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A Review Paper on Semi Automated Welding Machine Using PLC

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Abstract

In this project, we will be doing Design, Analysis & Manufacturing automation for circular parts welding with uniform weld structure using PLC. We will be designing & manufacturing the turntable, which will be rotating at specific required speed depending upon the requirement of fillet material to be added. In addition, the electrode nozzle is kept stationary, in contact with the surface of the components to be welded. Therefore, in this project, a detailed design for the conversion of the conventional MIG welding machine (ARC) into an automated machine for welding round components. Together with this main modification, the existing MIG welding machine – (a stationary, downward-facing ARG – HEAD, which has provisions for horizontal and upward movements) is to be modified into portable robotic welding machine.

1) INTRODUCTION

In today's age of mass production, it is often necessary to automate manufacturing processes that were previously carried out manually. In presence various welding technique is used for the welding purpose such as CO2 welding or Electric arc welding, TIG (tungsten inert gas welding), in that various fixture is use for various welding, but in many application, we use some techniques which does not work efficiently & accurately. Moving the electrode along the welding line is a job that requires a lot of skill and becomes much more difficult, especially with round components. To avoid such problems, we use a welding rotator, a special device that can rotate the deposit at a fixed speed to support the welding process for round components and ensure a good profile and a homogeneous weld. Many different energy sources can be used for welding, a gas flame, an electric arc, a laser, an electron beam, friction and ultrasound. Although it is often an industrial process, welding can be carried out in many different environments, including outdoors, underwater and in space. Regardless of location, welding remains dangerous and precautions are taken to avoid burns, electric shock, eye damage, toxic fumes and excessive exposure to ultraviolet light.

General

Welding is a process by which materials of the same basic type or class are brought together and joined (and become one) by the formation of primary chemical bonds under the combined action of heat and pressure. The definition in the IS0 standard is: “Welding is a process in which continuity is established between parts for assembly by various means”. Hence, the welding is the fusion of two or more pieces of metal together by using the heat produced from an electric arc welding machine. Arc welding dates back to the late 1800s, when a man welded on iron with a bare metal wire The sparks from welding caught a pile of newspapers near him on fire and as he welded, he noticed that his welds looked much better. The reason for this was that the smoke took the oxygen out of his welding environment and reduced the porosity. The arc is ignited between the electrode and the metal. It then heats the metal to a melting point. The electrode is then removed, breaking the arc between the electrode and the metal. This allows the molten metal to “freeze” or solidify. The electric arc is like

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a flame of intense heat generated when the electric current flows through a high-resistance air gap

Types of arc Welding processes: -

- SMAW (Shielded Metal Arc Welding)
- GTAW (Gas Tungsten Arc Welding)
- GMAW (Gas Metal Arc Welding)

a) SMAW (Shielded metal arc welding):

SMAW is the most common form of welding. An arc-welding machine supplies electric current to an electrode wire. . The electric current flows through the air gap between the end of the electrode wire and the base metal. When the electric current flows through this air gap, an electric arc is formed. The arc generates heat, which heats the base metal to its melting temperature. The heat of the base metal generates a shielding gas that protects the base metal, the arc, the electrode and the weld seam from the atmosphere during the welding process. As the flux covering on the electrode wire melts, a shielding gas is created. When the flux cools, it solidifies and forms a protective slag over the weld bead. As the electrode wire melts, it becomes the filler metal to the weld.

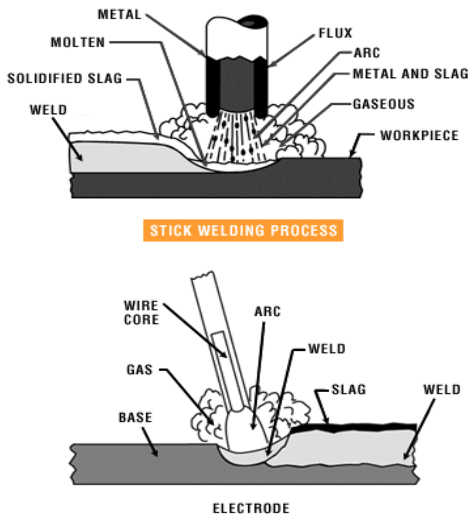


Fig.1.1 Shielded metal arc welding

b) GTAW (Gas Tungsten Arc Welding)

Gas tungsten arc welding (GTAW), also known as tungsten inert gas welding (TIG), is a process in which an arc is created between a non-consumable tungsten electrode and the workpiece to be welded. The heat-affected zone, the molten metal and the tungsten electrode are protected from atmospheric contamination by a layer of shielding gas which is passed through the TIG torch. Inert gas (usually argon) is inactive or has no active chemical properties.

