CNC shield. Typically, stepper motor connections are labelled X, Y, and Z for the respective axes. Ensure that you connect the wires according to the correct polarity. Usually, one wire from each pair goes to the terminal marked "+" or "A" and the other wire to the terminal marked "-" or "B".

Install GRBL on Arduino Uno:

Download the GRBL firmware from the official GitHub repository: [GRBL GitHub Repository](https://github.com/gnea/grbl).

Follow the instructions provided in the GRBL repository's README file for compiling and uploading the firmware to the Arduino Uno using the Arduino IDE.

Once uploaded, the Arduino Uno will be running the GRBL firmware, which allows it to interpret G-code commands for controlling the CNC machine.

Install Universal G-Code Sender (UGS):

Download the Universal G-Code Sender software from the official website: Universal G-Code Sender. Install the software on your computer according to the instructions provided. Launch Universal G-Code Sender and configure the connection settings to communicate with the Arduino Uno running GRBL. Typically, you'll need to specify the COM port and baud rate for the Arduino Uno. Once connected, you can use Universal G-Code Sender to load G-code files, send commands to the CNC machine, and monitor its operation.

Test the Setup:

With everything connected and configured, you can now test the CNC machine's operation. Load a simple G-code file into Universal G-Code Sender and send it to the CNC machine. Verify that the stepper motors move as expected and that the CNC machine responds correctly.

Robotic Arm

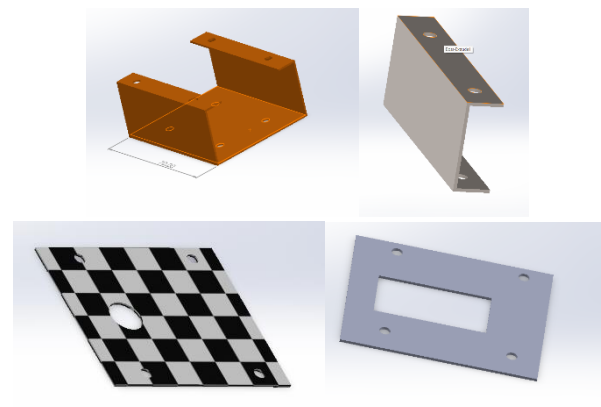
Fabrication steps

1. Base,
2. Axis 1,
3. Axis 2,
4. Axis 3,
5. Axis 4,
6. Axis 5,
7. suction cup

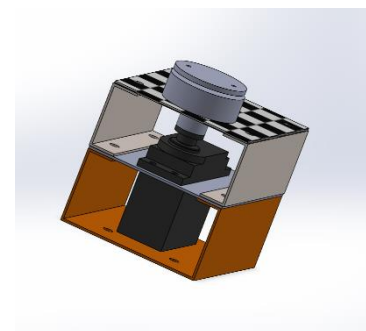
We are using six axis robotic arm to transport cnc milled parts so we are using a suction cup instead of magnetic gripper because we are using a pvc sheet

1. BASE

We have a base which holds base servo motor and bearing to give smooth rotation all the robotic arm weight is loaded on the base



Base 4 parts



assembled Base

The base serves as the foundation of the robotic arm system. It provides stability and support for the entire assembly. The servo motor mounted on the base is responsible for rotating the robotic arm. It provides the necessary torque and control to move the arm in different directions.

It is divided into four parts to facilitate different functions:

The first part is for fastening the base to the plywood or mounting surface, providing stability. The second part is a plate that attaches to the first part and contains rectangular holes for mounting the servo motor. The third part creates space between the servo motor and the robotic arm's base, allowing for the connection of the servo motor to the bearing. The fourth part is used to hold the bearing securely in place.

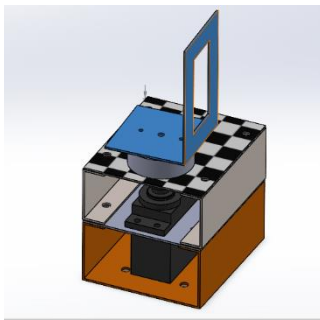


Fig 3.3.26 Axis 1

2. AXIS 1

This component serves as the foundation for the second axis of the robotic arm. It is fastened to the bearing part of the base, which ensures smooth rotation of the second axis. The base for Axis 2 likely includes a rectangular hole designed for mounting the servo motor.

