SEMI-AUTOMATED WELDING MACHINE USING ADAPTIVE CONTROL SYSTEM AND PREDICTION ANALYSIS USING SUPERVISED LEARNING

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

Quantity monitoring is an important task for controlling and correcting factors that are necessary for a proper weld. The major factors which affect the welding process are temperature, current and voltage, velocity, wind speed, and gas flow rate. They play a vital role hence monitoring of these factors is very essential. In this work, monitoring the data is done by motors and the Arduino microcontroller. The consumption of welding electrodes, temperature, gas flow rate, velocity, current, and voltage. This semi-automated welding machine is affordable compared to fully automated welding machines so it is economical for Small Scale Industries and can reduce human error. The prediction analysis for the obtained data set will be done using Multi-linear Regression.

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CHAPTER 1
INTRODUCTION

1.1 Semi-Automation

Semi-automation is a process or operation done by the combined efforts of man and machine, with both human and machine phases often coordinated by a centralised computer controller. In manufacturing, production processes may be totally manual, semi-automated, or fully automated. In this instance, the proportion of human and automated stages may vary for semi-automation. Typically, a computer controller orchestrates semi-automated manufacturing operations by sending signals to the worker at the appropriate moment to complete a step. Typically, the controller awaits confirmation that the human-performed phase has been completed through a human-machine interface or distributed electronic sensors. Controllers inside semi-automated processes may either directly operate equipment or provide signals to machines spread across the operation. Within semi-automated processes, centralised computer controllers orchestrate processes by instructing the worker, providing electronic communication and control to process equipment, tools, or machines, and performing data management to record and ensure that the process meets established process criteria.

Due to the intricacy of the work or the limited quantity of items produced, many firms opt for semi-automation rather than complete automation. Other procedures may not be completely automated since it may restrict their adaptability to production demands.

1.2 Feedback Control

There are two kinds of control loops: open-loop control and closed-loop feedback control. The output of an open-loop system is independent from its input. In a closed-loop system, the intended output is dependent on the input. The non-feedback system is the open-loop system, whereas the feedback system is the closed-loop system.

1. Discrete Control
2. PID Control
3. Sequential Control

1.2.1 Discrete control

On-off control is one of the basic methods of control. An example is a thermostat used on home appliances that may either open or shut an electrical circuit. Initially, thermostats were designed as actual feedback-control systems as opposed to the ordinary on/off domestic appliance thermostat.

1.2.2 PID Control

Industrial control systems make considerable use of PID controllers. In a PID loop, the controller continuously calculates an error value(t) as the difference between the planned setpoint and a measured process variable and performs a correction based on proportional, integral, and derivative terms, which give their names to the controller type. The theoretical understanding and application extend back to the 1920s and are used in almost all analogue control systems, first with mechanical controllers, then discrete electronics, and most recently industrial process computers.

1.2.3 Sequential control and logical sequence or system state control

Sequential control may adhere to either a predefined sequence or a logical sequence that executes distinct operations based on the various system states. A timer on a lawn sprinkler is an example of an adjustable but otherwise fixed sequence.

The States are the numerous circumstances that may arise in a system usage or sequence scenario. An elevator is an example of a system that employs logic based on the system state to conduct specific actions in response to its status and operator input. For instance, if the operator clicks the floor n button, the system will reply based on whether the elevator is stopped or moving, going up or down, the door is open or closed, and other variables.

Relay logic, in which electrical relays engage electrical connections that either start or cut power to a device, was an early development of sequential control. Relays were initially employed in telegraph networks before they were developed for regulating other devices, such as starting and halting industrial-sized electric motors and opening and shutting solenoid valves. Using relays for control enabled event-driven control, where activities may be performed out of order in reaction to external events. These were more responsive than the stiff, single-sequence cam timers. Complex instances included maintaining safe sequences for equipment such as swing bridge controls, where a lock bolt had to be freed before the bridge could be moved, and the lock bolt could not be released until the safety gates had been closed.

In certain plants, the total number of relays and cam timers might reach hundreds or even thousands. Ladder logic, where schematics of the linked relays resembled ladder rungs, was one of the first programming approaches and languages required to make such systems understandable. Later, programmable logic controllers were created to replace these hardware collections with a single, more readily reprogrammable device.

In a conventional hardwired motor start and stop circuit (called a control circuit), a motor is started by pressing a "Start" or "Run" button that triggers a pair of electrical relays. The "lock-in" relay secures connections that keep the control circuit active when the button is released. (The start button is a typically open contact, whereas the stop button is a normally closed contact.) Another relay activates a switch that powers the device that throws the motor starting switch (three sets of contacts for three-phase industrial power) in the main power circuit. Large motors employ high voltage and suffer a significant inrush current, making speed crucial for creating and breaking contact. With manual switches, this may be hazardous to employees and property. The "lock-in" contacts in the start circuit and the main power contacts for the motor are kept engaged by their respective electromagnets until a "stop" or "off" button is hit, de-energizing the lock in relay.

Interlocks are often introduced to control circuits. Assume that the example motor is powering equipment that has a vital requirement for lubrication. In this situation, an interlock might be installed to guarantee that the oil pump is functioning before the motor begins.

Timers, limit switches, and electric eyeballs are further frequent control circuit components.

For powering actuators on mechanical components, solenoid valves are often utilised with compressed air or hydraulic fluid. While motors are used to provide continuous rotary motion, actuators are typically a better choice for intermittently creating a limited range of movement for a mechanical component, such as moving various mechanical arms, opening or closing valves, raising heavy press-rolls, and applying pressure to presses.

1.3 Industrial Automation

In industries, automation is utilized to increase output while lowering labour expenses. In industrial automation, several industrial communication systems, such as programmable logic controllers and programmable automated controllers. By allowing for improved quality management, industrial automation increases productivity. It facilitates mass production by reducing product cycle time while maintaining excellent quality. As a result, a given labour input might produce a wide range of outputs.

The use of automated machinery to combine several production processes decreases processing times and effort while also removing the need for human labour. As a result of manufacturing automation, the cost of human labour has decreased. Because technology eliminates human interaction, the chance of human mistake is lessened. With increased automation enforcement, adequate and steady product production may be maintained by adaptively controlling and tracking manufacturing processes at all levels, from the laboratory to the factory floor. Automation will completely eliminate the requirement for manual process inspections. Manufacturing processes employ closed-loop management approaches to dynamically modify process variables and derive values using automation systems

1.4. Computer Control

Computers are capable of sequential control and feedback control, and generally a single computer will perform both functions in an industrial setting. Programmable logic controllers (PLCs) are a sort of special-purpose microprocessor that replaced numerous hardware components in relay logic systems, such as timers and drum sequencers. Increasingly, general-purpose process control computers have replacing standalone controllers, with a single computer able to execute the functions of hundreds of controllers.

Process control computers may process data from a network of PLCs, instruments, and controllers to execute standard (such as PID) control of numerous individual variables or, in certain situations, to implement complicated control algorithms using many inputs and mathematical manipulations. They can also analyse data, provide real-time graphical displays for operators, and generate reports for operators, engineers, and management.

1.4 Controlling Input Parameter using Arduino

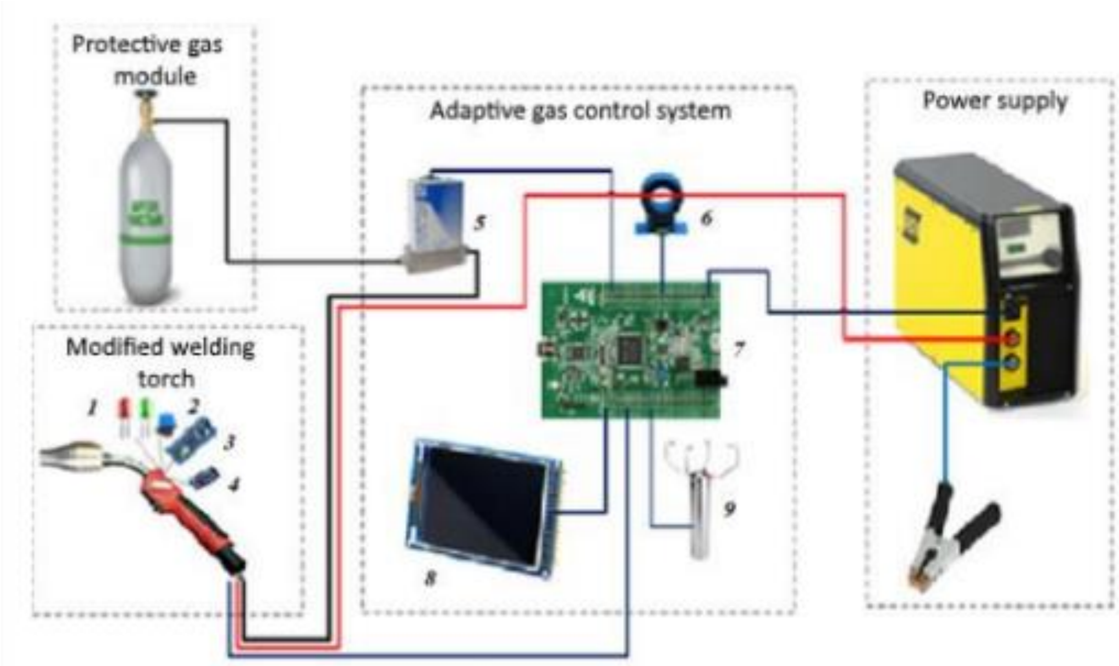


Fig 1. Adaptive Control

1.LEDs 2.Position Sensor 3.Burner Position Sensor 4.Microcontroller 5.Electronic protective Gas low meter 6. Current Sensor based on Hall effect 7.Main Microcontroller 8.Information Display

1.5 Welding

Welding is a manufacturing procedure used to create a high-strength junction between two or more pieces by heating them to their melting point, with or without the use of pressure and the use of filler metal. The filler metal has a similar melting point to the base metal.

1.5.1 Classification of welding process

1.5.1.1Plastic welding or Pressure welding:

When the metal develops a plastic condition due to heating, external pressure is applied. In this procedure, externally applied pressures play a significant part in the bonding action. Pressure Welding Process refers to "a range of welding methods that induce coalescence at temperatures virtually below the melting point of the base materials being connected without the inclusion of a filler metal." Without melting the base metal, coalescence is created via temperature, time, and pressure. Solid state welding includes some of the very first methods. The benefit of this technique is that the base metal does not melt, therefore the original characteristics of the linked metals are preserved.

