DESIGNING AND FABRICATION
OF
CNC, PLASMA CUTTING MACHINE

PREPARED BY

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CERTIFICATION

This is to certify that the project title "**DESIGINING AND FABRICATION OF CNC, PLASMA CUTTING MACHINE** was undertaken by **AGHATOR MITCHELL EDOSA**, with matriculation number **ENG2006280**, a student of the department of Industrial Engineering, Faculty of Engineering, University of Benin, Edo State, Nigeria. For the award of B.ENG in Production Engineering; under the supervision of PROF **A.O.A. IBHADODE**

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PROF A.O.A. IBHADODE ______________________________

Project Supervisor Date

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Dr. (MRS) I.C ILUOBE ______________________________

Project Coordinator Date

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Prof. P.E. AMIOLEMHEN ______________________________

Head of Department. Date

DEDICATION

This project is dedicated firstly to God for the privileges given me to attain this height in my academic and for the wisdom granted to me to conquer every trial along the way.

Secondly to my Family, Friends, Mentor, and my supervisor who unwavering support, encouragement, and guidance have been the cornerstone of my journey. Your belief in me has been the foundation of this work, and I am grateful for all your guidance every step of the way.

Thirdly to everyone who played even the smallest role in the success of this project, your support has not gone unnoticed. With deepest gratitude, I dedicate this work to you

ACKNOWLWDGEMENT

I express our heartfelt gratitude to all individuals and entities who contributed to the successful completion of this project, on the designing and manufacturing of a cnc plasma cutting machine.

First and foremost, I extend my sincere appreciation to my project supervisors **PROF A.O.A. IBHADODE** and **Engr. Dr. C.E. ETINOSA** whose guidance, expertise, and encouragement were instrumental in shaping the direction of this work. Their insights and constructive feedback greatly enhanced the quality of the project.

We are deeply grateful to University of Benin for providing access to essential resources, including laboratory facilities, tools, and materials, which made the fabrication and testing phases possible.

Special thanks go to my peers and colleagues who offered valuable suggestions, shared technical knowledge, and provided moral support throughout the project. Their collaboration and willingness to assist during challenging phases were truly invaluable.

Finally, I thank my families, friends for their unwavering support, patience, and encouragement, which motivated us to persevere through the demands of this project.

This endeavor would not have been possible without the collective efforts and support of everyone involved.

We are profoundly grateful for their contributions.

ABSTRACT

The machine is developed to cut different metal materials with high precision using plasma arc technology controlled by a computer system. The CNC plasma cutter improves cutting accuracy, reduces manual effort, and increases productivity in metal fabrication industries. The project includes the design process, material selection, fabrication of the frame, installation of electronic components, and testing of the machine.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Plasma cutting is a process that uses a high-velocity jet of ionized gas (plasma) to cut electrically conductive materials such as steel, aluminum, and copper. Traditionally, metal cutting was done manually, which required a lot of effort and often produced inaccurate results.

With the advancement of technology, Computer Numerical Control (CNC) machines have been developed to automate cutting processes. A CNC plasma cutting machine uses a computer program to control the movement of the cutting torch, allowing for precise and repeatable cuts.

1.2 HISTORICAL Context Of CNC, Plasma Cutting Machine

The evolution of plasma cutting from manual torches in the 1950s to CNC controlled systems in the 1980s marks significant advancements in precision, efficiency, and automation. In the 1950s, plasma cutting emerged as an industrial process, derived from plasma welding. Manual plasma torches, introduced around 1957, used a high-temperature plasma arc (ionized gas) to cut conductive metals like steel and aluminum. These torches, powered by basic power supplies, required skilled operators to manually guide the torch, resulting in inconsistent cuts and limited complexity.

The process was effective for thick materials but lacked precision and was labor-intensive the 1960s and 1970s, improvements in power supplies and gas mixtures (e.g., argon, nitrogen) enhanced cut quality and speed. Mechanized systems began to appear, using basic guides or templates to improve consistency, though still reliant on human control.

These advancements expanded plasma cutting's use in industries like shipbuilding and construction. The introduction of CNC (Computer Numerical Control) technology in the 1980s revolutionized plasma cutting. CNC systems, driven by early computers and G-code, automated torch movement via motorized gantries and linear rails.

This allowed for precise, repeatable cuts of complex shapes designed using early CAD/CAM software. CNC plasma cutters improved accuracy (to ±0.1 mm), reduced operator skill requirements, and enabled high-volume production. By the late 1980s, integration of torch height control (THC) systems further enhanced cut quality by adjusting for material irregularities.

This transition from manual to CNC-controlled plasma cutting transformed it into a cornerstone of modern manufacturing, enabling applications in automotive, aerospace, and metal fabrication with unprecedented efficiency and precision.

1.3 Problem Statement

Traditional manual cutting methods present several challenges. Manual operations often lead to inaccurate cuts, rough surfaces, and inconsistent results due to human error. In addition, manual cutting requires significant time and physical effort, which reduces productivity.

Another major challenge is the difficulty of producing complex shapes and designs using manual tools. Fabricators often struggle to achieve precision when cutting intricate patterns or repeated designs. This limitation affects the quality of finished products and increases material waste.

Although industrial CNC plasma cutting machines offer a solution to these problems, they are expensive and not easily accessible to small workshops, students, and local fabricators. As a result, there is a need for a more affordable CNC plasma cutting system that can perform accurate and automated cutting operations.

This project addresses these challenges by designing and fabricating a CNC plasma cutting machine that can improve cutting accuracy, reduce manual labor, and increase efficiency in metal cutting processes.

1.4 Aim and Objective of the Study

The aim of this project is to design and fabricate a CNC plasma cutting machine capable of accurately cutting metal sheets using computer control.

The project aims to develop a machine that integrates mechanical structures, electronic components, and control systems to automate the plasma cutting process. By achieving this aim, the machine will be able to follow programmed instructions to produce precise cuts and complex shapes on metal sheets with minimal human intervention.

The objectives of this project are as follows:

1. To design the mechanical structure of a CNC plasma cutting machine.
2. To select suitable materials and components for the fabrication of the machine.
3. To fabricate the machine frame and assemble the mechanical parts.
4. To install and integrate the motion control system using stepper motors.
5. To connect and configure the CNC control system and plasma cutting torch.
6. To test and evaluate the performance of the fabricated CNC plasma cutting machine.

1.5 Significance of the Study

First, it demonstrates the application of CNC technology in metal cutting operations. The development of a CNC plasma cutting machine can significantly improve cutting accuracy, speed, and efficiency compared to manual methods.