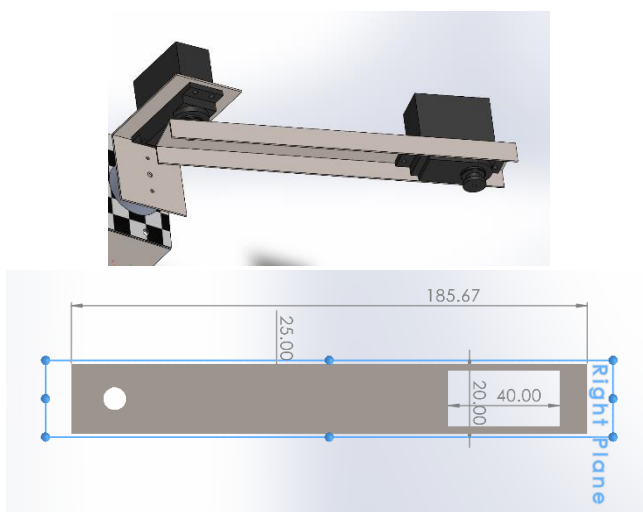


Fig 3.3.27 Axis 2

3. AXIS 2

The base for Axis 2 serves as the foundation for this specific movement in the robotic arm. It is directly fastened to the servo motor, which is responsible for controlling the movement of Axis 2. This base likely features a rectangular hole designed for mounting the servo motor securely.

4. AXIS 3

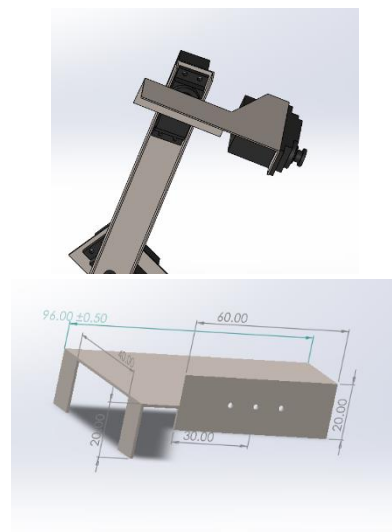


Fig 3.3.28 Axis 3

3 axis also made by sheet made, we are designed on solid works it gives strength at low mass and it is fastened to the 4 axis servo motor and another end have mounting place for the 5th axis

5. AXIS 4

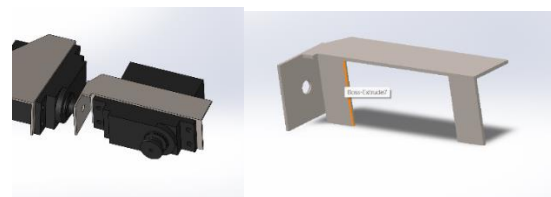
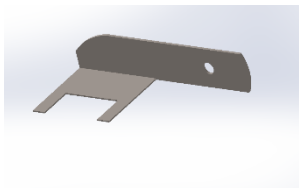


