International Journal of Engineering and Management Research
e-ISSN: 2250-0758 | p-ISSN: 2394-6962
https://ijemr.vandanapublications.com

Peer Reviewed & Refereed Journal
Volume-14, Issue-6 (December 2024)
https://doi.org/10.31033/ijemr.14.6.31-37

Design and Assessment of Automatic Arc Welding Machine Based on Programming Logic Controller

Anuj Saini[1*], Vibhuti Rehalia[2], Abhay Talgotra[3] and Shobit[4]
[1]Student, Department of Electrical Engineering, Sri Sai College of Engineering and Technology, Pathankot, INDIA
[2]Assistant Professor, Department of Electrical Engineering, Sri Sai College of Engineering and Technology, Pathankot, INDIA
[3]Student, Department of Electrical Engineering, Sri Sai College of Engineering and Technology, Pathankot, INDIA
[4]Student, Department of Electrical Engineering, Sri Sai College of Engineering and Technology, Pathankot, INDIA

[*]**Corresponding Author:** Anuj Saini

Received: 05-11-2024 Revised: 23-11-2024 Accepted: 11-12-2024

ABSTRACT

In the industry, automated technologies have gained significant traction since they appreciably contribute to productivity and enable better, faster production with less worker management. Equipment used in welding processes in different locations might cause problems for the welder, particularly when large regions are needed. An Arc welding machine is commonly used in the Automobile industry, railroads, industrial piping, and bridge power plants. An arc welding machine requires skilled workers to be properly safe. The present research provides the design of an autonomous robotic arc welding system based on the benefits of employing programmable logic controller (PLC). In examine the benefits of PLC over traditional microcontroller solutions that are currently authorized for use in industrial settings, studies have been conducted on the behavior of a PLC responsible for carrying out the developed machine control functions. This study models automatic arc welding equipment that uses a PLC for safety purposes. The electrode is mounted on a welding tray that moves vertically up and down, joining sheets. The recently developed instrument is simple to use, accurate, precise, quick, cost-effective, and guarantees worker safety while in use.

Keywords— Arc Welding, Programmable Logic Controller, Temperature Controller Relay

I. INTRODUCTION

Welding is a manufacturing method used to create a wide range of items, including pipelines, pressure vessels, ships, and vessels. The arc welding procedure is the most widely used and least expensive of these manufacturing techniques. Arc welding is a technique that can guarantee the integration of many parts with continuous curvature in a three-dimensional structure or it may be used to combine distinct pieces of materials with an imperfect curve in an isolated manner. While the weld joint circumstances should be examined and managed, the conditions of integration of a piece enable us to specify its primary attributes. Controlling the melting and mixing phases in a welding line is necessary to ensure that the heat input is uniform during the welding process. With the exception of mechanized or semi-automated welding, this is frequently not feasible in practice. Controlling these requires a different approach. There are multiple ways to control the welding process. The most common ones for these uses include breathing with variable or continuous current, mechanical guidance, and manual manipulation. In the first scenario, the operator's visual ability must be accurate; in the second, the piece must have new geometric conditions without alterations to the exterior evidence; and in the third, the operator must be more sophisticated.

Furthermore, transportation infrastructure is evolving toward more favorable circumstances from the isolated physical surroundings. After that, goods can be transported to far-off places, and construction projects must take time into account. Many experienced welders are employed in order to complete the building on schedule. These skilled workers with years of expertise are hard to come by, and a lack of labor can seriously impede the growth of the arc welding sector. An automated arc welding machine prototype with PLC has been designed to address the growing need for workers with years of experience to complete automated arc times [1]. The welding parameters for the prototype welding to work parts include the welding method, arc voltage, welding current, arc travel speed, wire feed speed of the welding torch, welding route coordinate, and reverse of the welding process [2-3]. The PLC system included soft inferences in the arc welding equipment, which has Human Equipment Interface (HMI) [4-5].

However, users can regulate how the welding parameters relate to one another, improving diagnostic precision. Every component of an automobile must be of high quality with standards; one of the most vital parts of a spark-ignition engine is the engine valve. It has always been challenging to cut spiral submerged arc welded pipes, which are necessary for the transmission of water and oil.