Second, the project provides a cost-effective solution that can be used by small workshops, educational institutions, and local fabricators who cannot afford expensive industrial machines.

Third, the project contributes to the advancement of practical knowledge in mechanical and manufacturing engineering by combining design, fabrication, electronics, and automation technologies.

Finally, the machine developed in this project can serve as a training tool for students to understand the principles of CNC machining and automated manufacturing systems.

1.6 Scope of the Project

This project focuses on the design, fabrication, and testing of a small-scale CNC plasma cutting machine used for cutting electrically conductive metals. The study covers the development of the machine structure, installation of motion control components, and integration of the plasma cutting torch with the CNC control system.

The project also involves programming the machine to perform automated cutting operations along the X and Y axes. The fabricated machine will be tested to determine its cutting performance, accuracy, and operational efficiency.

The scope of the study is limited to cutting thin metal sheets such as mild steel, aluminum, and stainless steel. Advanced industrial features such as automatic torch height control, multi-axis cutting systems, and large-scale industrial applications are not included in this project.

FIG 1: SKETCH OF A CNC PLASMA CUTTING MACHINE

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Over the years, several cutting techniques have been developed to improve productivity, accuracy, and efficiency. Among these techniques, plasma cutting has become one of the most widely used methods for cutting electrically conductive materials. The integration of plasma cutting with Computer Numerical Control (CNC) technology has further enhanced the capability of metal cutting systems by enabling automation, precision, and repeatability.

2.2 Overview of CNC Technology

Computer Numerical Control (CNC) is a manufacturing technology that uses computer programming to control machine tools. CNC systems automate machining processes by converting digital designs into precise mechanical movements. CNC technology allows machine tools to operate automatically based on coded instructions known as numerical control (NC) programs.

CNC systems provide several advantages over traditional manual machining methods. These advantages include higher precision, improved production speed, reduced human error, and the ability to produce complex shapes that would be difficult to achieve manually. CNC machines are widely used in industries such as aerospace, automotive manufacturing, construction, and metal fabrication.

The CNC system typically consists of three major components:

1. The machine tool, which performs the cutting operation
2. The control unit, which interprets the programmed instructions
3. The drive system, which moves the machine components according to the program

Through the use of motors, controllers, and software, CNC machines can accurately control the movement of cutting tools along multiple axes.

2.3 Plasma Cutting Technology

Plasma cutting is a thermal cutting process used to cut electrically conductive materials such as mild steel, stainless steel, aluminum, brass, and copper. The process involves generating a high-temperature plasma arc that melts the metal while a high-speed stream of gas removes the molten material from the cutting area.

Plasma is often referred to as the fourth state of matter, consisting of ionized gas with extremely high energy levels. When gas is exposed to a strong electrical arc, it becomes ionized and forms plasma. The temperature of plasma can exceed 20,000°C, which makes it capable of cutting thick metal materials efficiently.

Plasma cutting offers several advantages compared to other cutting processes such as oxy-fuel cutting and mechanical sawing. These advantages include:

I. High cutting speed
II. Ability to cut various conductive metals
III. Minimal material distortion
IV. Smooth and narrow cutting edges
V. Reduced heat-affected zone

Due to these benefits, plasma cutting has become widely used in fabrication workshops, shipbuilding industries, automobile manufacturing, and construction sectors.

2.4 CNC Plasma Cutting Machines

A CNC plasma cutting machine combines plasma cutting technology with CNC automation to achieve precise and programmable metal cutting operations. In a CNC plasma system, the plasma torch is mounted on a movable carriage controlled by stepper or servo motors. The CNC controller receives programmed instructions from a computer and directs the motors to move the torch along specified paths.

The use of CNC control allows the machine to cut complex shapes and patterns with high accuracy and repeatability. This capability is particularly useful in industrial manufacturing where identical parts must be produced consistently.

CNC plasma cutting machines typically operate along two or three axes, commonly referred to as the X, Y, and sometimes Z axes. The X and Y axes control horizontal movement across the cutting table, while the Z axis controls the vertical height of the plasma torch.

Modern CNC plasma systems often use computer-aided design (CAD) and computer-aided manufacturing (CAM) software to convert digital designs into machine-readable code known as G-code. This code instructs the machine on how to move the torch and perform cutting operations.

2.5 Components of a CNC Plasma Cutting Machine

A typical CNC plasma cutting machine consists of several key components that work together to perform automated cutting operations.

Mechanical Frame

The frame provides structural support for the machine and ensures stability during operation. It is usually made from steel or aluminum to withstand vibrations and maintain alignment of the moving parts.

Motion Control System

The motion control system is responsible for moving the cutting torch along the programmed path. It typically includes guide rails, linear bearings, belts or lead screws, and stepper motors. Stepper motors are commonly used in small-scale CNC machines because they provide accurate positional control and are relatively inexpensive.

Plasma Torch

The plasma torch generates the plasma arc required for cutting metal. It consists of electrodes, nozzles, and a gas supply system that produces the high-temperature plasma jet.

Control Unit

The CNC controller acts as the brain of the machine. It interprets the G-code instructions and sends signals to the motors to control their movement. The controller also manages the operation of the plasma torch during the cutting process.

Power Supply

The power supply provides electrical energy required to generate the plasma arc and operate the electronic components of the machine.

2.6 Advantages of CNC Plasma Cutting

The integration of CNC technology with plasma cutting offers numerous advantages compared to traditional manual cutting methods. Some of the key benefits include:

1. **High Precision:** CNC control allows for accurate cutting with minimal dimensional errors.
2. **Automation:** The cutting process can be performed automatically without constant human supervision.
3. **Complex Shape Cutting:** CNC machines can produce intricate shapes and patterns that are difficult to achieve manually.
4. **Increased Productivity:** Automated cutting significantly reduces production time.

5. **Reduced Material Waste:** Accurate cutting minimizes unnecessary material loss.

2.7 Limitations of Existing Systems

CNC plasma machines are often expensive and require specialized training to operate and maintain. The high cost of these machines makes them inaccessible to many small workshops and educational institutions.

Additionally, large industrial systems require significant space and complex infrastructure, which may not be suitable for small-scale operations.

These limitations have motivated researchers and engineers to explore the design and fabrication of low-cost CNC plasma cutting machines that can provide similar functionality while remaining affordable for smaller users.

2.8 Theoretical Principles of Plasma Arc Cutting

Plasma arc cutting is based on the principle of generating a high-temperature plasma arc capable of melting electrically conductive metals. Plasma is produced when a gas is heated to a very high temperature until it becomes ionized. At this stage, the gas contains free electrons and ions, allowing it to conduct electricity.