Fig 3.3.29 Axis 4

6. AXIS 5



7. ROBOTIC ARM ASSEMBLY

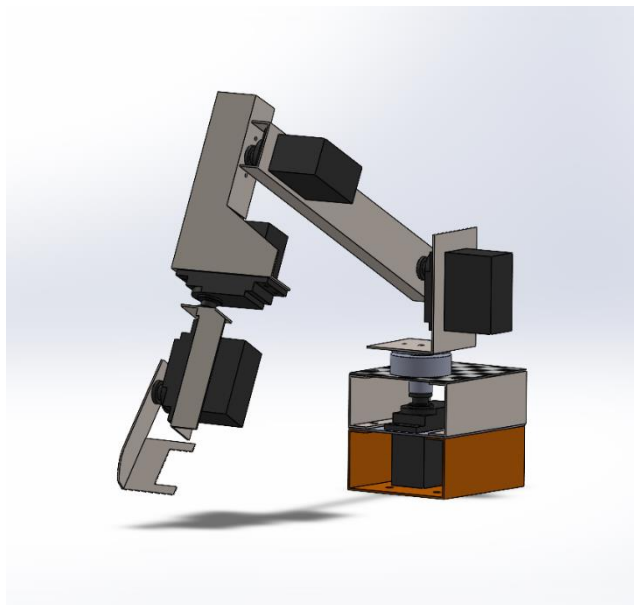


Fig 3.3.31 Robotic arm

8. CONNECTION

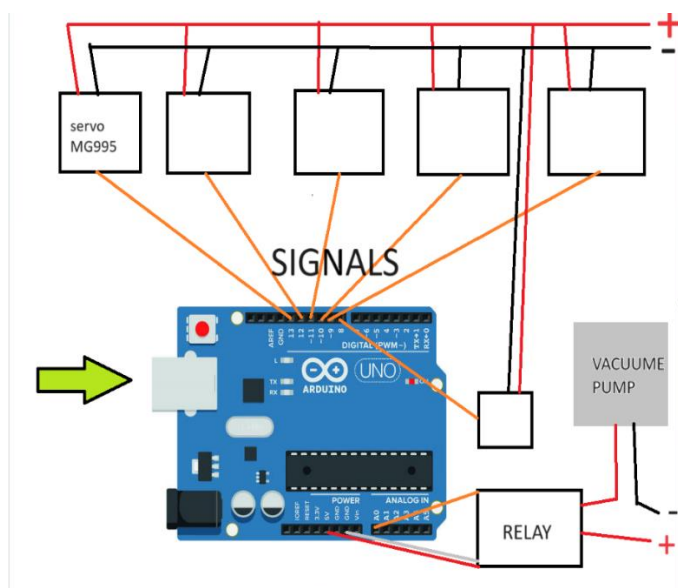


Fig 3.3.32 robotic arm wiring diagram

Servo Motors:All six MG995 servo motors for the robotic arm are connected to the Arduino Uno. Each servo motor is connected to a separate digital pin on the Arduino Uno, with pins 13 to 8 being utilized. Additionally, each servo motor is connected to an external power supply to provide sufficient power for their operation.

5V Relay for Vacuum Pump:A 5V relay is connected to pin A1 on the Arduino Uno to control the vacuum pump. The relay is used to switch the power supply to the vacuum pump on or off based on the control signal from the Arduino Uno.

Arduino Uno Power Supply:The Arduino Uno itself is typically powered via USB connection from your computer or through an external power adapter connected to the DC power jack (7-12V).The Arduino Uno regulates this input voltage to provide 5V to its components, including the microcontroller and any peripherals connected directly to its pins.

Servo Power Supply:Since the MG995 servos can draw significant current, it's common to power them separately from the Arduino Uno to avoid overloading the Arduino's onboard voltage regulator.Connect the positive (+) terminal of the external power supply to the positive terminal of each servo.Connect the negative (-) terminal of the external power supply to the ground (GND) terminal of each servo.Ensure the external power supply provides an appropriate voltage and current rating for the servos. For MG995 servos, a voltage of around 4.8V to 6V is typical, and the current rating should be sufficient to power all six servos simultaneously.

Relay Power Supply:The 5V relay can be powered directly from the Arduino Uno's 5V pin.Alternatively, if the relay requires more current than the Arduino Uno can safely provide, you can use a separate 5V power supply.Connect the positive (+) terminal of the 5V power

supply to the VCC terminal of the relay module. Connect the negative (-) terminal of the 5V power supply to the ground (GND) terminal of the relay module.

ROLL BENDING MACHINE

FABRICATION STEPS

1. ground plate,
2. Screw mechanism for initial sheet movement,
3. body frame,
3. Main Roller (Bottom Roller),
4. Second Roller (Top Roller),
5. second roller support,
6. Adjustable Roller (Moving Up and Down),
7. lever for adjustable roller,
8. driver for lever.

1. GROUND PLATE

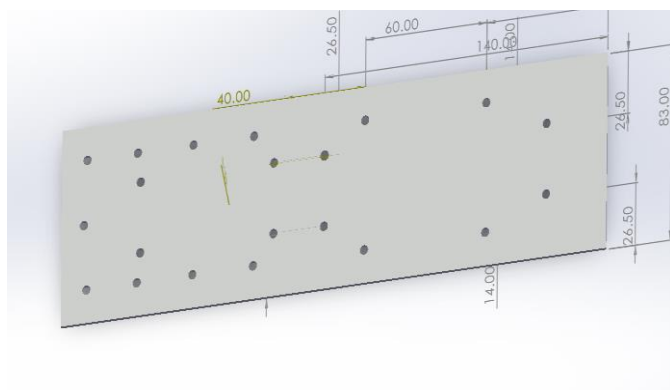


Fig 3.3.33 ground plate

The ground plate acts as a sturdy foundation upon which all other components are mounted. This ensures that the machine remains stable during operation, minimizing vibrations and inaccuracies in the bending process.