Many variables are related to the welding process; these parameters impact profit margin, cost, and production rate. Because welding was done by hand using welding pistols in the manual welding system, the weld was not formed with the necessary precision and quality [6, 7]. Welding quality is examined according to the effects of individual parameters, such as welding voltage, welding current and welding velocity.

This analysis has flaws and is biased [8]. Arc welding is so repetitious that it works well for large-scale manufacturing projects that call for structural beams or other similar welds. Configuration software has been used as the monitoring and simulation system to mimic the workflow of the medication bottling production line, while PLCs are used as the controllers to make up the control portion of the entire system [9]. Ladder logic control programs are capable of performing control and system management responsibilities. The rapid advancement of computer control and automation technology has addressed market demands for conventional control methods, and it will also replace analog control technology. PLC technology finds widespread application in several industries such as steel, metallurgy, petroleum, and chemical industry. It improves the control system's stability, dependability, and safety [10]. Resistance spot welding is a highly efficient and widely employed technique in the automotive industry and the manufacturing of household appliances while arc welding is used for industrial purposes [11]. Also, various researches have been carried out related to the use of PLCs as control systems for various systems and machinery, especially in the area of manufacturing and automotive industries.

Nevertheless, manipulating the electric arc, welding rod, and workpiece by hand while manual arc welding calls for a high level of competence. Robots that weld by following pre-programmed pathways in the CAD file of the workpiece are used in another arc welding technique. Although different kinds of automated modifications can make up for the shortcomings of the specific welding technique and become more economical for longer seams, this type only requires one level of shaping the metal that is parallel to the ground. A further technique involves turning the component on a lathe while feeding electricity through a specific rotating contact known as roller uranium. To maintain the lanium's correct location on the weld joint, the lathe feeds it down its center. An electric coil is used in a different technique to pass current through the formed item.

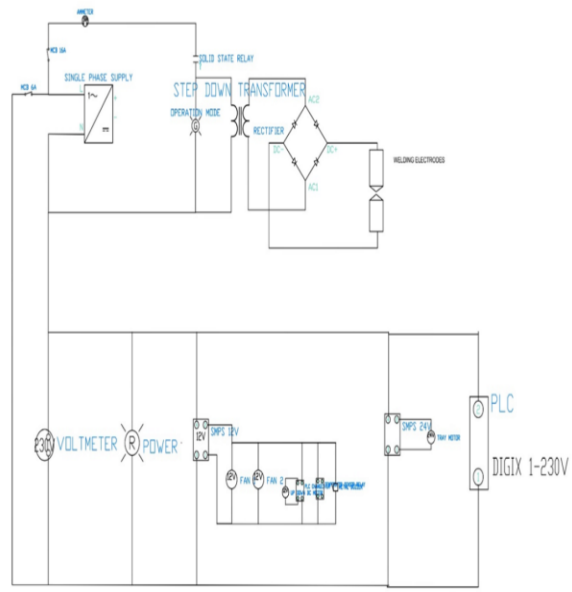

Figure 1: Circuit Diagram of Machine

As a result, users can regulate how the welding parameters relate to one another, improving diagnostic precision. Arc welding is so repetitious that it works well for large-scale manufacturing projects that call for structural beams or other similar welds., manipulating the electric arc, welding rod, and work piece by hand while manual arc welding calls for a high level of competence. Arc welding is a technique that forms a weld by concentrating the heat from an electric arc. The fusing and cooling of the metal generates enough thermal energy to form a weld bond. Figure 1 shows the circuit diagram of welding machine, which is divided by two MCBs (Miniature Circuit Breakers). Power flow to our indicators, measuring devices, plc, and SMPS is managed by a 6 ampere MCB. The power flow to the used transformer is managed by a 16 ampere MCB.