In plasma cutting systems, an electric arc is formed between an electrode and the workpiece. A gas such as compressed air, nitrogen, or argon is forced through a small nozzle at high speed. When the electric arc passes through this gas, it ionizes the gas and converts it into plasma.

The plasma jet generated during this process has extremely high energy and temperature, often exceeding 20,000°C. This intense heat melts the metal while the high-velocity gas stream blows away the molten material, thereby creating a narrow cut known as a kerf.

plasma arc cutting is particularly effective for materials such as:

- Mild steel
- Stainless steel
- Aluminum
- Copper
- Brass

The efficiency of plasma cutting depends on several factors including cutting current, gas pressure, cutting speed, and nozzle diameter.

2.9 Computer Numerical Control Programming

CNC machines operate based on programmed instructions written in a special language called G-code. G-code is a standardized programming language used to control CNC machines by specifying movement commands, feed rates, and cutting operations.

A CNC plasma cutting machine receives a digital design created using Computer-Aided Design (CAD) software. The design is then converted into machine instructions using Computer-Aided Manufacturing (CAM) software. The resulting G-code program guides the movement of the plasma torch along the X and Y axes.

For example:

- G00 – Rapid movement without cutting
- G01 – Linear cutting movement
- G02 – Clockwise circular motion
- G03 – Counterclockwise circular motion

These commands allow the CNC system to precisely control the path of the cutting torch and produce accurate shapes.

CNC programming enables machines to perform complex machining operations with minimal human involvement, improving both productivity and consistency.

2.10 Motion Control Systems in CNC Machines

Motion control is an essential component of CNC machines because it determines how accurately the cutting tool moves along the programmed path. CNC plasma cutting machines typically use stepper motors or servo motors to drive the mechanical movement of the cutting head.

Stepper motors are widely used in small-scale CNC machines due to their simplicity and ability to move in discrete steps. Each electrical pulse sent to the motor results in a fixed rotational movement, which allows precise positioning.

The motion system usually includes the following components:

- Linear guide rails
- Lead screws or timing belts
- Stepper motors
- Motor drivers
- CNC controller board

These components work together to ensure smooth and accurate movement of the cutting torch across the cutting table. Proper alignment and calibration of the motion system are critical for achieving accurate cutting results.

2.11 Review of Related CNC Plasma Machine Designs

Several researchers and engineers have explored the design and development of CNC plasma cutting machines in recent years. Many studies focus on creating affordable systems suitable for educational institutions and small fabrication workshops. For example, researchers have designed small CNC plasma cutting machines using microcontrollers such as Arduino and open-source CNC control software. These systems use stepper motors and belt-driven mechanisms to control the movement of the cutting torch.

Other studies have focused on improving machine stability by designing rigid steel frames that minimize vibration during operation. Reducing vibration is important because excessive movement can lead to inaccurate cuts and poor surface quality.

Some advanced CNC plasma machines also include automatic torch height control systems, which maintain the correct distance between the plasma torch and the metal surface. This feature helps maintain consistent cutting quality even when the metal surface is uneven. However, such advanced features significantly increase the cost of the machine, making them less suitable for low-cost applications.

2.12 Challenges in CNC Plasma Machine Development

Although CNC plasma cutting machines offer many advantages, several challenges must be considered during their design and fabrication.

One of the major challenges is maintaining machine rigidity. The frame must be strong enough to support the moving components without excessive vibration or deflection.

Another challenge is achieving accurate motion control. Improper alignment of guide rails or poor motor calibration can lead to positioning errors during cutting.

Electrical noise generated by the plasma arc can also interfere with the electronic control system. Proper shielding and grounding are necessary to prevent signal disturbances.

Additionally, ensuring proper safety measures is important because plasma cutting involves extremely high temperatures and electrical currents.

2.13 Summary of the Literature Review

CNC plasma cutting machines are widely used in modern manufacturing industries due to their high precision, speed, and automation capabilities. Plasma cutting technology provides an efficient method for cutting electrically conductive metals with minimal material waste.

The integration of CNC control systems allows automated movement of the plasma torch, enabling the production of complex shapes with high accuracy. However, industrial CNC plasma cutting machines are often expensive and may not be accessible to small-scale fabricators or educational institutions.

Therefore, the design and fabrication of a low-cost CNC plasma cutting machine can provide a practical solution for small workshops and training environments. This project aims to contribute to this area by developing a functional and affordable CNC plasma cutting system.

CHAPTER THREE

MATERIALS AND METHODS / DESIGN METHODOLOGY

3.1 Introduction

This chapter describes the materials used, design considerations, and fabrication procedures involved in the development of the CNC plasma cutting machine. It also explains the design calculations used to determine the required motor power, machine frame strength, and motion control system.

The design process involved several stages including conceptual design, material selection, mechanical fabrication, installation of the motion system, and integration of the control

3.2 Design Considerations

Several important factors were considered during the design of the CNC plasma cutting machine to ensure proper functionality and reliability.

Accuracy and Precision

The machine must be capable of producing accurate cuts along the programmed path. This requires proper alignment of guide rails, accurate motor control, and a stable machine frame.

Structural Strength

The frame of the machine must be strong enough to support the moving components and withstand vibration during cutting operations.

Cost Effectiveness

The machine was designed using locally available materials and affordable components in order to reduce the overall production cost.

Ease of Operation

The control system must be easy to operate so that users can easily load cutting programs and operate the machine.

Safety

Since plasma cutting involves high temperatures and electrical currents, proper insulation and grounding of electrical components are necessary.

3.3 Description of the CNC Plasma Cutting Machine

The fabricated CNC plasma cutting machine consists of the following major components:

- Machine frame
- Linear motion system
- Stepper motors
- CNC controller
- Plasma cutting torch
- Power supply system

The machine operates on two primary axes known as the X-axis and Y-axis, which allow the cutting torch to move horizontally across the cutting table.

The CNC controller receives commands from a computer in the form of G-code and converts them into electrical signals that control the movement of the motors.

3.4 Materials Used for Fabrication

The following materials were used in the fabrication of the CNC plasma cutting machine.

Component	**Material Used**
Machine frame	Mild steel
Guide rails	Hardened steel
Motion transmission	Timing belts and pulleys
Motor system	Stepper motors
Control unit	CNC controller board
Cutting tool	Plasma cutting torch

Mild steel was selected for the frame due to its strength, durability, and availability.

3.5 Design of the Machine Frame

The machine frame serves as the main support structure for the entire system. It holds the cutting table, guide rails, motors, and plasma torch assembly.