1.5.1.2 Fusion welding or non-Pressure welding:

The material at the joint is melted and then allowed to harden. In this process, the joining operation involves melting and solidification, and external forces have no effect on coalescence. Typically, filler material is used in fusion welding to guarantee that the junction is filled. All fusion welding processes require three elements: heat, shielding, and filler material.

1.5.2 Types of welding:

- Gas Welding
- Arc Welding
    - Carbon Arc Welding
    - Shielded Metal Arc Welding
    - Submerged Arc Welding
    - Metal Inert Gas Welding
    - Tungsten Inert Gas Welding
    - Electro Slag Welding
    - Plasma Arc Welding
- Resistance Welding
- Solid State Welding

- Thermo-Chemical Welding
- Radiant Energy Welding

1.5.3 Gas Metal Arc welding:

Gas metal arc welding (GMAW), commonly known to by its subtypes metal inert gas (MIG) and metal active gas (MAG), is a welding procedure in which an electric arc formed between a consumable MIG wire electrode and the workpiece metal(s), thus fusing them (melt and join). Along with the wire electrode, a shielding gas is sent through the welding gun to prevent ambient contamination.

The procedure may be semi-automatic or fully automated. The most common power source for GMAW is constant voltage, direct current, however constant current and alternating current systems may also be employed. Each of the four basic ways of metal transfer in GMAW, globular, short-circuiting, spray, and pulsed-spray, has specific features, benefits, and disadvantages.

1.5.3.1 Tungsten arc welding:

Gas tungsten arc welding (GTAW), also called tungsten inert gas (TIG) welding, is a type of arc welding that uses a tungsten electrode that doesn't need to be replaced. An inert shielding gas protects the weld region and electrode from oxidation and other ambient contaminants (argon or helium). Some welds, known as autogenous welds or fusion welds, do not need a filler metal. Using helium is referred to as heli-arc welding. Plasma is a column of highly ionised gas and metal vapours that conducts electrical energy across the arc. GTAW is often used to weld tiny portions of stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys. The operator has better control over the weld than with competing procedures such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher-quality welds. GTAW is more sophisticated and difficult to learn than most other welding processes, and it is also much slower. As a consequence, plasma arc welding is often automated.

1.5.3.2 Metal arc welding:

Manual metal arc welding (MMA or MMAW) is also known as shielded metal arc welding (SMAW), flux shielded arc welding, or stick welding. To create a weld, the rod and the surface of the work piece must melt together. When an arc is generated between a metal rod (electrode) and a workpiece, both the rod and the workpiece melt, generating a pool of molten metal weld. The flux layer on the rod melts simultaneously, producing gas and slag that hide the weld pool from the environment. The slag must be chipped off the weld bead once it has hardened and cooled after the completion of the weld run (or before the next weld pass is deposited).

The process only permits the fabrication of short weld lengths before a new electrode must be inserted into the welding electrode holder.

CHAPTER 2

LITERATURE REVIEW

[1] ShendageYogesh, etal. The paper conveyed the D-optimal method is relatively a new technique, related to response surface methodology, used for carrying out the design of experiments, the analysis of variance, and the empirical modeling. The D-optimal criterion was developed to select design points in a way that minimizes the variance associated with the estimates of specified mode coefficients. In a sense this method is more useful than central composite design (a conventional response surface method) method that it demands smaller number of experiments to be conducted and also it can tackle categorical factors included in the design of experiments.

[2] MOHD KHAIRULAMZARI BIN HAMJAH,etal. The paper conveyedthe selection of the parameters is a key factor in producing the optimal surface roughness of weld bead. Surface roughness plays a very important factor in mould industries. By improving the surface roughness, extra work or finishing can be avoided and it can reduce time and manpower constraint in producing mould. Nevertheless, the accurate selection of parameters is also very important in the success. Variable parameters such as ampere, travel speed and filler rod feed rate are major factors in producing the best welding surface, Parameters such as current, CFH, arc gap and other parameters must be taken as a constant parameter when setup is done based on the type and dimensions of the work piece.

[3] SanidhSanchala, etal. The paper conveyed in the welding process the number of parameters affected the quality of weld. In case of linear and angular welding, angular welding is much more difficult than linear welding. In order to get the desire quality of weld one has to give accurate feed, which is one of the most important parameter. Due to the automation using VFD the weld accuracy and quality is increase with controllable linear motion of Welding torch with precise

feed of work with less time utilization. By means of 6 degree of freedom the flexibility offers Ease of operation for moving the welding torch smoothly with appropriate adjustment of height, Angle, length etc. For Proper penetration of filler metal in different thickness of sheet metal parts with quality surface finished work is acquired by Angular welding. From this we obtained a quality welding technique by means of accurate surface finished worked with less welding defects is achieved.

[4] Vaishnav Karan,etal. The paper conveyedthe study suggests that the number of parameters affected the worth of weld. In case of linear and angular welding, angular welding is much more problematic than linear welding. In order to get the get quality of weld one has to give precise feed, which is one of the most significant factor. This can be delivered by semi automation which provides the benefit of precise feed, decrease the time of work, fewer skilled labor requisite for the work. The investigates will look to accept the semi automation for angular corner joint Mig welding by given that five degree of freedom for linear and angular motion of welding torch for feeding, and with appropriate controllable method for weld accuracy.

[5] Akshay M, etal. The paper conveyed they have developed “A SEMI-AUTOMATED ARC WELDING MACHINE” which is very useful in small industries and provides safety for the worker. Maximum thickness of work piece (mild steel) the machine can weld is less than 6mm. The maximum length up to which the machine can weld is 150mm and maximum width of the metal piece to be weld is up to 50mm. This would be very helpful in mass production industries having conveyors, MIG and TIG welding and other applications. The commercial production of this project is feasible economically. Semi-automated welding machine takes less time to weld, when compared to the unskilled labor. Adopting semi-automatic welding machine is better than opting unskilled labor for welding.

Portability – As the total weight of the machine is less than 20Kg, these materials are very easy to transport.

[6]AshwaneKumar Srivastava, etal. The paper conveyedthey have developed a fully automated welding which is using in medium and large scale industries. It consists of Drive, Controller, Multi axis robot which is programmed using Teach Pendant after the installation. It is a very high cost automation which the micro and small scale industries could not afford it.

[7]Seayon S. Dmello, etal. The paper conveyedas we seen in the above Literature. They have developed a fully automated 2-axis welding chine which is using in medium and large scale industries. It consists of Drive, Controller, Multi axis robot which is programmed using Teach Pendant after the installation. It is a very high cost automation which the micro and small scale industries could not afford it.

[8]Faiz F. Mustafa, etal. The paper conveyedmachine that hold and carry the welding gun of the MIG machine moving on a circular rail fixed near the pipe groove, can helpfully to improve the welding finish compared with the manual process by maintaining in parameters of welding such as keep the distance between the gun and the groove of weld joint, constant travel speed of the welding gun, also saving in time and funds. Many advantages such as maintain the health of workers, reduced in errors and troubles that occur during the welding process. The machine uses a three DC motors, one for moving around the pipe, the second used to control the gap, and the third for oscillating the welding gun.

[9]Monika, etal. Welding joins two materials. It beats both casting and riveting in terms of speed and cost. There are several things that use welding such as ships, rail road equipment, launch vehicles and boilers. Among the available welding methods are TIG (tungsten inert gas), MIG (metal inert gas), SMAW (shielded metal arc welding), PAW (plasma arc welding), FCAW (flux core arc welding),

SAW (submerged arc welding), GMAW (gas metal arc welding), ESW (electro slag welding), and OA (oxyacetylene) welding [22].

Welding methods are vital in metal manufacturing. The most prevalent welding processes are tungsten inert gas (TIG) and metal inert gas (MIG/MAG). TIG welding uses a non-consumable electrode, while MIG welding uses a consumable wire to join metal. A metal inert gas (MIG) welding procedure uses an AC motor to heat, an electrode to melt, a water tube to cool and solidify the parent metals, and a filler material to make a junction between the parent metals. The quality, productivity, and cost of welded joints are influenced by MIG welding parameters. Arc current, arc voltage, and welding speed all play a role in the welding process. By selecting the right shielding gas, electrode, and welding variable, GMAW can weld any commercially relevant metal in any position.

[10]Eyob Messele Sefene, etal. Before Friction Stir Welding, mechanical fasteners were used to join aluminium and its alloys in aeroplane structural elements. For example, the Eclipse Aviation industry employed 7,300 rivets every Eclipse 500 business class aeroplane (fuselage). The Welding Institute (TWI) of Cambridge, UK, created Friction Stir Welding in 1991 [1, 2]. FSW is a solid-state welding technology commonly used to combine non-ferrous materials like aluminium, magnesium, and copper structures where high strength to lightweight welds are required [3-7]. It uses less energy than traditional fusion welding and does not utilise consumable materials like electrodes or shielding gases. Aerospace, transportation, railway, shipbuilding and other industries use FSW.

CHAPTER 3
PROBLEM STATEMENT

During hand welding, problems such as undercut, lack of fusion, insufficient penetration, fractures, insufficient surface finishing, not having a fair feed, and so on might occur. The abovementioned welding faults can be reduced with the help of automation. This project helps to increase the efficiency of automation by integrating with Artificial Intelligence (AI), which helps in controlling input parameter. Welding is a very complicated process that includes the interplay of multiple nonlinear welding factors. As a result, quality assurance through defect-free welding necessitates in-process monitoring and control. The welding industry is always looking for ways to make automated systems adapt to changing welding circumstances while maintaining consistent quality at a low cost.

The main problems associated with controlling Input Parameter are as follows

- ✓ Shielding Gas Consumption
- ✓ Welding Current and Torch angle
- ✓ Welding Speed and Trajectory
- ✓ Weld Bead Geometry
- ✓ Electrode Positioning
- ✓ Weld Pool

CHAPTER 4

METHODOLOGY

4.1 METHODOLOGY

Step1: Literature Review

Literature review is defined as the set of ideas which is obtained from the projects, research papers etc. These ideas are used or further developed to execute the project

Step 2: Statement and Problem

Existing problems are identified and is researched according to the field at which the problem occurs. These problems are targeted to rectify design and calculation. The design process is done using solid works software the parts are selected and designed at an approximate value. And calculations are made according to the need.