The ammeter is connected in series with it to measure current during welding and is separated by solid state relay which opens the circuit during overheating of transformer and green led is connected in parallel with it and step down transformer is connected with it further in its secondary with transformer a bridge rectifier is connected which converts bidirectional current into unidirectional current with some ripples i.e. DC component in it which then through electrode mounted on welding tray welds the sheets accordingly. The 6 ampere MCB is to be switched on first as it turns on the measuring instrument and plc and indicators. After turning this MCB on it supplies power to our plc and two smps of which12 volts smps supplies power to two 12 volts fans i.e. fan 1 and fan 2 as shown in figure 1 and dc motor which performs reciprocating operation through plc switching, temperature sensor relay and metal detector and two buzzers one for overheating indication and other for metal detector.

II. DESIGN AND IMPLEMENTAION CONSIDERATION

The structure of this machine is made of old scrap, control unit box is made using old inverter body and welding tray is made by welding metal pieces. There are mainly two parts in control unit and welding tray. Control unit which is shown in Figure 2 consist of step-down welding transformer, rectifiers, solid state relay, temperature control relay, two dc fans, two led, one digital voltmeter and ammeter, two buzzers, one, two miniature circuit breakers(6A and 16A), two SMPS (12V and 24 Volts), one digix 1-230v plc. Main purpose of this unit is to send control signals to our welding tray and control power operations of welding and provides safety to our sophisticated parts like plc, and prevents overheating of our transformer beyond 60 degree Celsius.

Figure 2: Welding Machine (Control Unit)

As shown in figure 3 (a) and (b) the box consists of holes as shown for air ventilation and welding transformer is fixed in it. This box after painting becomes electrically insulated which protects user from any electrical shock.

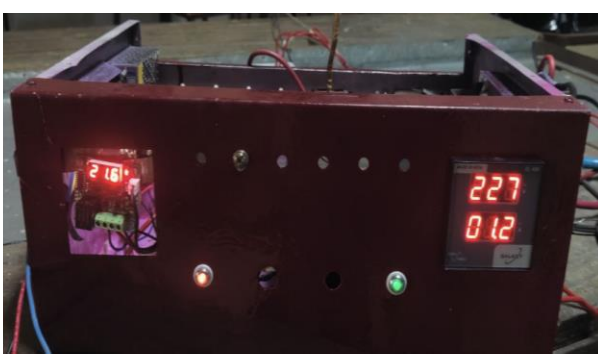

Figure 3: (a) Power and Control unit Front View **(b)** Control Unit Top View

Digital voltmeter is of range (0-400v AC) and is connected in parallel with 6 ampere MCB circuit to measure input voltage and Digital ammeter Is of range (0-50A AC). It is connected in series with HV winding of Transformer which is connected with 16 Ampere circuit to measure current merely during welding. Figure 4 shows the digital meter which is used in this project.

Figure 4: Digital Meter

The W1209 temperature controller serves as a crucial component in our system, where its primary role is to monitor and control the temperature of the transformer, effectively preventing overheating. Positioned strategically within the transformer system, the W1209 constantly detects the temperature, ensuring it remains within safe operating limits. Figure 5(a) (b) shows the temperature controller and operation of controller. This intelligent controller is equipped with programmable settings, allowing us to set temperature thresholds and triggers for cooling mechanisms or alarms.

Peer Reviewed & Refereed Journal
Volume-14, Issue-6 (December 2024)
https://doi.org/10.31033/ijemr.14.6.31-37

Figure 5: (a) Temperature Controller **(b)** Temperature Controller during Operation

Table 1: Specifications of W1209 Module

Parameter	Value
Temperature control range	-50~ 110 C
Resolution	9.9 to 99.9: 0.1 C
Resolution at all other temperature	1 C
Measurement Accuracy	0.1 C
Control Accuracy	0.1 C
Refresh Rate	0.5 Second
Input Power (DC)	12 V
Measuring Inputs	NTC (10K 0.5%)
Waterproof sensor	0.5 M
Output	1 Channel Relay Output
Capacity	10 A