The frame was designed using mild steel square pipes due to their high strength and rigidity. Welding was used to join the structural members.

These dimensions were chosen to allow the machine to cut medium-sized metal sheets while maintaining structural stability.

The **Lotos LTP5500D** CNC plasma cutter is preferred due to:

- **Precision cutting**: Cuts 3/4” (19 mm) metal with clean, smooth edges.
- **Versatility**: Handles various metals like stainless steel, alloy steel, mild steel, copper, and aluminum.
- **Ease of use**: Non-HF blowback start, simple setup, and user-friendly interface.
- **Portability**: Lightweight (15lbs) and compact, ideal for workshops or on-site work.
- **Cost-effective**: Offers professional-grade cutting at an affordable price point.

The Maxmech air compressor is paired with the Lotos LTP5500D CNC plasma cutter due to:

- **Compatibility**: Designed to meet the air pressure and flow requirements of the LTP5500D.
- **Reliability**: Provides consistent air supply for smooth plasma cutting.
- **Portability**: Compact and mobile, matching the LTP5500D's portability.
- **Sufficient airflow**: Meets or exceeds the LTP5500D's air requirements (at 60-80 PSI).

3.6 TABLE SCALE AND MATERIAL NEEDED

Quantity	**Steel Tube**
16635mm	50mm square tubing 2mm wall Thicker
380mm	65mm,70mm,75mm square tubing,3mm wall thickness
1800mm	12mm Electrical conduit

Y	Cut list for 2’’ square tubing	NOTE
2	95mm	Gantry standoff tube
4	635mm	Leg tube
2	1610mm	X direction tube
1	1555mm	X Gantry tube
2	1905mm	Y axis lower tube
2	1905mm	Y axis upper tube
1	1510mm	Water pan support
	PLATE STEEL	**NOTE**
8	125mm x 150mm x 160mm steel plate	For Y Connecting Plate
1	150mm x 25mm x 6mm Aluminum	For Touch Bar
2	250mm x 150mm x 3mm steel flat bar	For Y Axis Motor Mount
1	150mm x 100mm x 3mm flat bar	For X Axis Motor Mount
1	300mm x 100mm x 3mm flat bar	For Z Axis Backer
1	600mm x 600mm x 300mm steel sheet	For Triangle Bracket
	BELT MOUNTS	**NOTE**
8	75mm x 75mm x 3mm angle iron	For Y axis metal mount
4	50mm x 50mm x3mm angle iron	For X axis metal mount
2	80mm x 40mm pin	For Y axis metal mount

3.7 Motor Selection and Torque Calculation

Stepper motors were selected to drive the movement of the CNC plasma cutting machine because they provide accurate position control.

The torque required to move the cutting assembly can be estimated using the formula:

T = F x r

Where:

T = Torque (Nm),   F = Force required to move the load (N) r = Radius of pulley (m)

Assuming: Force required = 15 N,   Pulley radius = 0.02 m

T = 15 x 0.02

T = 0.3Nm

Therefore, a stepper motor with torque greater than 0.3 Nm is suitable for the machine.

In this project, a NEMA 23 stepper motor was selected because it provides sufficient torque for the motion system.

3.8 Power Requirement

The power requirement of the motion system can be estimated using the formula:

P = F x V

Where: P = Power (W), F = Force (N), V = Velocity (m/s)

Assuming: Force = 15 N, Velocity = 0.5 m/s,

P = 15 x 0.5,   P = 7.5 WT

Therefore, the motor must be capable of supplying at least 7.5 watts of mechanical power.

3.9 Motion Transmission System

The motion transmission system transfers rotational movement from the motors into linear motion of the cutting head.

The system used in this project consists of:

- Timing belts
- Pulleys
- Linear guide rails

Timing belts were selected because they provide smooth motion, low noise, and minimal backlash.

3.10 CNC Control System

The CNC control system is responsible for coordinating the movement of the machine components.

The control system includes:

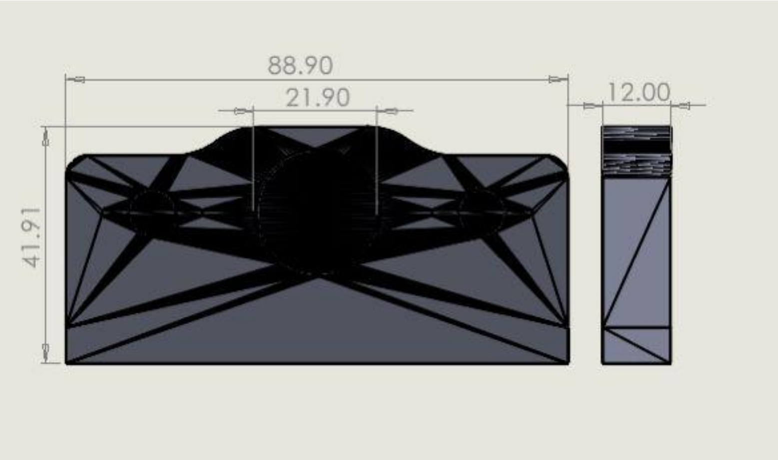
- CNC controller board
- Stepper motor drivers
- Computer interface
- Control software

The control software interprets G-code commands and sends signals to the motor drivers to control the speed and direction of the motors.

3.11 3D PRINTED PART

The components correspond to the JD's Garage design and include everything from major structural elements to small functional fittings

3.11.1 Bottom Plate



I. **Dimensions:** 88.90mm × 41.91 mm × 12 mm thickness

II. **Features:** Mounting holes for frame supports, ribs for stiffness, chamfered edges

Production:

5.1 Export STL from SolidWorks with high resolution

5.2 Orient flat to minimize supports

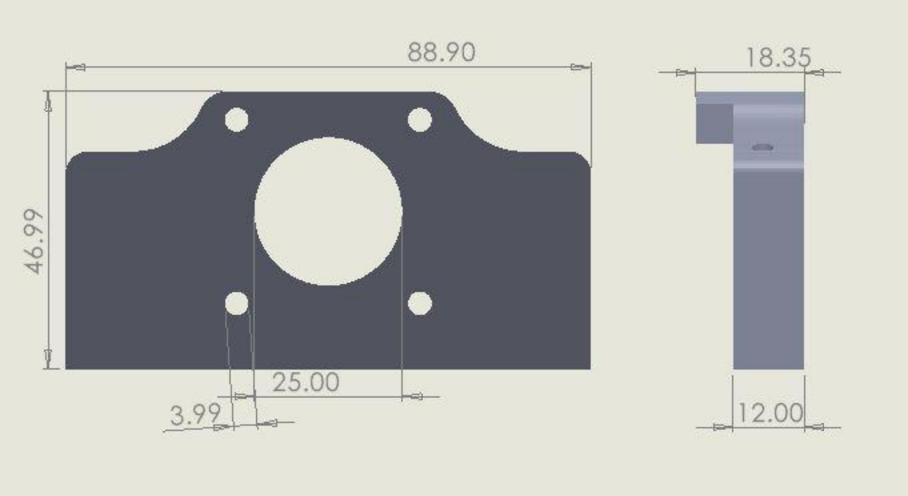
5.3 Print in stainless steel at 50-micron layers, 200W laser power