Step 3: Fabrication

The analysed part is checked and the parts are being fabricated as per calculations, the fabrication process is also called as the construction process of the machine.

Step 4: Assembly and Testing

The fabricated parts are assembled at minimum loss of material and it is assembled according to the design,

Step 5: Result and Discussion

Results of the products are found by how the machine runs and it is being compared to older types of machines.

Step 6: Conclusion

With the results being concluded, the product is being really good for running and for commercial purposes.

Step 7: Future Scope

As the product is made as per current requirements, but the machine can be further developed and made in future which is referred as the future scope.

CHAPTER 5

EXPERIMENTAL WORK

5.1 Terminology

5.1.1 Revolution per Minute

RPM is defined as revolution per minute and it is used to measure how the machines operating in given time speed. In this machine, rpm measures how many times the gears make one full rotation every minute, and it also calculates, how many times each piston goes to and fro in its cylinder.

5.1.2 Torque

Torque is defined as the force measure which can trigger rotation of an object around the axis. Just as force in linear cinematic accelerates an object, torque is what enables an object to accelerate angularly. It is vector quantity

5.1.3 Power

Power in mechanical system is the combination of forces and movement. And power is also defined as Sum of force on an object and velocity of particles.

5.1.4 Current

The flow rate of electrical charges past a region is considered to be an electric current. If there is a net electric charge flow through a region, it is said that there is an electric current. In electrical circuits charge is often carried by electrons which move through a wire

5.2 Design Calculation:

5.2.1Motor Torque Calculation

$$T=1/2\ \pi\ P(F+\mu Wg)$$

Where:

T- Torque (N-m)

F- External Force (N)

W-Mass of Load (kg)

μ- Friction Co-efficient on sliding Force (Approx:0.05 to0.2)

g- Gravity Acceleration (m/s²)

P-Ball screws lead (m)

F= 20% of the load N

W= 4Kg

μ=0.3

g=9.81m/s²

P=1m

20% of the load =0.8*9.81=7.848Nm

T=1(2*3.1415)*(1(7.848+(0.3*4*9.81)

T=3.123Nm.

5.2.2 Motor RPM Calculation:

Welding Speed – 5mm/sec

1 Revolution – 5mm/sec

RPM-60RPM

5.2.3 Screw Rod Calculation:

Major Diameter	= 16 mm
Pitch	= 1/number of threads per inch
	= 1/14 = 0.0714” = 1.813mm
Single thread height	= 0.75*pitch*cos(30)
	= 0.75*1.813*cos30
	= 1.1779mm

Pitch diameter d = Major diameter – single thread height

= 16-1.779

= 14.221mm~14mm

Area of threaded screw rod (A)= 3.14*length of screw rod*d*1.65

= 3.14*500*16*1.65

= 41448mm^2

5.2.4 Weld Pool

In GMAW, clear weld pool image is obtained by three-dimensional (3D) weld pool surface by using **3D vision sensing technology**. This technology showed the weld pool surface as a mirror. Among several welding procedures produced to date, gas metal arc welding (GMAW) is one of the most effective and commonly idealized. GMAW is also regarded a good welding technology for robotic applications because to its high productivity, dependability, and ease of automation. Sheet and bottom welds, on the other hand, present a difficulty in robotic GMAW due to the process's proclivity for melt-through or insufficient penetration. As a result, an intelligent GMAW robotic system is critical. Welding quality control and joint tracking technology are two critical aspects of robotic welding automation. A precise solution for joint tracking and quality control is a must for welding automation to be realized, and welding quality control is the primary challenge. During the actual welding process, the weld pool and weld bead always contain a plethora of important information that typically reflects weld penetration and other weld quality-related aspects. Currently, the primary sensing modalities for weld quality control are ultrasonic, infrared, x-ray, and vision.

Vision sensing has a greater application potential than other sensing techniques since its function is much more comparable to that of a human welder's eyes. Additionally, vision sensing can offer more information about the welding process than other sensing methods. However, the majority of study has been on GTAW, since it is more stable throughout the welding process and simpler to get a good view of the weld pool.

The researchers used 3D vision sensing technologies to assess the three-dimensional (3D) weld pool surface. This method revealed the surface of the weld pool to be a mirror. A laser pattern was fired onto the weld pool’s specular surface, and its reflection was intercepted. The weld pool surface, which controls the reflection of the projected laser pattern, was calculated using the reflection law.

However, the weld pool surface, particularly the GMAW pool surface, is inherently unstable due to dynamic vibration and molten slags, which mix and disorder the reflected laser lines. In this situation, reconstructing the three-dimensional weld pool surface using this approach will be challenging. Aviles-Vinas et al. employed a laser-based sensor to determine the geometry of the bead (width and height) for the control system’s input signal. The laser generator’s red line pattern was projected onto the weld bead, and the picture of the laser line on the weld bead was captured using a camera. An architecture based on artificial neural networks (ANNs) was presented for autonomously learning welding abilities. The laser beam was placed 5 cm away from the welding flame to minimize excessive light, which would have created a 5 to 12.5 second delay to the control system (since the welding speed is between 4 and10 mm/s). Due to the fact that the geometric characteristics of the weld pool and weld bead reflect the welding process’s quality, this article proposes a monitoring system consisting of an active vision sensor and a passive vision sensor for online measurement of the weld bead and weld pool geometry.

A set of image processing algorithms is built and validated using manual measurements and sensor detection. The study establishes a robust sensing technique for multivariable control of the GMAW sheet and bottom weld processes.

5.2.5 Electrode Position and Current consumption:

The Dirichlet Process (DP) clustering approach is developed to forecast process conditions for electric current and electrode location. The anchor chain is a crucial component in vessel anchoring because it must endure not only the ship's weight but also the impact of seawater. Traditional anchor chain quality control consists mostly of stress testing after production, which cannot completely guarantee the quality of each chain. Without specialised training, human operators have difficulties making control choices based on the patterns and features of real-time sensory data. There is an immediate need to use conveniently accessible sensor data from the flash welding process to establish online quality assurance systems that would allow and assist operators in managing the quality of anchor chain. In this paper, we characterise the electric current and electrode position data and develop an online monitoring system. This is one of the first efforts to build unique spatiotemporal warping algorithms for online information extraction and pattern recognition within the context of flash welding process quality assurance. This project seeks to create unique multi-sensor data fusion methods for real-time quality assurance in flash welding processes. To address the problem of misalignment, an unique spatiotemporal warping strategy is proposed. The proposed technique optimally embeds high-dimensional recordings as nodes in a low-dimensional environment. Dirichlet Process (DP) models are used to partition the feature space into local clusters. This maintains the warping distance between any two recordings and emphasises their directional differences. The suggested technology has the potential to revolutionise live monitoring of flash welding operations by offering an indispensable tool.

5.2.6 Weld quality Inspection

Artificial Neural Network (ANN) and Random Forest (RA) microprocessor-controlled ultrasonic welder can give power, energy, force, and displacement data for online monitoring of weld quality.

Non-destructive test (NDT) and Wavelet Packet Transform (WPT) are the two methods are powerful for spot weld quality. Ultrasonic testing and radiography are the most used non-destructive techniques for detecting weld effects. In ultrasonic-based fault classification system, TOFD (Time of Flight Diffraction) scan was combined with ANN (Artificial Neural Network). Welding is a crucial procedure used by a variety of industries, and the introduction of Non-Destructive testing technology has allowed more accurate, quicker, and more effective defect categorization methods.

5.3 3D-Modelling of the system

This 3D view represents the whole assembly of the project.

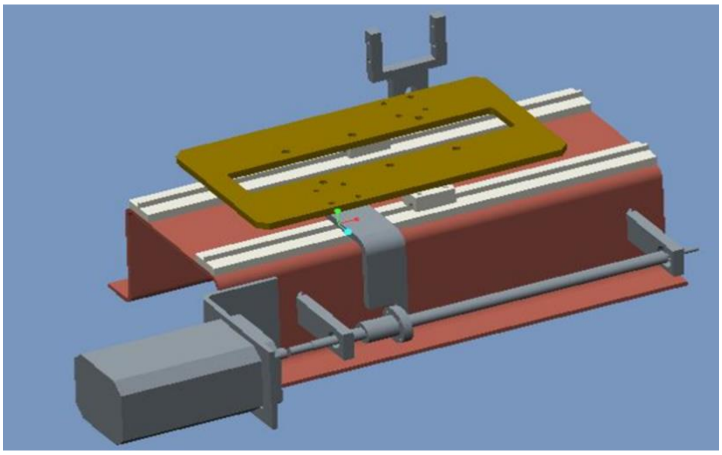


Fig. 2 Orthogonal View

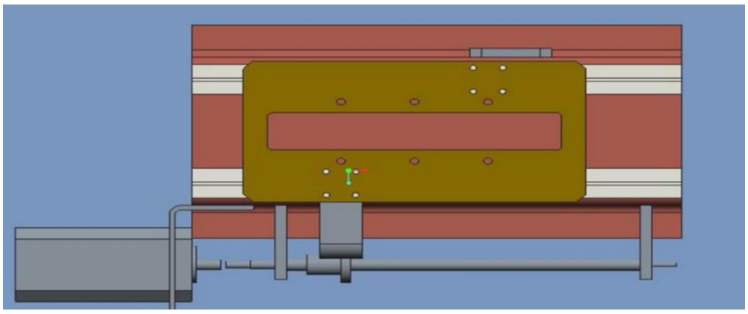


Fig. 5.9. Top View

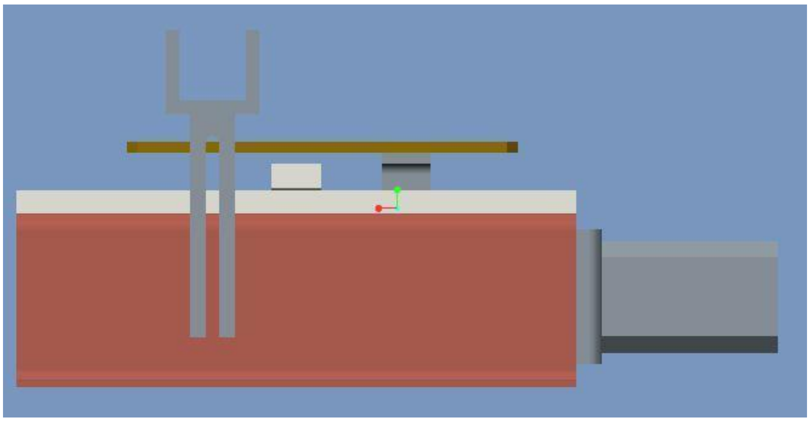


Fig. 3 Side View

5.4 Fabrication

Table no. 1 Components of the machine

S.No	Components	Qty
1	Arduino Controller	1
2	Stepper Motor	1
3	Lead Screw	1
4	Guide Ways	2
5	Driver	1
6	Servo Motor	3
7	Fixture Table	1

5.4.1 Components required

5.4.1.1 ARDUINO UNO

Arduino computer hardware and software company, project, and user community that develops and produces microcontroller kits for making digital devices and interactive things that can detect and control items in the real world. Arduino board designs use a range of microprocessors and controllers. The boards are outfitted with digital and analogue input/output (I/O) pins that can interact with different expansion boards (shields) and other circuitry.