2.SCREW MECHANISM FOR INITIAL SHEET MOVEMENT

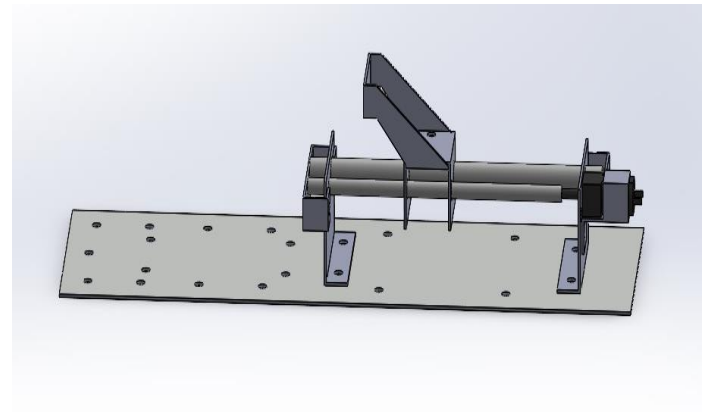


Fig 3.3.34 Screw mechanism for initial sheet movement

You have two supports: One for the N20 motor: This support holds the N20 motor securely in place, ensuring that it remains stable during operation. Another for the smooth rod and lead screw: This support holds the smooth rod and lead screw assembly, which is likely part of the screw mechanism used for feeding the sheet metal into the roll bending machine.

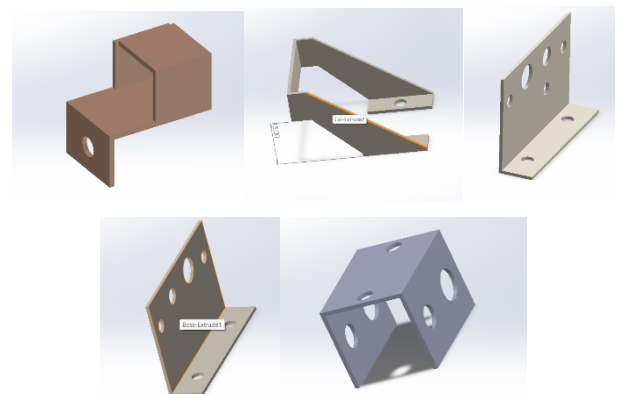


Fig 3.3.35 All parts (feeding mechanism)

3. BODY FRAME

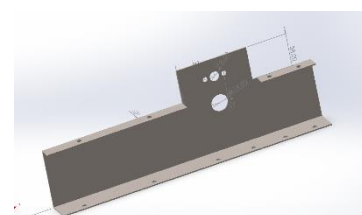


Fig 3.3.36 body frame

3. MAIN ROLLER (BOTTOM ROLLER)Main

Roller (Bottom Roller):

This roller is the primary roller responsible for bending the sheet metal. It is driven by an N20 motor, which provides the necessary torque to rotate the roller. The speed of rotation can be controlled to adjust the bending process according to the desired curvature of the sheet metal.

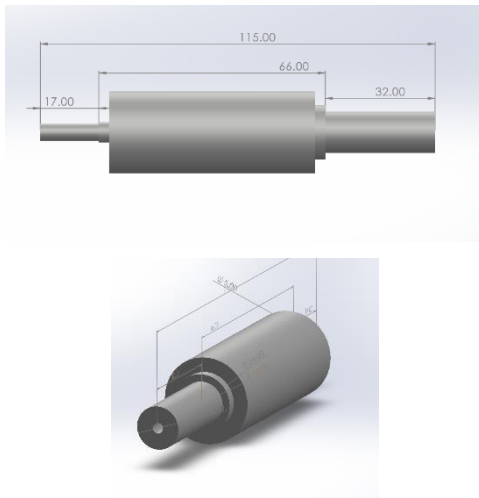


Fig 3.3.37 Main roller

4. SECOND ROLLER (TOP ROLLER)



Fig 3.3.38 SECOND ROLLER (TOP ROLLER)

The second roller is positioned above the main roller. It likely serves as a support roller to help guide the sheet metal as it passes through the bending process. While it may not be directly driven, its position and alignment are crucial for achieving accurate bends.