A Programmable Logic Controller is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. It is a solid-state user programmable control system with functions to control logic, sequencing, timing, arithmetic data manipulation and counting capabilities. It can be viewed as an industrial computer that has a central processor unit, memory, input output interface and a programming device. The central processing unit provides the intelligence of the controller. It accepts data, status information from various sensing devices like limit switches, proximity switches. Executes the user control program stored in the memory and gives appropriate output commands to devices such as solenoid valves, switches etc. A constant demand for better and more efficient manufacturing and process machinery has led to the requirement for higher quality and reliability in control techniques. With the availability of intelligent, compact solid state electronic devices, it has been possible to provide control systems that can reduce maintenance, down time and improve productivity to a great extent. One of the latest techniques in solid state controls that offers flexible and efficient operation to the user is programmable controllers.

III. INTEGRATION OF PLC IN SPOT WELDING

A Programmable Logic Controller is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. It is a solid-state user programmable control system with functions to control logic, sequencing, timing, arithmetic data manipulation and counting capabilities. It can be viewed as an industrial computer that has a central processor unit, memory, input output interface and a programming device. The central processing unit provides the intelligence of the controller. It accepts data, status information from various sensing devices like limit switches, proximity switches. Executes the user control program stored in the memory and gives appropriate output commands to devices such as solenoid valves, switches etc.

A constant demand for better and more efficient manufacturing and process machinery has led to the requirement for higher quality and reliability in control techniques. With the availability of intelligent, compact solid state electronic devices, it has been possible to provide control systems that can reduce maintenance, down time and improve productivity to a great extent. One of the latest techniques in solid state controls that offers flexible and efficient operation to the user is programmable controllers.

There are four basic steps in the operation of all PLCs; Input Scan, Program Scan, Output Scan, and Housekeeping. These steps continually take place in a repeating loop. Digix 1-230v plc provides human interface programming facility which makes it easier for user to understand the present stage of machine welding process. Figure 6 shows PLC and Figure 7 shows the LADDER graph. This plc uses RS-285 programming cable for its programming and SELPRO version 5.4.3 for ladder programming through pc. Table 2 shows the specification and parameter used in this project.

Figure 6: PLC

The equipment, which is based on a programmable logic controller, detects in real time and performs welding control operations without the need for an external system. Software with instructions in structured text, graphs, function block diagrams, or ladder language can be produced since all management is done by simple programming commands. These are typical programmable logic controller programming structures; an extension card that supplies useful I/O resources in the required amount and an integrated HMI are the main components of the controller's operation**.**

Table 2: Specifications

Parameter	**Value**
Display	2x8 LCD (Green back-light)
No. of Keys	5 (4-user configurable)
Supply Voltage	230v AC (180 ~270v AC)
Sensor Supply (SS)	10V, 50mA

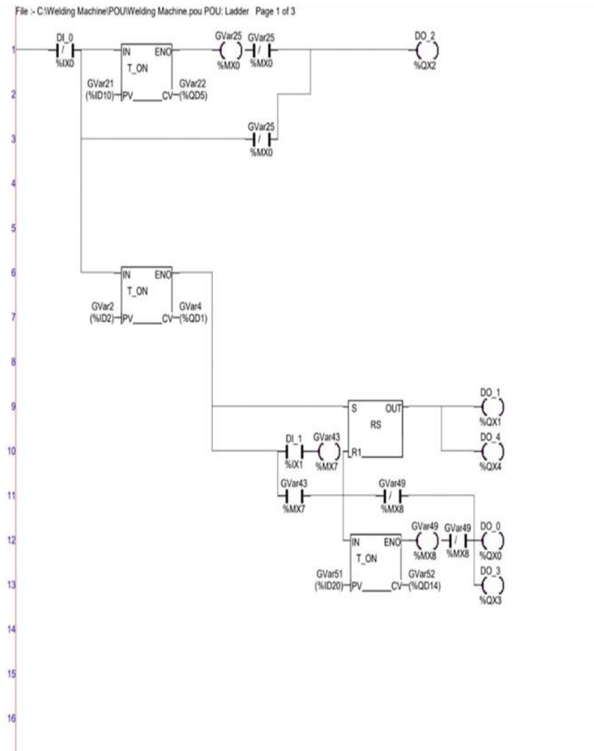

Figure 7: LADDER diagram

The steps for simulation of PLC with ladder

Step 1**:** DI0 is the metal detector (NC) which starts operation of our machine whenever it detects metal under it.