The boards contain serial communications ports, including USB on certain variants, which are also used to load applications from personal computers. Typically, microcontrollers are programmed using a dialect of features from the programming languages Cand C++. In addition to typical compiler tool chains, the Arduino project offers an integrated development environment (IDE) based on the Processing language project.

5.4.1.2 STEPPER MOTOR

DC stepper motors travel in distinct increments. Multiple coils are grouped into groupings termed "phases" By sequentially activating each phase, the motor will revolve step by step. Computer-controlled stepping allows for very fine placement and/or speed control. For this reason, stepper motors are the motor of choice for several precise motion control applications. Stepper motors are available in a variety of sizes, types, and electrical characteristics. A stepper motor may include any number of coils. However, they are related in groupings known as phases. All of the coils in a phase are activated simultaneously.

Always energise the phases in the same manner for unipolar drives. One lead, the "typical" lead, will always be negative. The other lead is always good. Simple transistor circuits may be used to create unipolar drives. Since only half of the coils may be activated at once, there is less available torque. Bipolar drivers use H-bridge circuitry to reverse the current flow across the phases. By electrifying the phases with alternating polarity, all the coils may be used to operate the motor.

A two phase bipolar motor features two coil groups. A 4 phase unipolar motor has four phases. A two-phase bipolar motor will have four wires, two for each phase. Some motors use flexible wiring that permits bipolar or unipolar operation.

5.4.1.3 LEAD SCREW

Lead screws are a common method for converting motor rotation into linear motion. They may provide enough axial rigidity and extremely excellent, smooth minor displacements. Typically, lead screws are preloaded with an axial load that helps to ensure persistent contact between the nut and screw fillets. This reduces hysteresis but also creates heat in the contact region owing to friction. Therefore, lead screws are often restricted to low-load applications with speeds below 10 revolutions per second. A lead screw may be simply engineered to be self-locking under load action and provide a secure solution for vertical applications.

5.4.1.4 GUIDE WAYS

Tool engineering is dependent upon the design of machine tool components. They must endure an externally imposed load. In the next part, machine tool components such as guideways, slideways, and spindle units are explored in depth. In addition, needs, functions, and kinds of guideways and spindle are described. The Guideway is an essential component of machine tools. The primary role of the guideway is to ensure that the cutting tool or operating element of the machine tool follows a specified route. The operating component of the machine tool transports the workpiece.

5.4.1.5 MOTOR DRIVER

Built on the Toshiba TB6600HG IC, the TB6600 micro stepping driver may be used to power two-phase bipolar stepper motors. With a maximum continuous current of 3.5 A, the TB6600 driver may be utilised to handle very large stepper motors such as a NEMA 23. Ensure that you do not connect stepper motors with a current rating more than 3.5 A to the driver. Multiple safety features, including overcurrent, undervoltage shutdown, and overheating protection, are included into the driver. That the actual specs and measurements may vary significantly across manufacturers.

5.4.1.6 SERVO MOTORS

A servomotor is a closed-loop servomechanism that regulates its motion and final position using position feedback. The command position for the output shaft is represented by an analogue or digital signal supplied to the control.

A position encoder is linked to the motor in order to provide position and speed feedback. In the most fundamental instance, just the position is measured. The measured output position is compared to the command position, which is the external input of the controller. If the output position does not match the required position, an error signal is produced, prompting the motor to spin in either direction to bring the output shaft into the right position. As the position approaches zero and the motor stops, the error signal lowers.

5.4.1.7 FIXTURE TABLE

Different kinds of materials are used to make the Jig and its parts. There are times when metals are made harder to make them less likely to wear down. Sometimes they are made of nylon or fibre to protect the work pieces. The paper gave a detailed explanation of what jigs and fixtures are and listed the many benefits of using them in manufacturing. Some of these benefits are: higher production, lower costs, interchangeability and high accuracy of parts, less need for inspection and quality control costs, fewer accidents because safety is improved, significant automation of machine tools, and easy machining of complex and heavy components.

The work also said that jigs and fixtures should be made of rigid, light materials so that they are easy to move around. This is because the design depends on a lot of different factors that are looked at to get the best results. For a sample jig and fixture, mild steel with a 16-millimeter diameter was chosen because it is strong and rigid enough. Mild steel, which has about 0.29 percent carbon and is very cheap, is often the best material for making jigs and fixtures because it is so easy to get. With a feed rate of 0.17 millimetres per revolution and a drill diameter of 16 millimetres, the Thrust/Drilling force was calculated to be 3094 N. The force acting on each lip was found to be 1700 N, the torque was found to be 1360 N-mm, and the clamping force was found to be 4080 N.

The calculated values showed that a 16-millimeter-diameter mould will lead to the construction of rigid and strong jigs and fixtures that will ensure high machining accuracy, consistent product quality, and interchangeability. Lastly, the paper argued that jigs and fixtures should have enough space around them to account for differences in the size of parts, especially when forging, milling, or casting.

5.4.2 Fabrication Process

5.4.2.1. METAL CUTTING

Metal cutting, also called "machining," is the process of taking chips of unwanted metal from a block of metal.

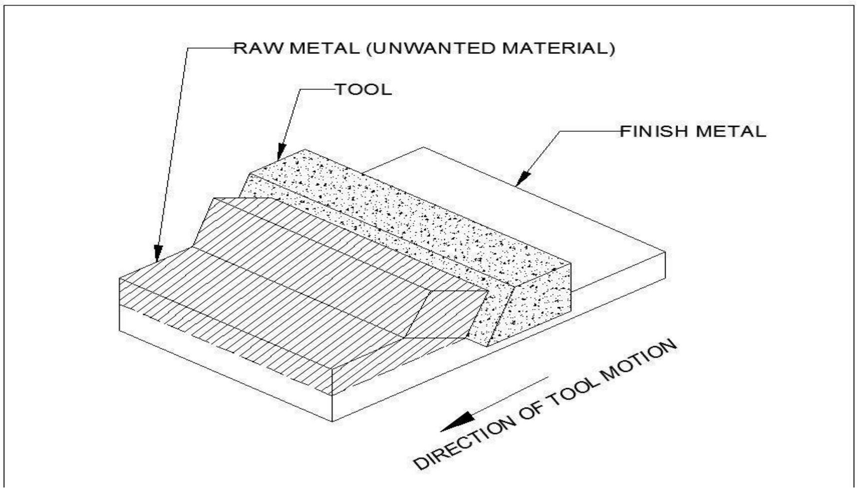


Fig.No 4 Metal cutting

The way cutting processes work is by causing the material being cut to break. Most of the time, the part that breaks off is in small pieces called chips. Sawing, shaping (or planning), broaching, drilling, grinding, turning, and milling are all common ways to cut. Even though the actual machines, tools, and processes for cutting look very different from each other, a simple model called "orthogonal cutting" makes it easy to understand how the break happens.

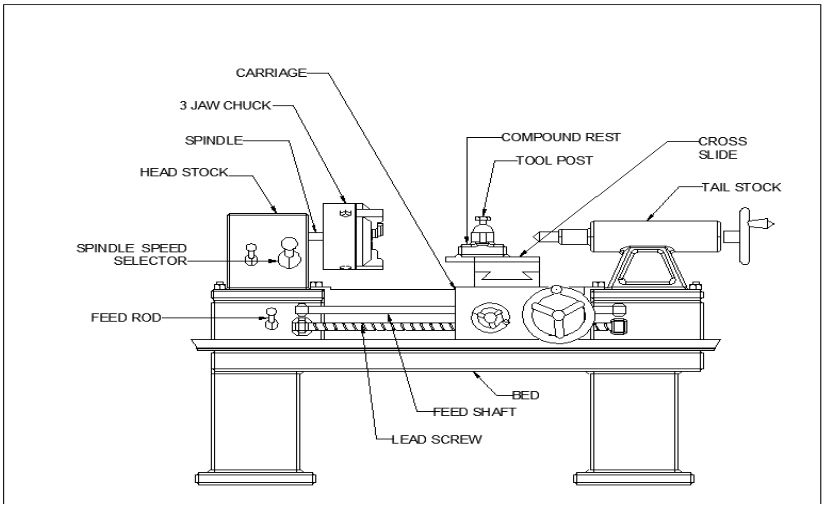


Fig.No 5 Lathe

In every machining process, the work piece is a shape that can completely cover the shape of the finished part. The goal is to get rid of the extra stuff and get the final part. Most of the time, this cutting has to be done in several steps. In each step, the part is held in a fixture so that the tool can get to the part that is exposed. Fixtures like vises, clamps, 3-jaw or 4-jaw chucks, etc. are used often. Each way the part is held is called a "setup." In each setup, one or more cutting tasks can be done with one or more cutting tools. To switch from one setup to the next, we must release the part from the previous fixture, change the fixture on the machine, clamp the part in the new position on the new fixture, set the coordinates of the machine tool with respect to where the part is now, and then start the machining operations for this setup.

Because setup changes take time and cost money, we should try to complete the whole cutting process in as few setups as possible. Process planning is the task of figuring out the order of the individual operations, grouping them into (a minimum number of) setups, and figuring out the fixture used for each setup.

There will be three parts to these notes:

1. Introduction to the processes,
2. The orthogonal cutting model and tool life optimization, and
3. Process planning and machining planning for milling.