The shielding gas is used to cover the weld seam and exclude the active properties of the ambient air. Inert gases such as argon and helium do not react chemically and do not combine with other gases. They pose no odour and are transparent, Permitting the welder maximum visibility of the arc. In some cases, hydrogen gas can be added to increase the cruising speed. The GTAW process can produce temperatures of up to 35,000° F (19,426° C). The torch contributes heat only to the work-piece. If a filler metal is required for the weld, it can be added manually as in oxyfuel welding. GTAW is used to weld stainless steel, nickel alloys such as Monel and Inconel, titanium, aluminium, magnesium, copper, and brass, bronze and gold. TIG can also weld dissimilar metals together, e.g. copper with brass and stainless steel with mild steel.

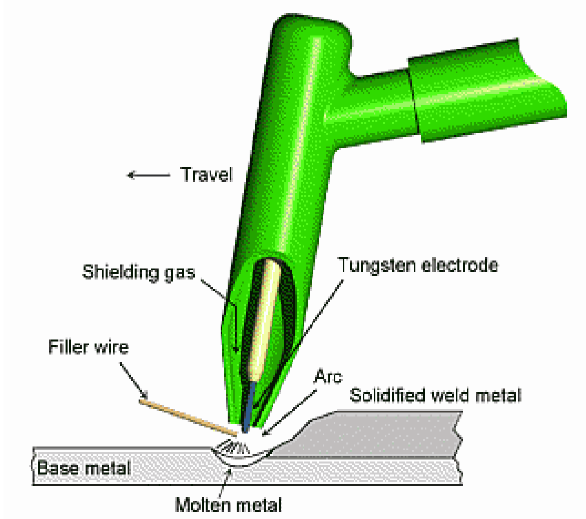


Fig.1.2 Gas Tungsten arc welding

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

c) GMAW (Gas Metal Arc Welding):

Gas metal arc welding (GMAW) is a welding process in which metals are joined by heating them to their melting point with an electric arc. The arc is located between a continuous, melting electrode wire and the metal to be welded. The arc is shielded from impurities in the atmosphere by a shielding gas.

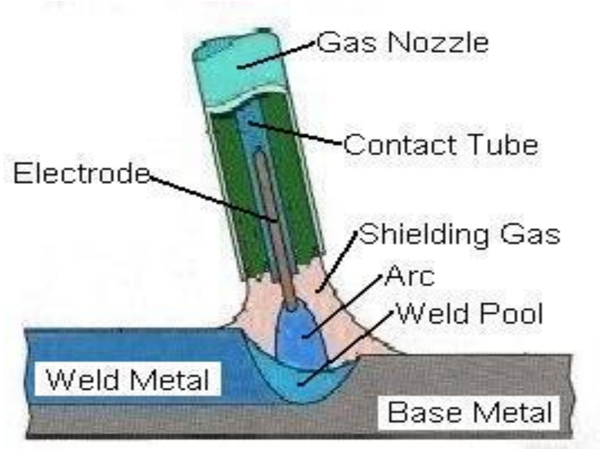
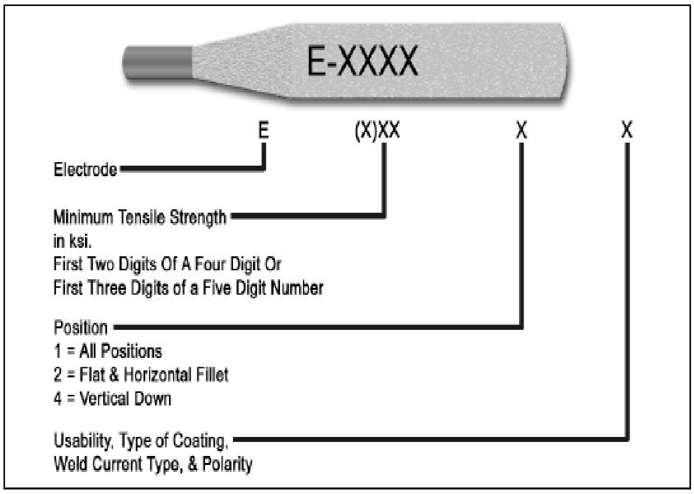


Fig.1.3 Gas Metal arc welding

❖ Electrode used in SMAW:

The American Welding Society or AWS sets guidelines for SMAW electrodes with which manufacturers have to comply. These guidelines include chemical and mechanical properties as well as user-friendliness tests. Each letter and each number stands for something very specific. The E stands for electrode. AWS defines an electrode as the current-carrying device, not necessarily the consumable that becomes the weld. In the case of SMAW, the electrode core is consumed as well as any metallic elements in the coating to become the weld deposit. 70 stand for minimum tensile strength in 10,000 psi. The weld deposit made by this SMAW electrode must consistently meet a minimum tensile strength requirement of 70,000 pounds per square inch (psi). The next digit is either a 1 or a 2 and indicates welding position. A "1" indicates that the electrode is an all position electrode-- (flat, horizontal, vertical up, vertical down, and overhead). While the 2 stands for weld seams that can only be executed in a flat/horizontal position. The 3rd and 4th digits together indicate the type of current with which the electrode works, as well as the type of coating.