Step 2**:** DO2 is the buzzer which operates for few seconds after metal presence

Step **3:** DO1 and D04 are positive connections of our dc motor i.e it will move electrode downwards till it touches the metal

Step 4: DO0 and DO3 is negative connections of our dc motor i.e it will run upwards for few milliseconds so as to start and maintain the arc

Step 5: When input DI0 NC receives input 0 from metal detector the off delay timer circuit triggers with latch circuit as shown in figure and buzzer will sound for few seconds then it becomes off .

Along with this timer on delay which is used because of gap between metal detector and electrode, The positive output connections i.e +12v to wire A And 0v to wire B and when our electrode touch the metal the input DI1 gives output 1 and our RS latch gives 0 output and another circuit for negative motor connection for moving motor very slight upward we used timer circuit which is off delay The negative connections are 0 to wire A and +12v to wire B. We have used dc permanent magnet motor instead of stepper motor and programmed plc in such way that it reverses the connection of motor as soon as electrode touches metal which is to be weld for stepper motor additional cost of stepper motor driver and cost of stepper motor was main issue which has been avoided in this machine.

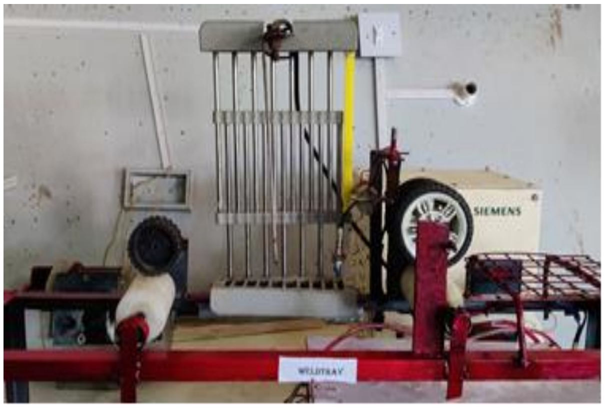

Figure 8: Welding Tray

Welding tray present in Figure 8 performs welding operation in which two sheets are inserted from right side of the machine simultaneously under the movement of roller and then wheels sheets start moving in clockwise direction to make those thin sheets move inwards, proximity sensor detects the presence of sheets and buzzer makes beep and after about 2 seconds plc makes dc motor to operate in such way that electrode move downwards and touches sheet and a metallic roller which is placed underneath and rolling along with others makes return path of current through it the other wire from machine welding set is connected to that roller with a series current sensing relay and normally closed switch which gives input to plc through DI1 and it operates dc motor slightly upwards for few milliseconds which maintains an arc in between them and our sheet moving forward will be welded continuously.

IV. DESIGN AND MODELLING

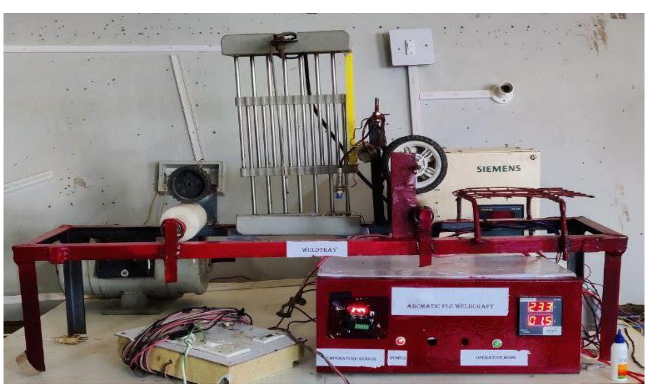

Figure 9: Arcmatic PLC Weld Craft

Complete setup of our machine is shown in Figure 9 in which plc is placed on the right side of our control unit and

Our control unit is placed underneath the welding tray the tray has provision to place two sheets together, electrode is placed on holder which can move up and down it is also provided with rack and pinion mechanism which ease to its control through our dc motor.