5.4.2.2. SAWING:

Cold saws are saws that employ a circular saw blade to cut through different metals, including sheet metal. The name of the saw refers to the motion that occurs throughout the cutting process, which prevents both the metal and the blade from overheating. A cold saw is driven by electricity and is often a fixed saw equipment as opposed to a portable saw.

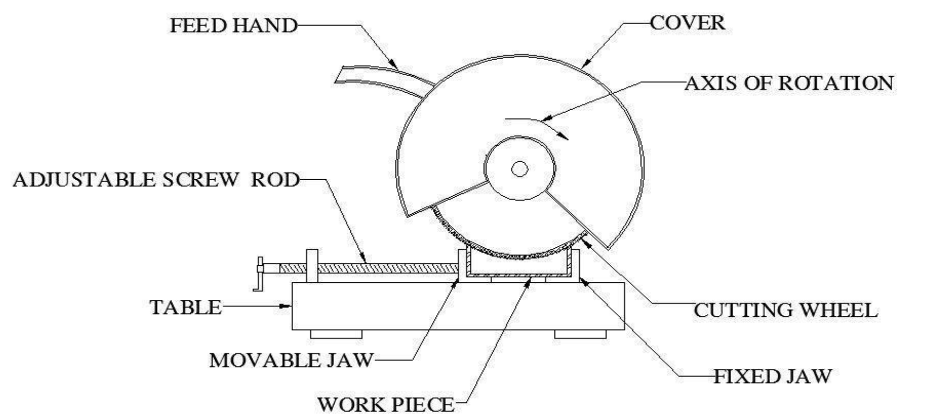


Fig.No 6 Sawing

With a cold saw, the circular saw blades are often made of high speed steel. This kind of steel blade is resistant to wear even with regular use. As a consequence, it is able to finish many cutting jobs before replacing the blade. When saws are used to cut through thicker portions of metal, high-speed steel blades are very advantageous.

In addition to high-speed steel blades, a cold saw may also be fitted with a tungsten carbide-tipped blade. This sort of blade structure is also resistant to wear and strain. Tungsten-tipped blades may be periodically resharpened, so increasing their lifespan. This kind of blade is suitable for use with moderately thin sheet metal and other metallic components.

5.4.2.3 WELDING:

Welding is a way to join two metals that are the same kind. When metals are welded together, both the base metals being joined and the filler metal are melted and fused together. When welding, heat is put into a specific spot. Most metals used for welding are made of iron, like steel and stainless steel. Most welds are stronger than or at least as strong as the metals they are made of.

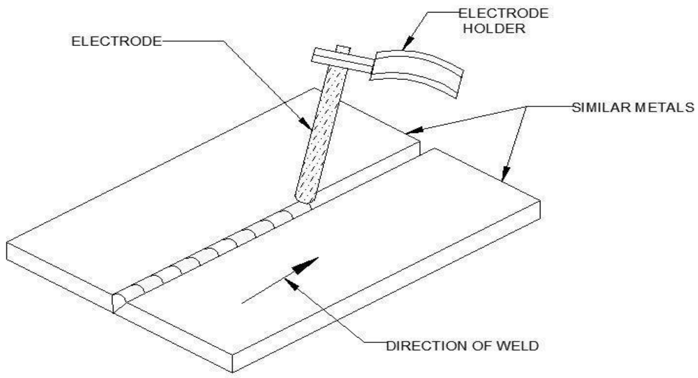


Fig.No 7 Welding

Welding is used to make joints that won't come apart. It is used to make car bodies, aeroplane frames, train cars, machine frames, building structures, tanks, furniture, boilers, general repairs, and ships.

5.4.2.4 OPERATION:

Several welding methods use an electric arc to heat the metal, but we'll only look at a few of them here. We'll start with simple arc welding, also called shielded metal arc welding (SMAW) or stick welding, which is the oldest method. In this process, a DC or AC (mostly AC) electrical machine sends electricity to an electrode holder that holds an electrode that is usually covered with a mixture of chemicals or flux. The work piece is connected to the welding machine by an earth cable, which gives the current a way to go back to where it came from. The weld starts when the tip of the electrode is tapped (or "struck") on the work piece, which starts an electric arc. The high temperature (about 6000oC) makes a pool of molten metal almost instantly, and the end of the electrode keeps melting into this pool to make the joint.

While moving the electrode along the joint, the operator must control the distance between the electrode tip and the work piece.

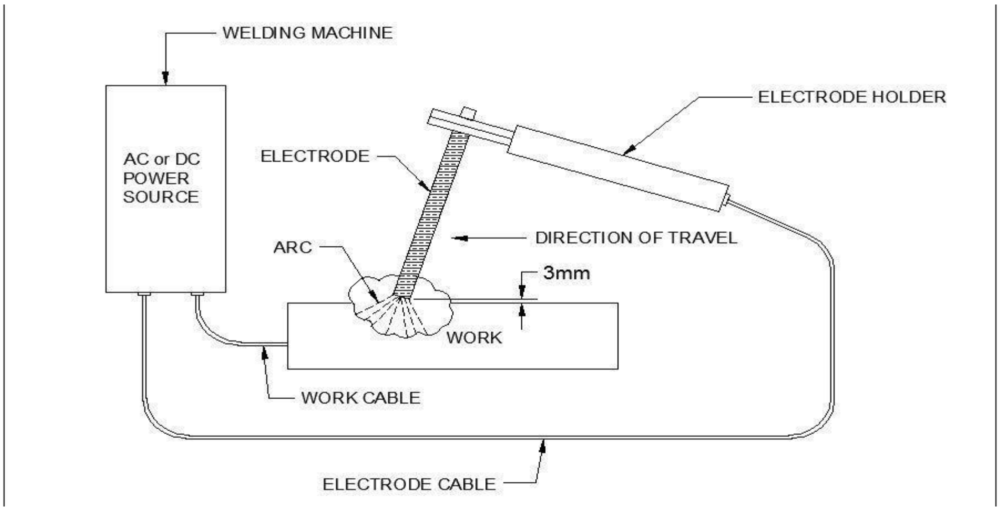


Fig.No 8 Welding Process

In the shielded metal arc welding (SMAW) process, a coating of flux is pushed onto the "stick" electrode. The heat of the arc melts the flux, which makes a gaseous shield to keep air away from the molten pool. The flux ingredients also react with unwanted impurities like surface oxides to make slag, which floats to the top of the weld pool. This makes a crust that protects the joint as it cools. The slag is chipped off when the weld is cold.

The SMAW process can't be used on steel that is thinner than about 3 mm, and since it is a discontinuous process, it can only be done by hand. It is used a lot in jobbing shops and when building steel on-site. There are a lot of different types of electrode materials and coatings, so the process can be used on most steels, heat-resistant alloys, and many kinds of cast iron.

5.4.2.5 DRILLNG:

When drilling, a drill bit is used to cut or widen a hole with a circular cross-section in solid materials. The drill bit is a rotary cutting tool that usually has more than one point. The bit is pressed against the work piece and turned at speeds of hundreds to thousands of turns per minute. This pushes the cutting edge against the workpiece, removing chips (swarf) from the hole as it is drilled.

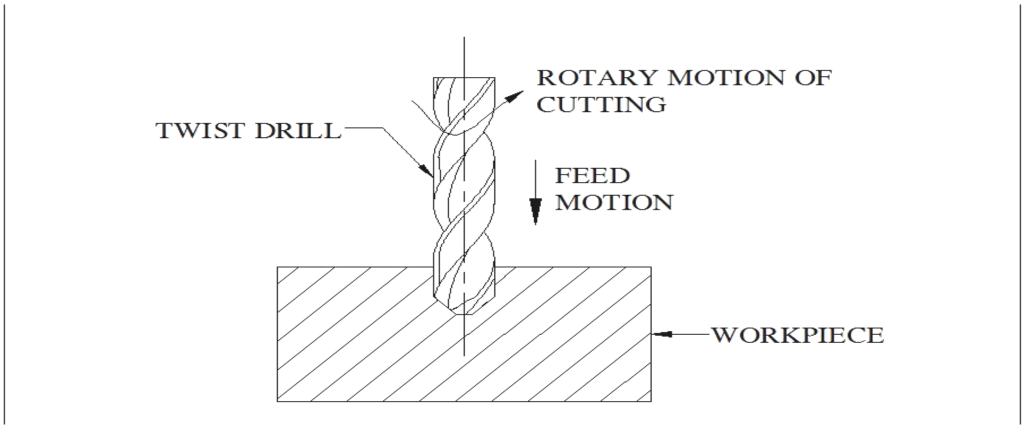


Fig.No 9 Drilling

5.4.2.6 Assembly:

In assembling process all the mechanical component is arranged and is placed in a specific area according to the calculation. Each component is carefully placed in order to have more quality in material. Each and every component is tested and placed and again tested after assembly. This will reduce the cause of error occurred by the machine and in case if there is any error, we can rectify before the final run.

5.4.3 Automation

Automation is done by using the Arduino Controller, TB 6600 Driver and Stepper Motor using Arduino Software.