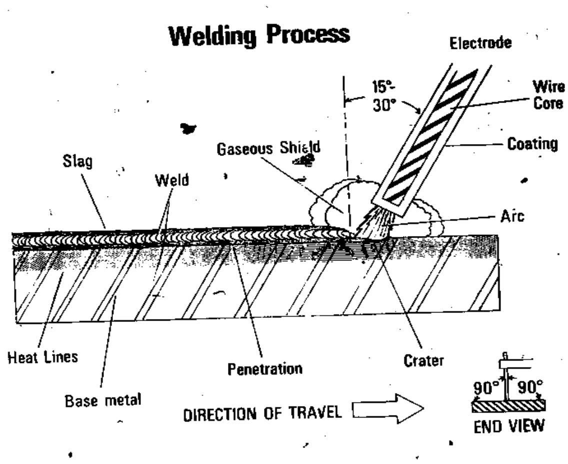


AWS Shielded Metal Arc Covered Electrode Classification System

Fig.1.4 Designation of welding electrode

❖ Welding process of SMAW:

Shielded metal arc welding (SMAW), also known as manual metal arc welding (MMA), shielded metal arc welding or informally as stick welding, is a manual arc welding process in which a consumable, flux-coated electrode is used to make the weld. An electric current, either in the form of alternating current or direct current from a welding power source, is used to form an arc between the electrode and the metals to be joined. During welding, the flux coating of the electrode breaks down and releases vapors that act as a shielding gas and form a slag layer that protects the weld area from atmospheric contamination.



International Journal of Scientific Research in Engineering and Management (IJSREM)
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Fig.1.5 Welding Process

I) WELD QUALITY AND WELD GEOMETRY

i) **Weld quality: -**

To ensure the satisfactory performance of a welded structureThe quality of the weld seams must be determined by suitable test procedures. These tests include the measurement of various defects that occur in a weld. Acceptance standards are the minimum quality of welds that must be achieved for satisfactory weld performance.

ii) **Defects in weld-pieces-**

The defects which occur in the weld-pieces due to the imperfect welding conditions and their causes are as follows:

iii) **Undercutting:-**

Undercutting is the burning away of the base metal at the tip of the weld seam.

Causes:

- ➢ Current adjustment that is too high.
- ➢ Arc gap that is too long.
- ➢ Failure to fill the crater completely with weld metal.

iv) **Incomplete penetration: -**

This term is used to describe the failure of the fusion of filler and base metal at the root of the joint.

Causes:

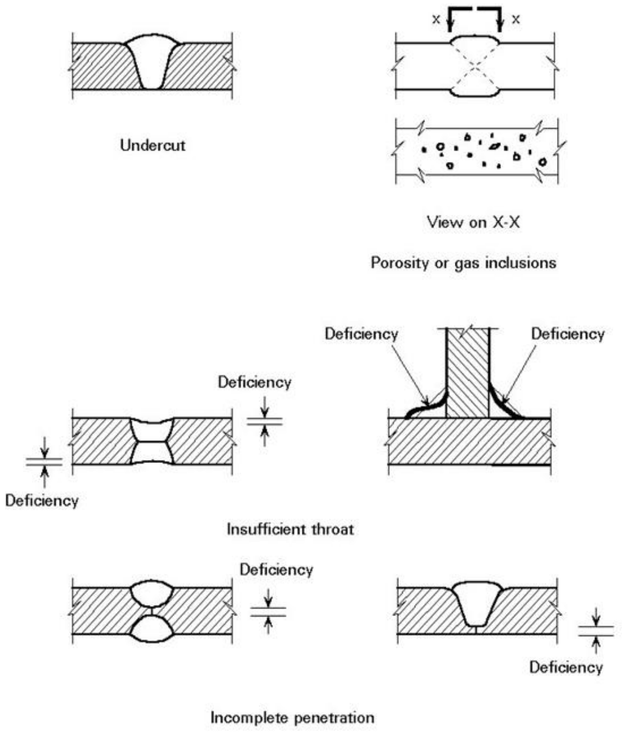
- ➢ The rate of travel is too high.
- ➢ The welding current is too low.

v) **Lack of fusion:-**

Lack of fusion is the failure of a welding process to fuse layers of weld metal or weld metal and base metal together.