5.4 Heat treat for stress relief

5.5 Bead blast and machine mounting holes flat

Assembly: Mounts on machine base frame, provides foundation for bottom slider and supports

3.11.2 Top Plate



I. **Dimensions:** 88.90mm × 46.99 mm × 12mm thickness

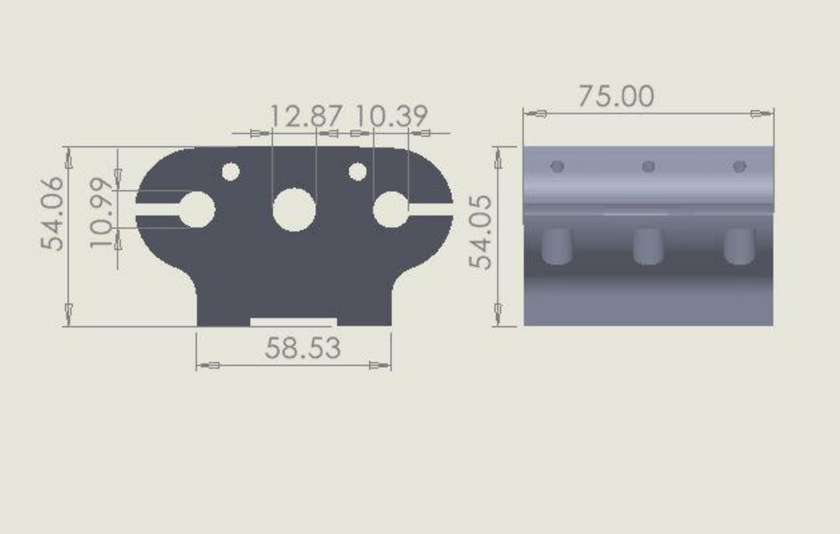
II. **Features:** Cutouts for belt paths, mounting holes, ribs for lightweight rigidity

Production:

1. Same printing and post-processing as bottom plate

Assembly: Secured atop frame supports, supports top slider and gantry assembly

3.11.3 Bottom Slider



I. **Dimensions:** 75 mm × 54.05 mm

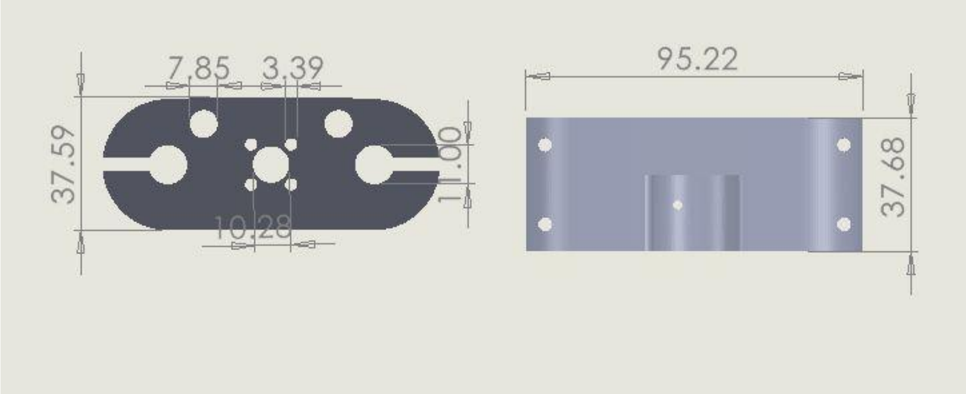
II. **Features:** Linear bearing slots, mounting holes, ribs

Production:

1. Orient bearing slots upward for accuracy
2. Print with solid infill
3. Heat treat and machine bearing slots precisely

Assembly: Houses linear bearings, slides along bottom plate rails

3.11.4 Top Slider



I. **Dimensions:** 95.22mm × 37.68 mm

II. **Features:** Bearing slots and mounting points for gantry arms

Production:

1. Same as bottom slider, with machining on bearing surfaces

Assembly: Supports gantry arms, moves along top plate rails

3.11.5 Gantry and Structural Components

Gantry Arm

I. **Dimensions:** 600 mm length × 50 mm width × 30 mm thickness

II. **Features:** Internal ribs, mounting holes for flanges and torch holder

Production:

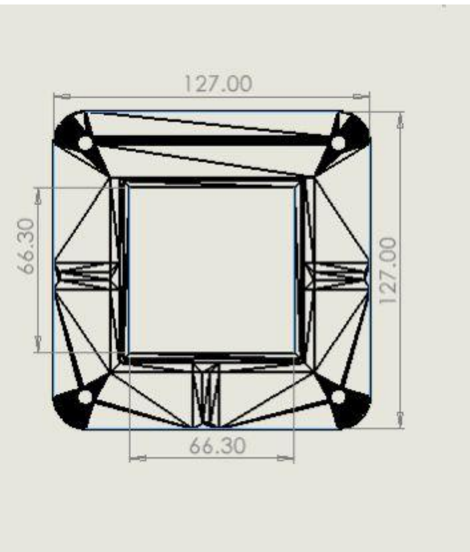
4.1 Print vertically to maximize strength

4.2 Heat treat and bead blast

4.3 Machine mounting surfaces and holes

4.4 **Assembly:** Connects torch holder and bearing blocks

Gantry Flange



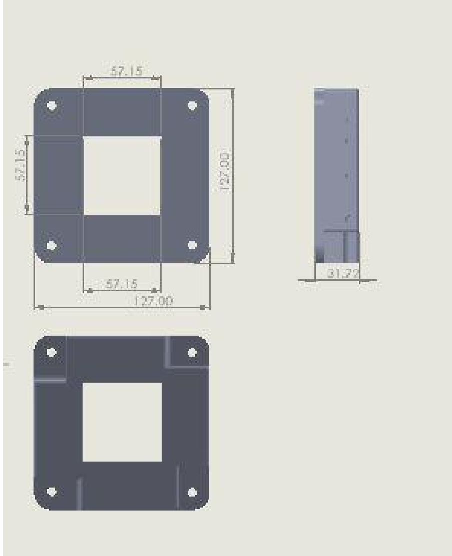
I. **Dimensions:** Circular flange, 127 mm diameter