5.4.3.1 Circuit

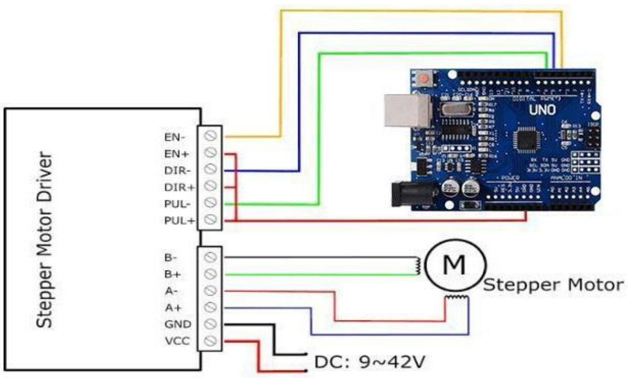


Fig.No 5.10 Circuit Diagram

5.4.4 Source Code

```
#include <AccelStepper.h>

#include <Servo.h>

Servo Voltage_servo;

Servo Speed_servo;

Servo Torch_servo;

#define initial_sw A1

#define final_sw A0

#define torch_ 10

#define voltage_ 5

#define speed_ 6

int flag=0;

int Voltage_value = 0;

int Speed_value = 0;

int Torch_value = 0;

//User-defined values

long receivedSteps = 0; //Number of steps

long receivedSpeed = 0; //Steps / second

long receivedMaxSpeed = 0; //Steps / second

long receivedAcceleration = 0; //Steps / second^2

long CurrentPosition = 0;

char receivedCommand; //a letter sent from the terminal
```

```
long StartTime = 0;

long PreviousTime = 0;

//------------------------------------------------------------------------------

bool newData, runallowed = false; // booleans for new data from serial, and
runallowed flag

bool lastStepPosition = false; //follows the steps to see if the last step was
preformed

//------------------------------------------------------------------------------

AccelStepper stepper(1, 9, 8);// direction Digital 9 (CCW), pulses Digital 8
(CLK)

void setup()

{

  pinMode(initial_sw,INPUT_PULLUP);

  pinMode(final_sw,INPUT_PULLUP);

  Torch_servo.attach(torch_);

  Voltage_servo.attach(voltage_);

  Speed_servo.attach(speed_);

  Torch_servo.write(0);

  Serial.begin(115200); //define a baud rate

  Serial.println("Demonstration of AccelStepper Library"); //print a messages

  Serial.println("Send 'C' for printing the commands.");
```

```
  //setting up some default values for maximum speed and maximum
acceleration
  Serial.println("Default speed: 400 steps/s, default acceleration: 800
steps/s^2.");
  stepper.setMaxSpeed(500); //SPEED = Steps / second
  stepper.setAcceleration(500); //ACCELERATION = Steps /(second)^2
    while(digitalRead(initial_sw)==HIGH)
    {
      receivedSteps -= 100; //value for the steps
      receivedSpeed = 1600;
      RotateAbsolute();
      RunTheMotor();
    }
      receivedSteps = 0; //value for the steps
      receivedSpeed = 0;
  stepper.setCurrentPosition(0);
  stepper.disableOutputs(); //disable outputs
  StartTime = millis(); //start the timer
}
void loop()
{
  //Constantly looping through these 4 functions.
```

```
  //We only use non-blocking commands, so something else (should also be non-blocking) can be done during the movement of the motor
  checkSerial(); //check serial port for new commands
  RunTheMotor(); //function to handle the motor
  SendPosition();
}
void RunTheMotor() //function for the motor
{
  if ((stepper.distanceToGo() != 0))
  {
    stepper.enableOutputs(); //enable pins
    stepper.run(); //step the motor (this will step the motor by 1 step at each loop)
    lastStepPosition = true;
  }
  else //program enters this part if the runallowed is FALSE, we do not do anything
  {
     stepper.disableOutputs(); //disable outputs
     if(lastStepPosition == true)
     {
      Torch_servo.write(0);
      Serial.print("LP");
```

```
      Serial.println(stepper.currentPosition());//Print the message
      Serial.println("TORCH OFF..."); //print the action
      //Serial.print("V"); //You can do the same with speed, but it slows down the
arduino
      //Serial.println(stepper.speed());//Print the message
      lastStepPosition = false;
     }
    return;
  }
}

void SendPosition()
{
  if (stepper.distanceToGo() != 0)
  {
    //The larger this number (300) the better. Multiple serial.println interferes
with the stepper motor
    if((millis()-StartTime) >= 400)
    {
      StartTime = millis();
      Serial.print("P");
      Serial.println(stepper.currentPosition());//Print the message
```

```
      //Serial.print("V"); //Alternatively, we can print speed too, but it can interfere with the motor at high speeds
      //Serial.println(stepper.speed());//Print the message
    }
  }
  else
  {
  // skip
  }
}


void checkSerial() //function for receiving the commands
{
  if (Serial.available() > 0) //if something comes from the computer
  {
    receivedCommand = Serial.read(); // pass the value to the receivedCommad variable
    newData = true; //indicate that there is a new data by setting this bool to true

    if (newData == true) //we only enter this long switch-case statement if there is a new command from the computer
```

{

switch (receivedCommand) //we check what is the command

{

case 'R': //R uses the moveTo() function of the AccelStepper library, which means that it moves absolutely to the current position.

receivedSteps = Serial.parseFloat(); //value for the steps

receivedSpeed =Serial.parseFloat(); //value for the speed

Serial.println("Absolute position (+)."); //print the action

Torch_servo.write(60);

Serial.println("TORCH ON..."); //print the action

RotateAbsolute(); //Run the function

//example: R800 400 - It moves to the position which is located at +800 steps away from 0.

break;

case 'S': // Stops the motor

stepper.stop(); //stop motor

stepper.disableOutputs(); //disable power

Serial.println("Stopped."); //print action

runallowed = false; //disable running

Torch_servo.write(0);

```
break;

case 'A': // Updates acceleration
//runallowed = false; //we still keep running disabled, since we just update a variable
//stepper.disableOutputs(); //disable power
receivedAcceleration = Serial.parseFloat(); //receive the acceleration from serial
stepper.setAcceleration(receivedAcceleration); //update the value of the variable
//Serial.print("New acceleration value: "); //confirm update by message
//Serial.println(receivedAcceleration); //confirm update by message
break;

case 'V': // Updates speed
//runallowed = false; //we still keep running disabled, since we just update a variable
//stepper.disableOutputs(); //disable power
receivedSpeed = Serial.parseFloat(); //receive the acceleration from serial
stepper.setSpeed(receivedSpeed); //update the value of the variable
//Serial.print("New speed value: "); //confirm update by message
//Serial.println(receivedSpeed); //confirm update by message
break;
```

case 'v': // Updates Max speed

//runallowed = false; //we still keep running disabled, since we just update a variable

//stepper.disableOutputs(); //disable power

receivedMaxSpeed = Serial.parseFloat(); //receive the acceleration from serial

stepper.setMaxSpeed(receivedMaxSpeed); //update the value of the variable

//Serial.print("New Max speed value: "); //confirm update by message

//Serial.println(receivedMaxSpeed); //confirm update by message

break;

case 'L': //L: Location

runallowed = false; //we still keep running disabled

stepper.disableOutputs(); //disable power

Serial.print("L");//Print the message

Serial.println(stepper.currentPosition()); //Printing the current position in steps.

break;

case 'U':

runallowed = false; //we still keep running disabled stepper.disableOutputs(); //disable power

stepper.setCurrentPosition(0); //Reset current position. "new home"

stepper.setSpeed(receivedSpeed); //We have to reupdate this, because the above function resets it.

Serial.print("L"); //Print message

Serial.println(stepper.currentPosition()); //Check position after reset.

break;

case 'I':

Voltage_value = Serial.parseFloat();

Voltage_value = constrain(Voltage_value, 0, 180);

Serial.print("Voltage Value:");

Serial.println(Voltage_value);

Voltage_servo.write(Voltage_value);   // sets the servo position according to the scaled value

break;

case 'D':

Speed_value = Serial.parseFloat();

Speed_value = constrain(Speed_value , 0, 180);

Serial.print("Speed Value:");

Serial.println(Speed_value);

```
     Speed_servo.write(Speed_value);
    break;

    case 'T':
     Torch_value = Serial.parseFloat();
     Torch_value =  constrain(Torch_value , 0, 180);
     Serial.print("Torch_value:");
     Serial.println(Torch_value);
     Torch_servo.write(Torch_value);
    break;

    case 'C':
    PrintCommands(); //Print the commands for controlling the motor
    break;


    default:
    //skip
    break;
  }
}
```

```
    //after we went through the above tasks, newData is set to false again, so we
are ready to receive new commands again.
    newData = false;
  }
}



void RotateAbsolute()
{
  //We move to an absolute position.
  //The AccelStepper library keeps track of the position.

  runallowed = true; //allow running - this allows entering the RunTheMotor()
function.
  stepper.setMaxSpeed(receivedSpeed); //set speed
  stepper.moveTo(receivedSteps); //set relative distance
}

void PrintCommands()
{
  //Printing the commands
  Serial.println(" 'C' : Prints all the commands and their functions.");
```

```
  Serial.println(" 'R' : Rotates the motor - absolute using moveTo().R8000 1600");
  Serial.println(" 'S' : Stops the motor immediately.");
//  Serial.println(" 'A' : Sets an acceleration value.");
//  Serial.println(" 'V' : Sets a speed value using setSpeed().");
//  Serial.println(" 'v' : Sets a speed value using setMaxSpeed().");
  Serial.println(" 'L' : Prints the current position/location of the motor using currentPosition().");
  Serial.println(" 'U' : Updates the current position and makes it as the new 0 position using setCurrentPosition().");
  Serial.println(" 'D' : Sets a speed value For Knob.. From 0-180.D60");
  Serial.println(" 'I' : Sets a voltage value For Knob.. From 0-180.I80");
  Serial.println(" 'T' : Sets a Torch value ON/OFF is 30/0.T30");
```

Working:

Our model is an Semi-automatic as in the parameters will be controlled manually using computer whereas the actual welding process is fully automated The work piece is now tightly secured in the vice, which is moving in the same direction as the base plate movement. The screw rod allows the vice to be moved to and fro with the aid of the screw. The motor is responsible for initiating the movement of the screw rod, to proceed with the process of welding. When a electrode holder is moved, The movement is controlled by magnetic reed switches situated at the upward and downward part of the device and at the bottom of the vertical frame's bottom end. In this step, you will activate the entire setup by hitting the switch. The magnetic reed switch located at the very top of the device. The vertical frame detects a magnet that has been inserted or attached on it. Electrode holder, in order for the switch of magnetic reed to function. The input data of the microcontroller, which in turn provides input to the rest of the system. The relay should be set such that the motor turns in a clockwise manner. The clockwise rotation of the screw rod aids in vice-like situation. Task to progress in a forward direction, which consecutively advances. The welding equipment, as well as the workpiece or project to be welded, is linked to the electrode holder and the appropriate earthing system must be assigned to item of the job. The electrode is a conductive material. The holder, together with the electrode, travels in the downward direction. As a result, because of adequate connections on the circuit board and with the assistance of Arduino UNO We can complete the procedure with the appropriate assembly of all pieces. the process of welding.

Voltage and Current consumption:

Voltage and current are controlled using a stepper motor wherein motor angle of rotation determines the adjustment of respective parameters

Code Chunk:

D - Feed speed/Current (0 to 180)

I - Voltage (0 to 180)

5.4.4.1 Volt and Current Servo Motor

5.4.4.2 Torch Angle and Arc Length

Torch angle and position:

Torch position is fixed and angle is changed according to the metal position. The switch is controlled using Arduino UNO.