Causes:

- ➢ Failure to raise the temperature of the base metal or the previously applied weld metal to the melting point.
- ➢ Dirty plate surfaces.
- ➢ Improper electrode size or type.
- ➢ Wrong current adjustment.



vi) **Slag inclusion: -**

Slag inclusions are elongated or globular pockets of metallic oxides and other solid compounds. They produce porosity in the weld metal.

Fig.1.6 Welding defects

Causes:

If the slag between the layers is not removed, slag inclusions will occur.

Porosity:

Porosity is the presence of pockets that do not contain solid material. They differ from slag inclusions in that the pockets contain gas rather than a solid. Gases are derived from:

- ➢ Gas released by cooling weld
- ➢ Gases formed by the chemical reactions in the weld.

2.PROBLEM STATEMENT

In CO2 welding, or sometimes in arc welding, it is often necessary to weld circular components by welding around the entire circumference or a partial length of the arc. In the conventional method, the electrode is moved along this circular path. However, the movement of the electrode is much more difficult and it is much easier to index the job. For welding the current workpiece cycle, the time is higher, i.e. 45-60 seconds. Therefore, a system must be developed to facilitate the loading of the workpiece and the automatic positioning of the welding gun. Automatic switching on and off of the welding machine switches to ensure a smooth process.

Fig. 2.1 CO2 welding for pipes

3.OBJECTIVES

The main purpose of this research is to develop this system & In order to approach this purpose, we follow.

i. Design the indexing table rotary motion of component to be welded.
ii. Load caring capacity up to 25 kg.
iii. Material procurement & Drawing Release for manufacturing.
iv. Fixture design for welding gun fitment for angular motion during loading & unloading of job.
v. Utilization of Mitsubishi PLC for automation work of Complete project work.
vi. Utilization of pneumatic cylinder for griping job / locating the welding gun.
vii. Testing & complete of complete project within prescribed time

Factors to be considered during system Design:

- Reduced errors.
- Cost saving.
- Increased productivity.
- Uniform and precise welding.
- Reduced labour requirement.
- Increased machine utilization.

4.COMPONENT & DESIGN:

i) Spur Gears:

Spur gears is are the most common type of gear. They are used to transmit rotary motion between parallel shafts, i.e. they usually have a cylindrical shape and the teeth are straight and parallel to the axis of rotation. Sometimes spur gears are used simultaneously to generate very large reduction ratios. Spur gears are used in many appliances, but not in cars, as they make a lot of noise. A gear is a rotating cylindrical wheel with teeth that meshes with another toothed part to transmit power or torque. Spur gears are the simplest type of gear, with teeth parallel to the axis of the shaft on which the gear is mounted. Spur gears are used to transmit power between parallel shaftss. A spur gear has an efficiency of 98-99%.

Fig.4.1 Spur Gear

This gear can be meshed together correctly only if they are fitted to parallel shaft. The main reason for the popularity of spur gears is their simplicity of design and manufacture. The two parameters, i.e. the tip radius and the tooth width, which play a key role in the design of gears, are examined. A gear is a rotating machine part with ground teeth that mesh to transmit torque. A geared device can be changed the speed, direction of power sources and magnitude. A spur gear is a cylindrical gear with the teeth parallel to the axis. It has the most applications and is the easiest to manufacture. Spur gears are the most commonly used type. Tooth contact is primarily rolling, with sliding occurring during engagement and disengagement. Some noise is normal but it may become objectionable at high speeds Nowadays there are so many mechanisms to do with stress and the requirement to understand the stress on the component has increased. The mechanism always come together and they have a strong relation between each other.

Fig.4.2 Spur Gear

ii) MOTOR SELECTION:

This section describes certain points that need to be calculated in order to find the optimum motor for a particular application. Selection procedures and examples are given.