II. **Features:** Bolt holes for gantry arm and bearing block connection

Production:

1. Print flat for surface accuracy
2. Post-process as above

3.11.6 Bearing Blocks



I. **Dimensions:** 127 mm × 127 mm × 31.72 mm thickness

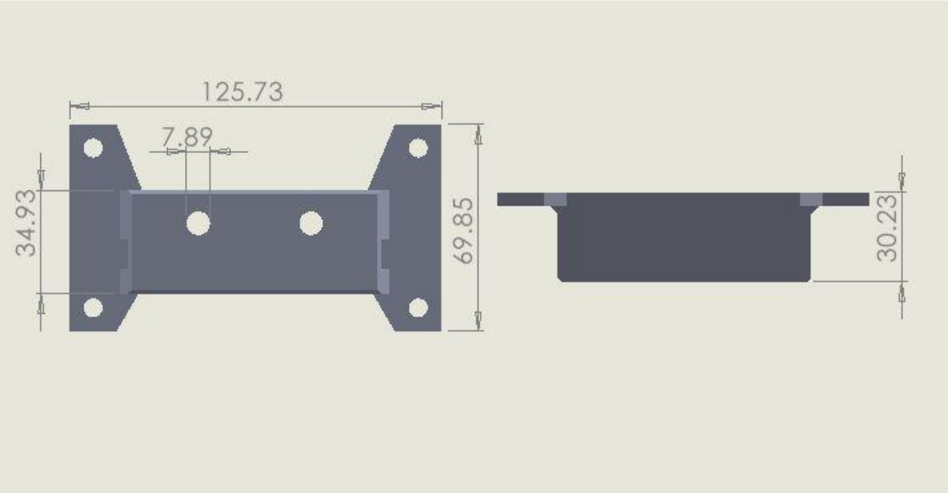
II. **Features:** Precision bearing slots, bolt holes, reinforcement ribs

Production:

1. Orient bearing slots upward
2. Print, heat treat, and machine slots for bearing fit

Assembly: Mount linear bearings for gantry guidance

3.11.7 Bearing



Captures

I. **Dimensions:** 125.73 mm × 69.85 mm

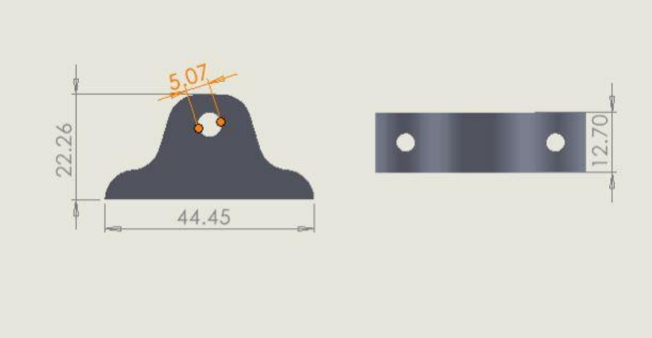
II. **Features:** Snap-fit clips to secure bearings

Production

1. Print clips carefully, sand for smooth snap action
2. Heat treat after printing

Assembly: Hold bearings securely in bearing blocks

3.11.8 Belt Tensioners



I. **Dimensions:** 44.45 mm × 22.26 mm × 12.70 mm

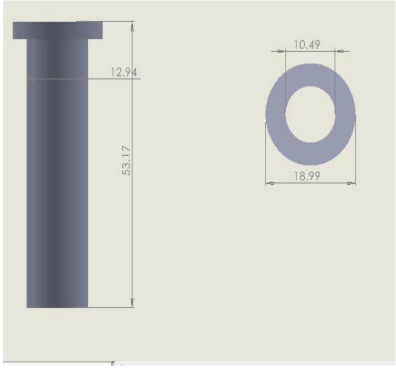
II. **Features:** Adjustable slots for tension control, mounting holes

Production:

1. Orient to minimize support on sliding surfaces
2. Heat treat and sand sliding areas

Assembly: Maintain belt tension for accurate gantry motion

3.11.9 Bolt Spacers



I. **Dimensions: 18.99** mm diameter

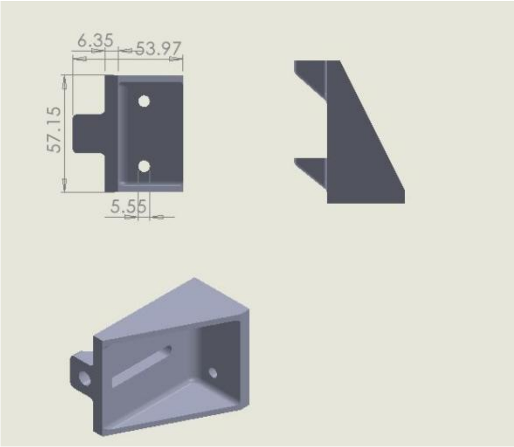
II. **Features:** Central bore for shafts, chamfered edges

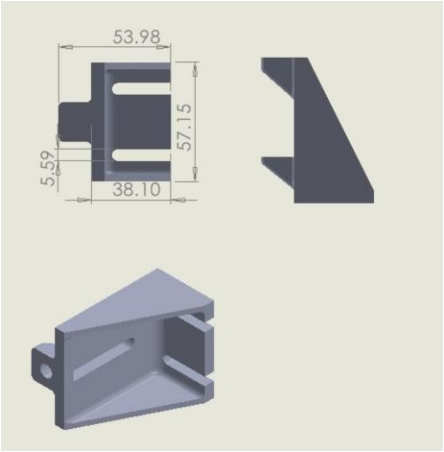
Production:

1. Print standing vertically for roundness
2. Post-process bore for smooth fit

Assembly: Position on shafts to maintain belt and pulley spacing

3.11.10 Belt Mount Active & Belt Mount Idler





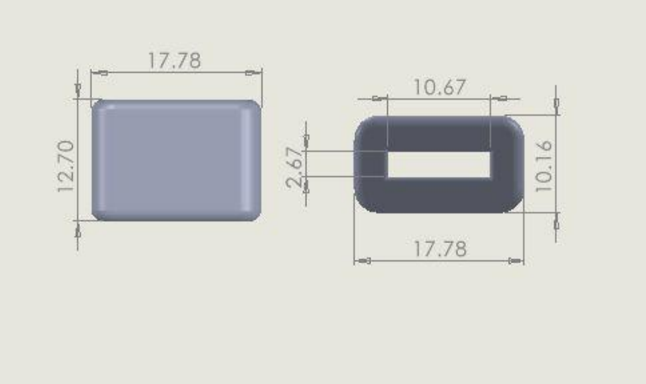
I. **Features:** Mounts for drive and idler pulleys, bolt holes, ribs