Code Chunk:

T0 ‘ON’

T30‘OFF’

Fixture Table:

Base Table is controlled using a servo motor that has three-speed level

of 400 RPM, 800 RPM, and 1600 RPM.with travel distance of about 30 cm which are controlled by position points that is from 0 to 60000 where 1cm is equal to 2000 position points

Code Chunk:

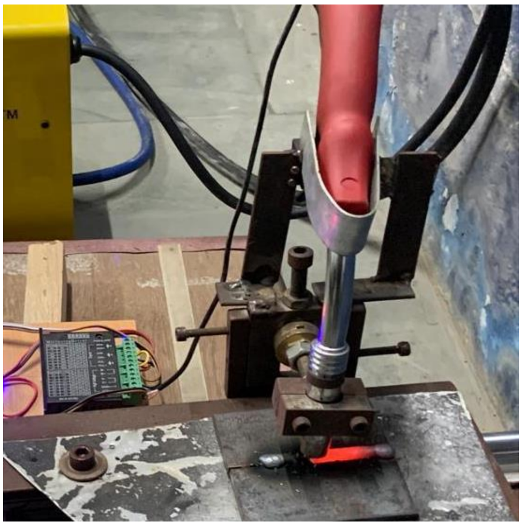
R (position points)<Space>Speed level

5.4.4.3 Fixture Table

5.4.4.3 Fixture Table Top view

Weld Process:

Once the values have been entered the base plate moves to the required position and simultaneously the torch will ON and the welding process will be carried out according to the entered parameters.



5.4.4.4 Weld Pool

5.4.4.5 Weld Pool Top view

CHAPTER 6

RESULTS & DISCUSSION

The welded workpiece using a Semi-automated Welding Machine and the Hardness and Microscopic Structure was done. A comparison between a Manually welded workpiece and a Semi-automated welded workpiece was conducted.

6.1 Butt Joint Automated and Manual

6.2 T-Joint Automated and Manual

Vickers Hardness Testing Results:

Vickers hardness tester with a 1kg load and a 10s dwell time was used to measure the hardness of the base metal, the Heat Affected Zone, and the welds. The depth of the indenter mark or the size of the indenter mark were used to figure out how hard the material was. The hardness of each area was measured in three different places, and the results were put in a table.

TEST REPORTS

Hardness Analysis:

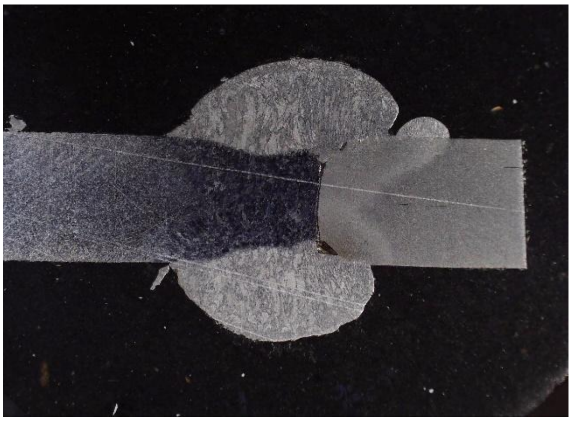
Table No. 2 Hardness Test

	Hardness Values, Hardness Vickers @ 0.5 Kgf; Dwell : 10Sec		
sample I.D	Zone-1 Parent	Zone-2 HAZ	Zone-3 Weld
1	211.6	208.4	212.8
2	172.0	191.1	203.6
3	211.8	204.1	169.1
4	180.4	208.8	158.6

Macroscopic view of weld:

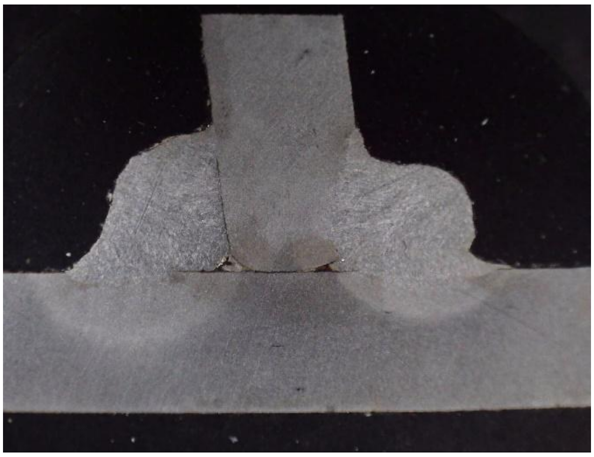
Butt-Joint:

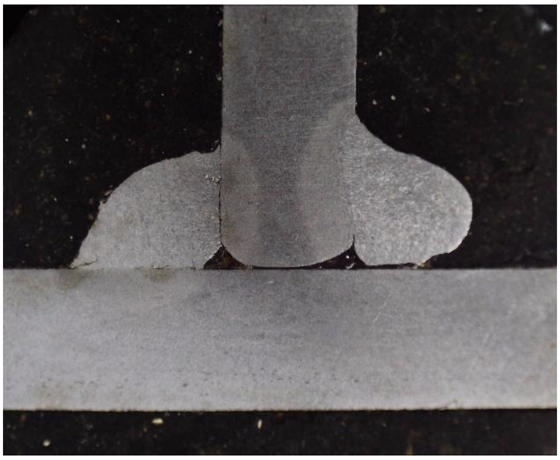
Manual



Automated

T-Joint :



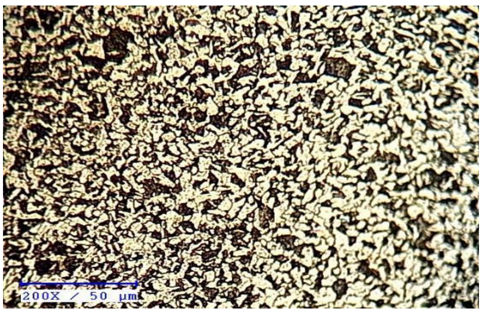


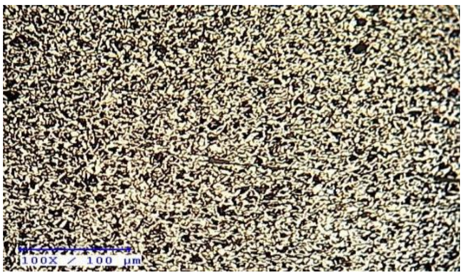
Manual **Automated**

Metallurgical Microscopic Test Results

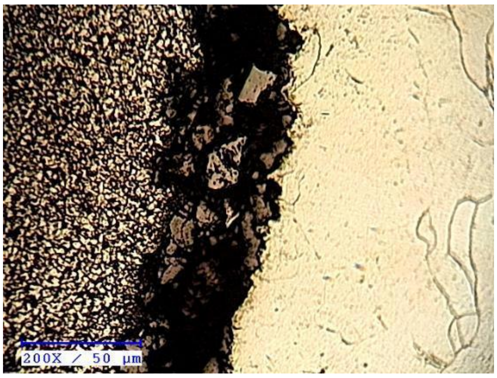
Photographic portions of the samples were collected once the microscopic analysis was completed. The microstructure of the base metal, Heat Affected Zone (HAZ) of base metal, and welded area of the four samples were investigated. Microstructure of weldment areas corresponding to different process parameters were thoroughly studied to determine the existence of hot cracking. Welded joints exhibit a high degree of microstructure heterogeneity. Weldment cross-section profiles and microstructure at various weld zones of Gas Metal Arc Welding Mild Steel 30L are shown in the figures below.

Butt-Joint:





Parent(Manual) **Parent(Automatic)**



Interface(Manual)

Interface(Automati c)

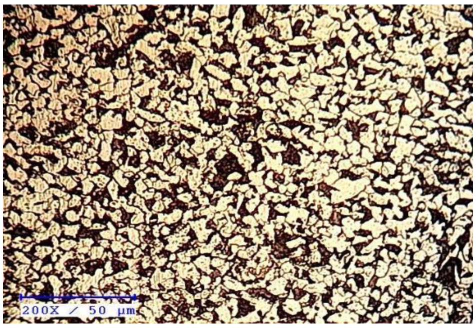
Heat Affected Zone(Manual)

Heat Affected Zone (Automatic)

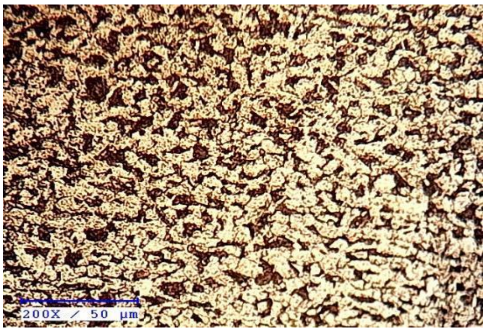
Weld Region (Manual)

Weld Region (Automated)

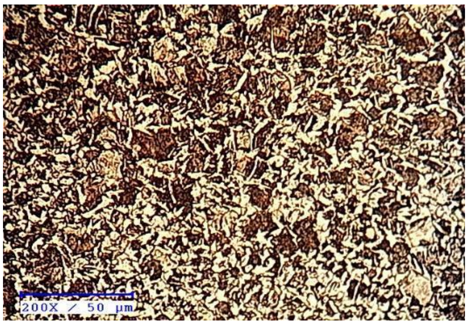
T-Joint:



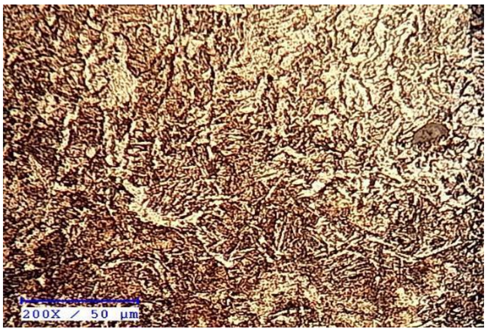
Parent Region (Manual)



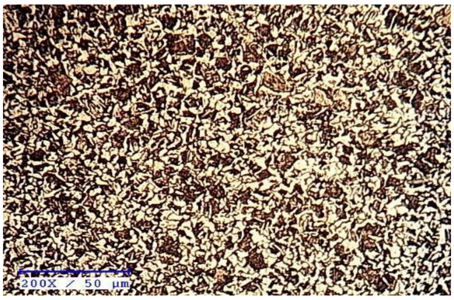
Parent(Automatic)