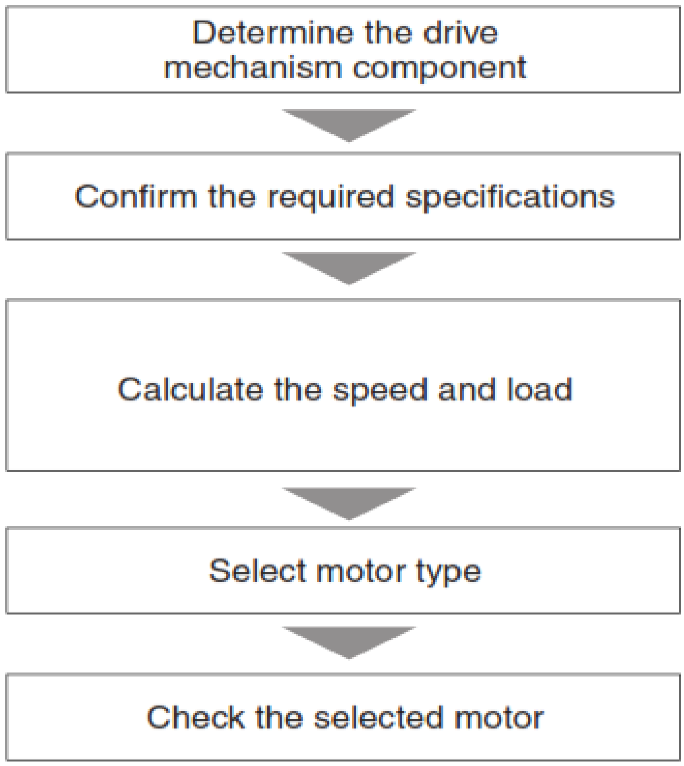


Fig. 4.3 Motor selection flow chart

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

- First define certain characteristics of the design, e.g. the drive mechanism, the rough dimensions, the moving distances and the positioning duration.
- Confirm the required specifications for the drive system and equipment (stopping accuracy, position retention, speed range, operating voltage, resolution, durability, etc.).
- Calculate the value for the load torque, load inertia, speed, etc. on the motor drive shaft of the mechanism. To calculate speed, load torque and load inertia for different mechanisms.
- Select a motor type from AC motors, brushless DC motors or stepper motors, depending on the required specifications.
- Finalise the motor after making sure that the specifications of the selected motor/gearbox meet all requirements (mechanical strength, acceleration time, acceleration torque, etc.).

➢ **Power Calculation**

Torque = Force X Radius Spur gear

Human force required for rotating the disk = 225 N

Where,

Radius of spur gear (ro) = 75 mm,

Torque = Force x Radius

= 225x 75

= 16875 N – mm

Bus Wiper Motor (150W 12V / 24V)

Bus Wiper Motor (150W 12V / 24V)

Product Description

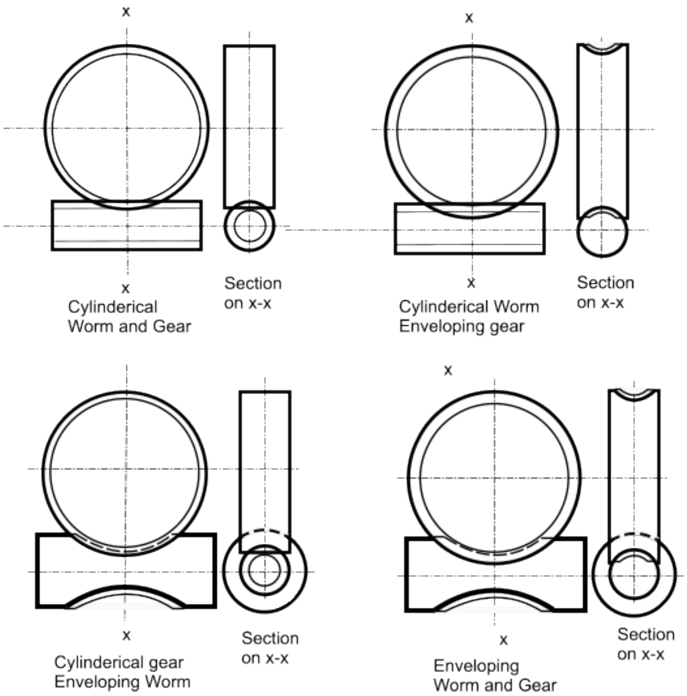
Item name: Wiper motor
Item NO.: ZD2732 150W 24V
ZD1732 150W 12V
Stall torque: 95N. M
Double-speeds; High speed: 25 ± 5RPM
Low speed: 35 ± 5RPM
Application: Wiper assembly of luxury bus
N. W.: 5kg

Model	Nominal Voltage	Nominal Power	No-load Current ≤ A		Stall Current ≤ A		No-load Speed rpm		Stall Torque ≥ N.m
			Low Speed	High Speed	Low Speed	High Speed	Low Speed	High Speed	
ZD1733	DC12V	150W	2.5	4.5	65		25 ± 5	35 ± 5	95
ZD2733	DC24V		1.5	2.5	35				

Fig & Table. 4.4 Motor Description

iii) WORM GEAR SELECTION:

A worm gear is used when a large reduction ratio is required between intersecting shafts that do not overlap. A simple spur gear can also be used, but the transmittable power is low. A worm gear consists of a large diameter worm wheel and a worm that meshes with the teeth on the circumference of the worm wheel. The worm resembles a screw and the worm wheel resembles part of a nut. When the worm is turned, the worm wheel is rotated by the screw-like action of the worm. The size of the worm wheel set generally depends on the centre distance between the worm and the worm wheel. If the worm gears are always machined as crossed helical gears, this results in a highly loaded point contact gear. Normally, however, the worm wheel is not cut straight, but concave. This is called a single envelope worm gear set. If the worm is machined with a concave profile to effectively wrap around the worm wheel, the gear set is called a double enveloping worm gear set and has the highest power capacity for the size. Single



enveloping gear sets require accurate alignment of the worm wheel to ensure full line tooth contact.