Production:

1. Print with supports as needed
2. Heat treat and bead blast

Assembly: Attach pulleys for belt drive system

3.11.11 Belt Clamps



I. **Dimensions:**17.78 mm × 12.7 mm

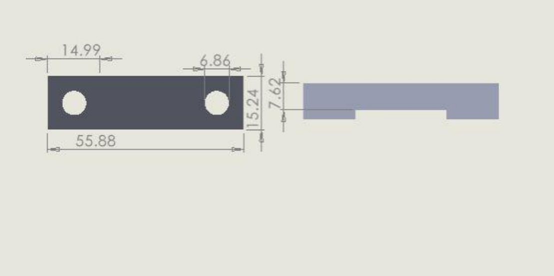
II. **Features:** Clamping slots, mounting holes

Production:

1. Print with solid infill
2. Post-process for smooth clamping surfaces

Assembly: Secure belts at anchor points

3.11.12 Torch Clamp



I. **Dimensions:** 55.88mm × 15.24 mm

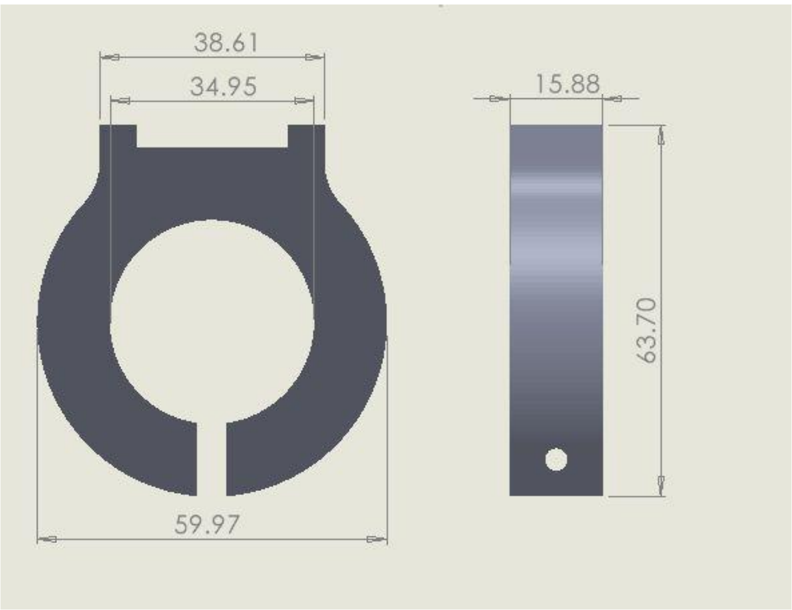
II. **Features:** Adjustable clamp jaws, bolt holes

Production

1. Print with suitable orientation to preserve clamp details
2. Heat treat and bead blast

Assembly: Secure plasma cutting torch firmly in place

3.11.13 Torch Holder



I. **Dimensions:** 59.97 mm diameter x 15.88mm thickness

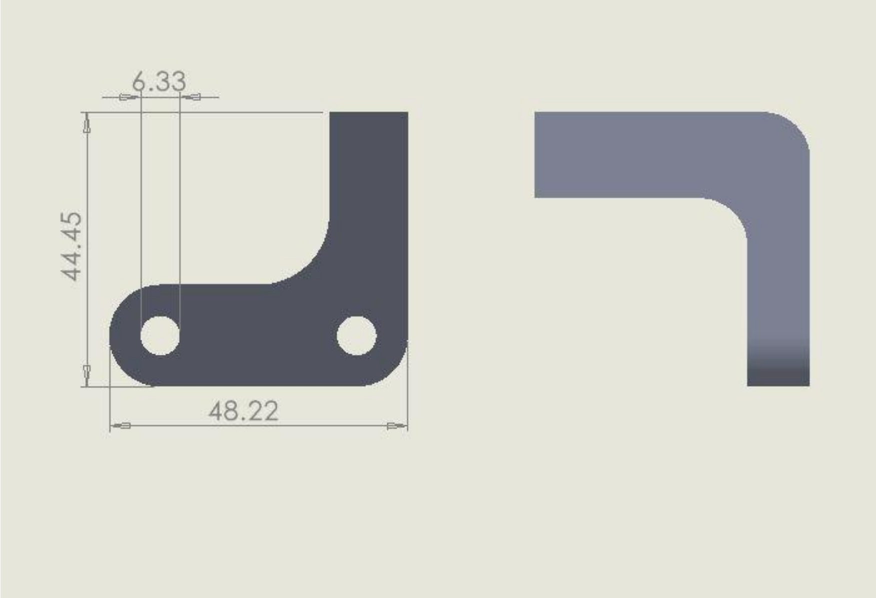
II. **Features:** Mounting points, cable routing channels

Production:

1. Print with supports as needed
2. Post-process and machine mounting holes

Assembly: Holds torch and guides cables neatly

3.11.14 Switch Triggers



I. **Dimensions:** 44.45 mm × 48.22 mm

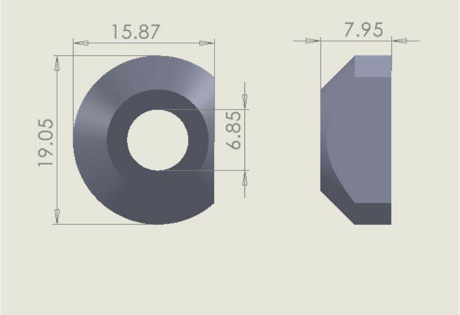
II. **Features:** Lever arm to activate limit switches

Production

1. Print flat for precision
2. Post-process for smooth operation

Assembly: Installed to actuate machine limit switches reliably

3.11.14 Standoffs



I. **Dimensions:** 19.05mm diameter

II. **Features:** Threaded ends for mounting electronics and accessories

Production:

1. Print vertically for thread quality
2. Tap threads post-printing

Assembly: Provide spacing and mounting points for control board

3.12 Fabrication Procedure

1. The fabrication of the CNC plasma cutting machine involved the following steps:
2. Designing the machine layout using CAD software
3. Designing and printing 3D parts
4. Cutting the steel materials according to the required dimensions
5. Welding the machine frame
6. Installing the linear guide rails
7. Mounting the stepper motors
8. Installing timing belts and pulleys
9. Mounting the plasma torch holder
10. Connecting the electronic control system
11. Testing the machine operation

3.13 Assembly of the Machine

After fabrication, all mechanical and electronic components were assembled together. The stepper motors were connected to the motion system, and the CNC controller was installed.