V. RESULTS AND CONCLUSION

The detailed analysis of cost and price of components which are used to make this welding machine are described in Table 3.

Table 3: Cost Analysis

S.NO	Parameter	Quantity	Cost
1	Transformer	1	450 Rs (Scrap)
2	Indicators	2	40 Rs
3	Temperature Controller	1	171 Rs
4	Rectifier	6	359 Rs
5	Solid State Relay	1	506 Rs
6	Proximity Sensor	1	222 Rs
7	Digital Meter	1	438 Rs
8	SMPS 12V	1	260 Rs
9	SMPS 24V	1	280 Rs
10	Rack	1	50 Rs
11	DC Motor	2	150 Rs
12	Wires	9 Meter	540 Rs
13	PLC (Digix)	1	4041 Rs
14	PLC Programming cable, USB-Rs 485 (RJ25)	1	3362 Rs
TOTAL			**10,869Rs/**

In the industry, automated technologies have gained significant traction since they significantly boost productivity and enable better, faster production with less worker manipulation. When extensive gaps are needed, welding process equipment employed in different locations might cause a number of problems for the welder. When the method is used in the large-scale production sector of the automotive industry, certain spaces are required. As a result, the worker spends a lot of time doing repetitive tasks.

Transformer and basic structure of this project have brought from scrap which reduces cost of these components up to half, our PLC costs 4041 Rs and PLC programming cable 3363 Rs and net cost of our machine is 10,869Rs market cost of similar machines will be around 45,000 Rs.

REFERENCES

[1] Yang, Z., Sun, Y., Qin, T., Lv, J. & Cheng, S. (2024, September). Design of welding control system for industrial pipeline positioner. In: *Tenth International Conference on Mechanical Engineering, Materials, and Automation Technology (MMEAT 2024)*, *13261*, pp. 1198-1206. SPIE.

[2] Calderón Campaña, J. R. (2024). *Optimisation and simulation of the manufacturing process of train frames by welding*. Master's Thesis, Universitat Politècnica de Catalunya.

[3] Calderón Campaña, J. R. (2024). *Optimisation and simulation of the manufacturing process of train frames by welding*. Master's Thesis, Universitat Politècnica de Catalunya.

[4] Ardi, S. & Diana, F. A. (2020, April). Control system design of arc welding by hand machine based on programmable logic controller (PLC) and CC-link master module. In: *IOP Conference Series: Materials Science and Engineering*, *830*(3), pp. 032046. IOP Publishing.

[5] Shah, D. N. (2021, August). Automatic welding and soldering machine using PLC in automobile application. In: *Asian Conference on Innovation in Technology (ASIANCON)*, pp. 1-6. IEEE.

[6] Wang, G., Sun, X., Luo, Z. & Ye, T. (2021). Cutting device for production of spiral submerged arc welded pipe based on plc control system. In: *Big Data Analytics for Cyber-Physical System in Smart City: BDCPS 2020, 28-29 December 2020, Shanghai, China*, pp. 901-906. Springer Singapore.

[7] Massaid, A., Alama, A. & Al-Hashlamoon, R. (2019). *Design and implement of welding machine for circular welding process*.

[8] Li, X., Li, J. & Xing, X. (2023, December). The automatic control system for information acquisition of arc welding linear energy based on PLC. In: *5th International Academic Exchange Conference on Science and Technology Innovation (IAECST)*, pp. 1593-1598. IEEE.

[9] Qi, L., Yuan, B., Ma, P., Yao, Y. & Wang, F. (2020, July). Simulation design of control system based on plc and configuration software. In: *International Conference on Virtual Reality and Intelligent Systems (ICVRIS)*, pp. 741-744. IEEE.

[10] Lu, Y. (2022). *Application analysis of electrical engineering automation control under PLC technology*.

[11] Saini, Anuj & Vibhuti Rehalia. (2023 September). Assembly of portable spot-welding machine. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*. https://doi.org/10.22214/ijraset.2023.55640.