Fig. 4.5 Different worm gear selection

iv) SELECTION OF BEARING

The spindle bearing will only be subjected to a medium radial load, so we will use ball bearings for our application.

Select; single row deep groove ball bearing as follows;

Series 62

ISI No	Bearing of Basic design No.	d	D 1	D	D 2	B	Basic capacity	
20BC 02	6003z	17	10	35	30	9	10000	6550

Table. 4.6 Specification of Bearing

$P = X F + Y F a$

For our application F a = oo

$P = X F r$

Where F r = 204.5 N

As; F r < e → X = 1

$P = F r$

Max radial load = F r = 204.5 N

$P = 204.5$ N

Calculation dynamic load capacity of bearing

L = (C) p where p =3 for ball bearings

When P for ball Bearing

For m/c used for eight hr. of service per day;

L h = 12000- 20000 hr.

But ; L = 60 nLh

L = 600 mrev

Now; 600 = (C) 3

= (204.5)3

C =1724.8 N

Since the required dynamic capacity of the bearing is less than the nominal dynamic capacity

Of bearing;

Bearing is safe

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Bearing

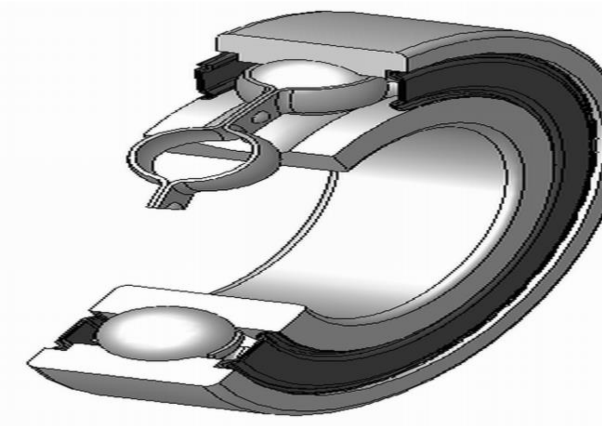


Fig. 4.7 Roller contact Bearing

v) Delta PLC - DVP14SS2

The 2nd generation of the DVP-SS2 series slim PLC has the basic sequential control functions of the DVP-SS series PLC, but with higher execution speed and improved real-time monitoring functions

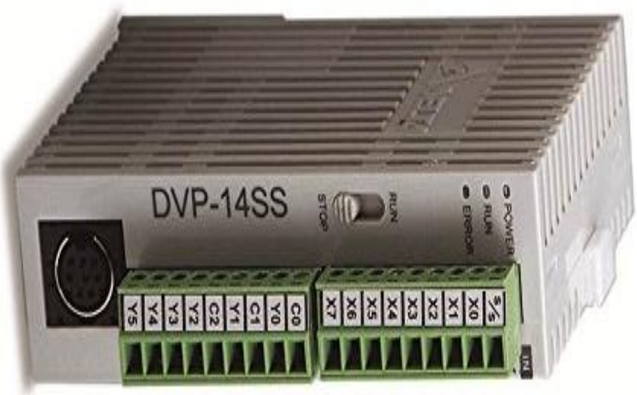
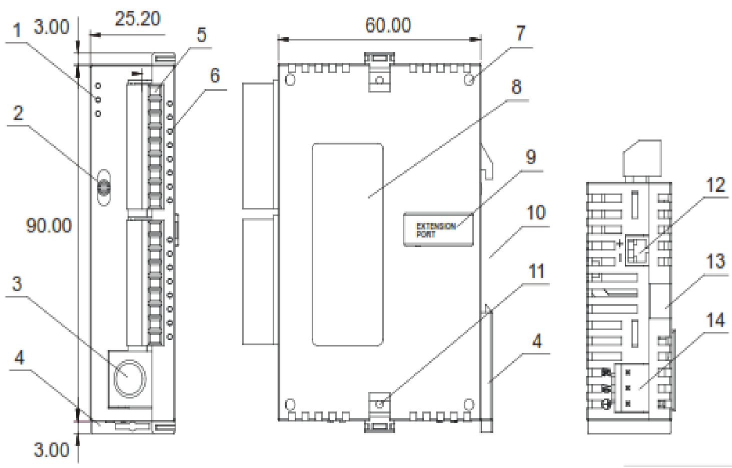


Fig. 4.6 Delta Plc

DVP12SS2/14SS2



Specifications: -

- MPU points: 14 (8DI + 6DO)
- Max. I/O points: 494 (14 + 480)
- Program capacity: 8k steps.
- COM port: Built-in RS-232 & RS-485 ports, compatible with Modbus ASCII/RTU protocol. Can be master or slave.
- High-Speed Pulse Output：Supports 4 points (Y0 ~ Y3) of independent high-speed (max. 10kHz) pulse output.
- Supports PID auto-tuning：DVP-SS2 automatically saves the parameters after PID auto-tuning is completed.
- Built-in High-Speed Counters.