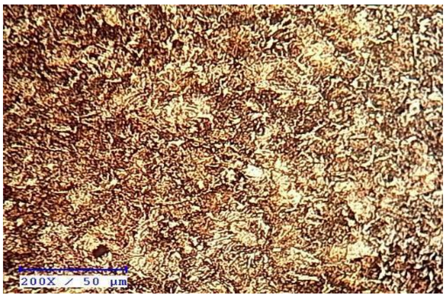
Interface(Manual)



Interface(Automatic)

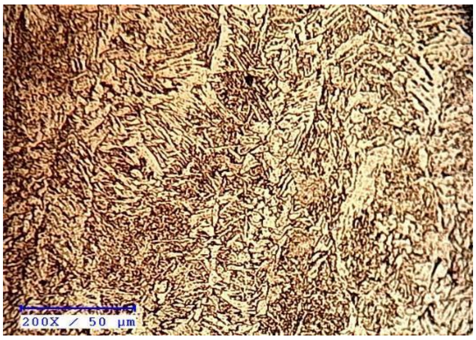


Weld Region(Manual)



Weld Region(Automatic)

Heat Affected Zone(Manual)



Heat Affected Zone(Automatic)

Implementation of Machine Learning Algorithms:

The process of implementing the machine learning algorithms Firstly, the necessary Python libraries such as pandas, NumPy, seaborn, matplotlib, and seaborn are imported to the working environment. In the second step, the dataset was imported to the Jupyter notebook environment and further checked for missing values. Thirdly, exploratory data analysis is carried out to analyze the dataset to extract the main characteristics features using a graphical statistical approach.

Importing Packages

]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sea
```

]:
```
weldingdata= {
    "Current" : [250,250,250,300,300,300,350,350,350],
    "Voltage" : [30,35,40,30,35,40,30,35,40],
    "Gas Flow Rate" : [20,25,30,25,30,20,30,20,25],
    "Hardness of weld Zone" : [158.83,166.33,170.00,163.50,177.33,177.00,171.33,181.00,183.73]
}
```

]:
```
df= pd.DataFrame(weldingdata)
df
```

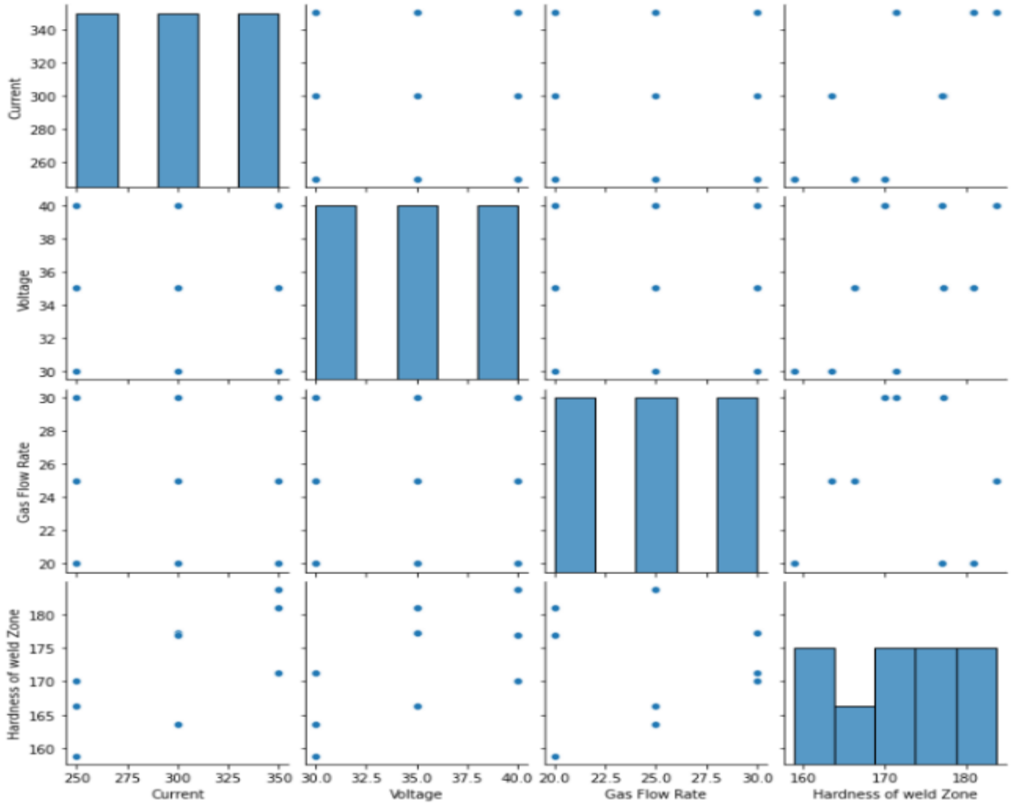
]:

	Current	Voltage	Gas Flow Rate	Hardness of weld Zone
0	250	30	20	158.83
1	250	35	25	166.33
2	250	40	30	170.00
3	300	30	25	163.50
4	300	35	30	177.33
5	300	40	20	177.00
6	350	30	30	171.33
7	350	35	20	181.00
8	350	40	25	183.73

`

In [28]:
```
sea.pairplot(df)
```

Out[28]:
```
<seaborn.axisgrid.PairGrid at 0x2227f3c2f40>
```



Define x and y

In [25]:
```
x=df.drop('Hardness of weld Zone',axis=1).values
y= df['Hardness of weld Zone'].values
```

In [30]:
```
print(x)
```

```
[[250  30  20]
 [250  35  25]
 [250  40  30]
 [300  30  25]
 [300  35  30]
 [300  40  20]
 [350  30  30]
 [350  35  20]
 [350  40  25]]
```

In [32]:
```
print(y)
```

```
[158.83 166.33 170.   163.5  177.33 177.   171.33 181.   183.73]
```

Split the dataset into Training and Test Set

In [33]:
```
from sklearn.model_selection import train_test_split #importing ML package
```

In [35]:
```
X_train,X_test,y_train,y_test = train_test_split(x,y,test_size = 0.3,random_state=0) #splitting 70% training and 30% for testing
```

Train the model on Training Set

In [38]:
```
from sklearn.linear_model import LinearRegression
ml = LinearRegression()
ml.fit(X_train,y_train)
```

Out[38]:
```
LinearRegression()
```

Predict the test set result

In [40]:
```
y_predict = ml.predict(X_test)
print(y_predict)
```

```
[170.76133333 183.76066667 170.984      ]
```

In [42]:
```
ml.predict([[250,35,25]])
```

Out[42]:
```
array([170.984])
```

Evaluate model

In [44]:
```
from sklearn.metrics import r2_score
```

In [45]:
```
r2_score(y_test,y_predict)
```

Out[45]:
```
-1.709745584840297
```

Concluding that model does not yield expected result and need more dataset

Multi-Linear Regression algorithm is used to predict the Heat affected zone (HAZ).

CHAPTER 7

CONCLUSION

The manual welding process has lot many limitations and disadvantages like less productivity, inconsistence quality of welding and dimensional inaccuracy, and dependency on operators to large extent. All these disadvantages are overcome by Semi-Automatic Welding Machine. Semi-automated welding machine takes less time to weld when compared to unskilled labor. Adopting a semi-automatic welding machine is better than opting for unskilled labor for welding. The prediction of HAZ using multi-linear regression failed to yield results as the data required was insufficient.

CHAPTER 8

FUTURE SCOPE

Industry 4.0 is transforming the industrial world. Nearly half of the worldwide workforce is predicted to be replaced by automated technology. Economists believe that artificial intelligence and automation will continue to change the way people work. Automation is being used in a variety of sectors, from manufacturing to banking, to increase productivity, safety, profitability, and quality. The future of automation is bright, with everything being made accessible and accessible.

The project contributed in the welding industry and also in the area where the machines can be simplified and made cost efficient. The project did work in making the work easy, the main purpose of the machine is risk free, safety, accuracy of the welding, to make the semi-automated welding machine affordable to all the Micro and Small-Scale Industries and to give slightly equal output as powerful as the other higher end machines. This is being developed by the mechanical, electrical and electronic components. It performs accurate operations by using semi-automatic machine and also this prototype is transportable, easy to carry. It contains stepper motor, driver, these components are controlled by ARDUINO UNO. This machine can be easily operated by unskilled worker. Hence, no skilled labours required. Cycle time of the machine also can maintain consistently. So, the production output will be consistent.

REFERENCES

[1]ShendageYogesh, etal. The paper conveyed the D-optimal method is relatively a new technique, related to response surface methodology, used for carrying out the design of experiments, the analysis of variance, and the empirical modeling.

[2]MOHD KHAIRULAMZARI BIN HAMJAH,etal. The paper conveyedthe selection of the parameters is a key factor in producing the optimal surface roughness of weld bead.

[3]SanidhSanchala, etal. The paper conveyed in the welding process the number of parameters affected the quality of weld. In case of linear and angular welding, angular welding is much more difficult than linear welding.

[4]Vaishnav Karan,etal. The paper conveyedthe study suggests that the number of parameters affected the worth of weld. In case of linear and angular welding, angular welding is much more problematic than linear welding.

[5]Akshay M, etal. The paper conveyed they have developed "A SEMI-AUTOMATED ARC WELDING MACHINE" which is very useful in small industries and provides safety for the worker.

[6]AshwaneKumar Srivastava, etal. The paper conveyedthey have developed a fully automated welding which is using in medium and large scale industries. It consists of Drive, Controller, Multi axis robot which is programmed using Teach Pendant after the installation.

[7]Seayon S. Dmello, etal. The paper conveyedas we seen in the above Literature. They have developed a fully automated 2-axis welding chine which is using in medium and large scale industries.

[8]Faiz F. Mustafa, etal. The paper conveyedmachine that hold and carry the welding gun of the MIG machine moving on a circular rail fixed near the pipe groove, can helpfully to improve the welding finish compared with the manual process by maintaining in parameters of welding such as keep the distance between the gun and the groove of weld joint, constant travel speed of the welding gun, also saving in time and funds.

[9]Monika, etal. Welding joins two materials. It beats both casting and riveting in terms of speed and cost. There are several things that use welding such as ships, rail road equipment, launch vehicles and boilers.

[10]Eyob Messele Sefene, etal. Before Friction Stir Welding, mechanical fasteners were used to join aluminium and its alloys in aeroplane structural elements.