5. SECOND ROLLER SUPPORT

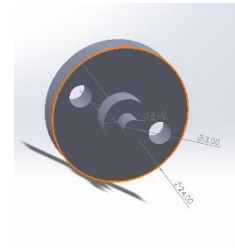


Fig 3.3.39 second roller support

6. ADJUSTABLE ROLLER (MOVING UP AND DOWN)

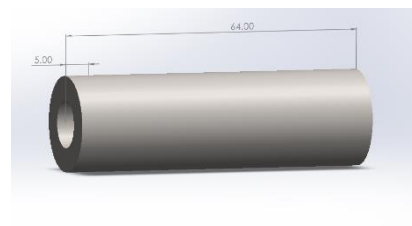


Fig 3.3.40 Adjustable Roller

This roller is adjustable in its vertical position. Its movement up and down is controlled by an Arduino Uno, indicating that it's likely motorized for precise control. The vertical movement of this roller helps to apply pressure to the sheet metal, facilitating the bending process. Additionally, by controlling the position of this roller, you can control the curvature and shape of the bend.

7. LEVER FOR ADJUSTABLE ROLLER

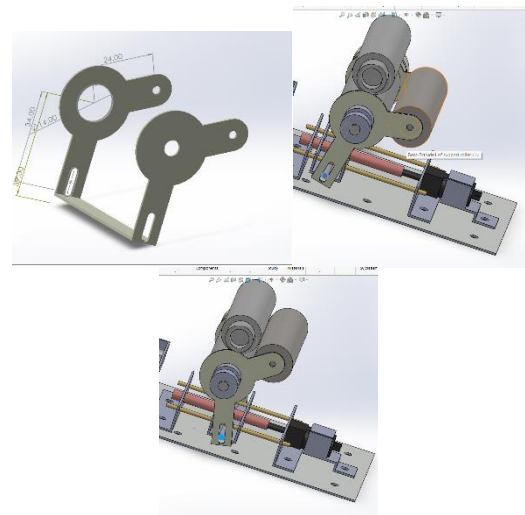


Fig 3.3.41 lever for adjustable roller Screw mechanism

8. ROLLERS ASSEMBLY

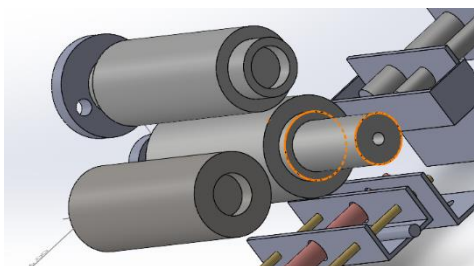


Fig 3.3.42 the three main rollers

5.RESULTS AND DISCUSSION

In conclusion, the fabrication of the Multifaceted Automated System is a testament to the integration and coordination of several components, each playing a crucial role in the overall process. The Material Container, CNC Milling Machine, Robotic Arm, Roller Bending Machine, and Welding Robotic Arm all work in harmony to ensure the successful fabrication of the desired product. Each component, from the transportation of materials to the precision of welding, contributes significantly to this process, highlighting the complexity and complex of modern manufacturing systems. This intricate process, from roller bending to welding, underscores the importance of each element in the overall system, demonstrating the marvel of engineering and automation in today's world.

6.CONCLUSION:

In conclusion, this project has successfully demonstrated as an efficient manufacturing process. By referring all the literatures, we can conclude that to enhancement in production line in the manufacturing of excavator bucket by adding multifaceted automation systems. This system allows for customization of the excavator bucket as per design, reduces production time and minimizes the need for manual labor. This project showcases the potential of automation in enhancing manufacturing efficiency.

7.FUTURE SCOPE:

Customization of the product can be achieved by this multifaceted manufacturing system can make products that meet our specific needs by way of making minor changes in machineries setup as similar to the flexible manufacturing system. **Material Changes** Another promising area of development lies in the modification of materials used in manufacturing. By altering the materials used, we can achieve better finishing and stronger components. This not only enhances the aesthetic appeal of the products but also improves their durability and longevity. **CNC Milling and Robotic Arms** Technological advancements will play a crucial role in shaping the future of manufacturing. CNC milling and robotic arms, for instance, can be designed more effectively and accurately. These technologies will enable us to manufacture products with unprecedented precision, thereby improving the overall quality of the products. **Roller Bending Machine** The roller bending machine is another area where we can expect significant advancements. In the future, these machines could operate independently, eliminating the need for a heating element for the bending of PVC sheets. This will make the process more efficient and cost-effective. **Welding Processes** In the real world, traditional welding processes are often preferred over 3D printing for certain applications. However, as technology evolves, we might witness a shift towards more advanced manufacturing techniques. This could open up new possibilities for product design and creation, thereby redefining the future of manufacturing.