vi) DOP- B03S211

Specifications: -

- 4.3-inch (480 x 272 pixels) TFT LCD 65536 colours
- 2 sets of COM ports, supports RS-232 / RS-422 / RS-485
- For data transfer/download: RS-232, USB
- Complies with IP65 standard
- Supports horizontal / vertical display
- PC editing software, DOP Soft is compatible with operating systems: Windows XP, Windows Vista, Windows

Fig. 4.7 DOP-B03S211

vii) DC Motor PWM Speed Regulator 1.8V, 3V, 5V, 6V, 12V-2A speed control switch function

Features:-

- Input supply voltage: 1.8V- 15V DC.
- The maximum output power: 30W
- Output current: 2A (Max).
- With resettable fuse.
- Equipped with LED indicator.
- Potentiometer with switch function for PWM adjustment

Fig. 4.8 Motor

The D C Motor PWM Speed Regulator 1.8V, 3V, 5V, 6V, 12V-2A Speed Control.

The switching function for DC motors enables the direction of a DC motor to be controlled using a pulse width modulated (PWM) DC voltage with a fully adjustable duty cycle of 0%-100%. The Motor Speed Controller can easily supply a continuous current of 2A to your DC motor or other DC load. This Motor Speed Controller Allows Controlling The Direction Of A DC Motor Using A Pulse-Width-Modulated (PWM) DC Voltage. With A Resettable Fuse, It Can Automatically Break The Connection And Automatically Recover. With A LED Indicator and a Rotary Switch, Convenient To Use.

Operating Instruction:

- Connect your DC motor (or DC load) to the motor terminals as shown in the wiring diagram
- Connect A Voltage Of 1.8V-15V DC To The Circuit Making Sure Of The Correct Polarity Of The Connection. Note That The Voltage Applied To The Motor Will Be The Supply Voltage Applied To The Circuit
- You Can Now Control The Speed Of The Motor Through The Potentiometer.

5) **Body Frame**

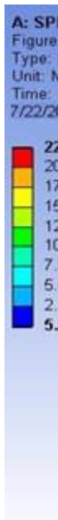
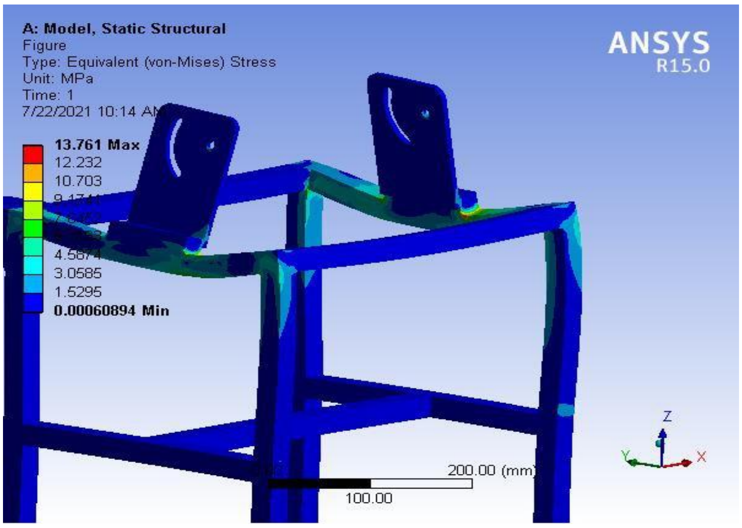


Fig. 5.1 Equivalent stress in Body Frame

Fig. 5.2 Total deformation in body frame



From ANSYS Results, it is clear Design considerations of Base frame is in permissible limit.