Electrical wiring was carefully done to ensure proper connection between the controller, motor drivers, and power supply.

The plasma torch was mounted on the moving carriage so that it could move along the programmed cutting path.

3.14 Testing of the Machine

The completed CNC plasma cutting machine was tested to verify its performance.

The testing process included:

- Checking motor movement along X and Y axes
- Running sample G-code programs
- Cutting test patterns on metal sheets
- Evaluating cutting accuracy and surface quality

The results showed that the machine was capable of performing automated cutting operations with reasonable accuracy

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

After the design and fabrication stages were completed, the machine was assembled and subjected to a series of operational tests to determine its performance and reliability.

The main objective of this testing phase was to examine whether the machine could successfully perform automated cutting operations according to the programmed instructions. The evaluation focused on factors such as cutting accuracy, speed of operation, quality of the cut edges, and overall machine stability.

4.2 System Testing Procedure

The testing of the CNC plasma cutting machine was carried out in several stages to ensure that each component of the system was functioning properly before performing the actual cutting operation.

Mechanical Testing

The first stage involved testing the mechanical components of the machine. The guide rails, belts, pulleys, and moving carriage were carefully inspected to ensure proper alignment and smooth movement along the X and Y axes. The stepper motors were activated to confirm that they could move the cutting head accurately along the programmed paths. The movement of the cutting carriage was observed to ensure that there was no excessive vibration or obstruction during operation.

Electrical Testing

The second stage involved testing the electrical components of the system. The CNC controller board, stepper motor drivers, power supply, and wiring connections were checked to ensure proper electrical connectivity.

The motors were tested individually to confirm that they responded correctly to control signals sent from the CNC software.

Software Testing

The CNC control software was then connected to the machine to test the communication between the computer and the CNC controller. Several sample G-code programs were loaded into the system to verify that the machine could interpret and execute the programmed instructions correctly.

4.3 Cutting Performance Evaluation

After confirming that all mechanical and electrical components were functioning properly, the CNC plasma cutting machine was tested by performing actual cutting operations on metal sheets.

Test Materials

The materials used for the cutting test included:

- Mild steel sheets
- Aluminum sheets

These materials were selected because they are commonly used in fabrication industries and are suitable for plasma cutting operations.

Test Conditions

During the cutting process, the following parameters were observed:

- Cutting speed
- Plasma arc current
- Torch height above the metal surface
- Stability of the machine during operation

The CNC plasma cutting machine was able to follow the programmed cutting path accurately and produce the desired shapes.

4.4 Cutting Quality Assessment

The quality of the cut produced by the CNC plasma cutting machine was evaluated based on several factors including:

- Smoothness of the cut edges
- Dimensional accuracy of the cut shapes
- Presence of slag or molten metal deposits
- Uniformity of the cut width (kerf)

The results showed that the machine produced relatively smooth cuts with minimal slag formation. The kerf width remained fairly consistent throughout the cutting process.

However, slight variations were observed in some areas due to minor vibration of the machine frame and variations in torch height.

4.5 Accuracy Analysis

To evaluate the accuracy of the machine, several test shapes such as squares and circles were cut from the metal sheets. The dimensions of the cut shapes were measured using a measuring tape and compared with the dimensions specified in the design program.

The comparison showed that the machine produced cuts that were close to the expected dimensions, with only small deviations observed. These deviations were mainly caused by mechanical tolerances and slight misalignment in the motion system.

Despite these small variations, the overall performance of the machine was satisfactory for small-scale fabrication applications.

4.6 Machine Efficiency

The CNC plasma cutting machine demonstrated improved efficiency compared to manual cutting methods. Once the cutting program was loaded into the CNC controller, the machine was able to perform the cutting operation automatically without continuous human supervision.

This automation significantly reduced the time required to complete cutting tasks and allowed the machine to produce multiple parts with consistent accuracy.

4.7 Observed Limitations

Although the fabricated machine performed successfully, several limitations were observed during testing. One of the main limitations was the vibration of the machine frame when the motors operated at higher speeds. This vibration slightly affected cutting accuracy in some cases.

Another limitation was the absence of an automatic torch height control system. Maintaining a constant distance between the plasma torch and the workpiece is important for achieving optimal cutting quality.

Additionally, electrical noise generated by the plasma arc occasionally interfered with the electronic control system. Proper shielding and grounding of the electrical components can help minimize this problem.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The design and fabrication of the CNC plasma cutting machine were successfully completed. The machine was developed using locally available materials and affordable components, making it suitable for small workshops and educational institutions.

The fabricated system demonstrated the ability to cut electrically conductive metal materials using computer-controlled movements. The integration of CNC technology with plasma cutting significantly improved cutting accuracy and efficiency compared to manual methods.

The testing results showed that the machine could successfully perform automated cutting operations and produce different shapes with reasonable precision. Therefore, the project achieved its main objective of developing a functional CNC plasma cutting machine.

5.2 Recommendations

Based on the observations made during the development and testing of the machine, the following recommendations are suggested for future improvements:

1. A stronger and more rigid machine frame should be used to reduce vibration during operation.
2. An automatic torch height control system should be added to improve cutting quality on uneven surfaces.
3. More powerful stepper motors or servo motors can be used to improve machine performance.

4. Proper electrical shielding should be implemented to reduce interference from the plasma arc.
5. Advanced CNC control software can be integrated to improve machine precision and efficiency.

5.3 Contribution of the Project

This project contributes to the development of a low-cost CNC plasma cutting system that can be used for training, research, and small-scale metal fabrication.

The machine can serve as a practical demonstration tool for students studying mechanical engineering, manufacturing technology, and automation systems.

REFERENCES

Mikell P. Groover (2015). Automation, Production Systems, and Computer-Integrated Manufacturing. 4th Edition. Pearson Education Limited.

Serope Kalpakjian & Steven Schmid (2014). Manufacturing Engineering and Technology. 7th Edition. Pearson Education.

M. Adithan (2007). Computer Numerical Control Machines. New Age International Publishers.

Hypertherm (2016). Plasma Cutting Technology: Theory and Practice. Hypertherm Technical Manual.

Peter Smid (2008). CNC Programming Handbook. Industrial Press Inc.

S. K. Hajra Choudhury, A. K. Hajra Choudhury & Nirjhar Roy (2010). Elements of Workshop Technology. Media Promoters and Publishers.