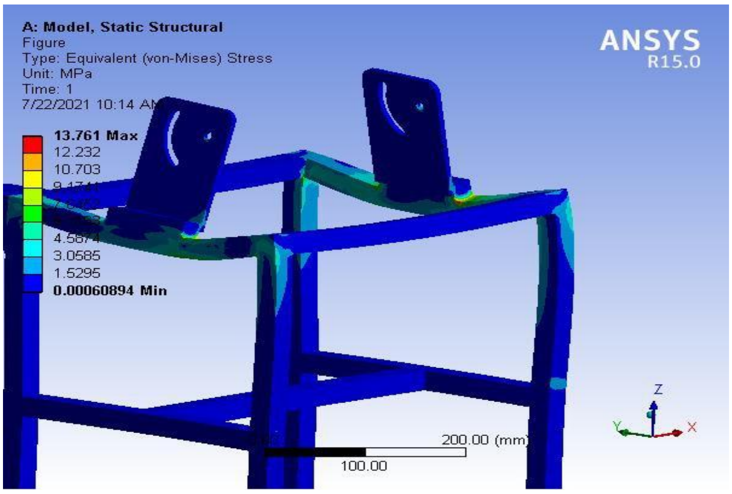


Fig. 5.3 Equivalent Stress

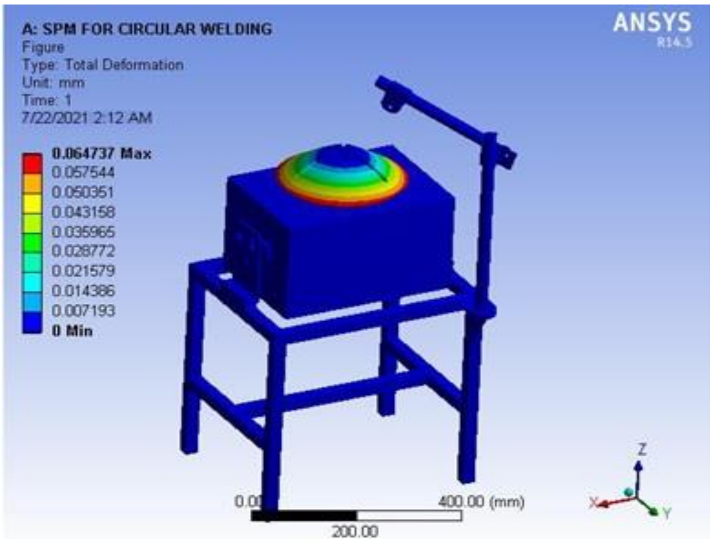
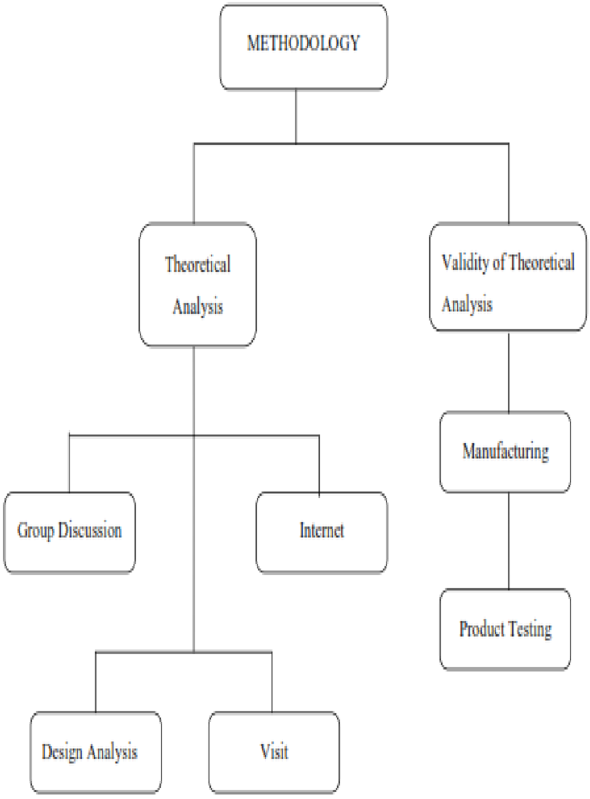
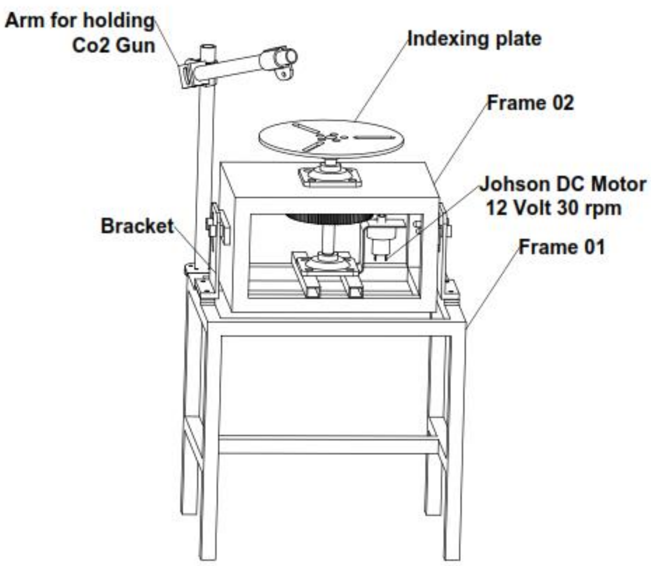


Fig. 5.4 Total Deformation

From ANSYS Results, it is clear Design considerations of complete system is in permissible limit.

4. METHODOLOGY





5. CAD MODELING

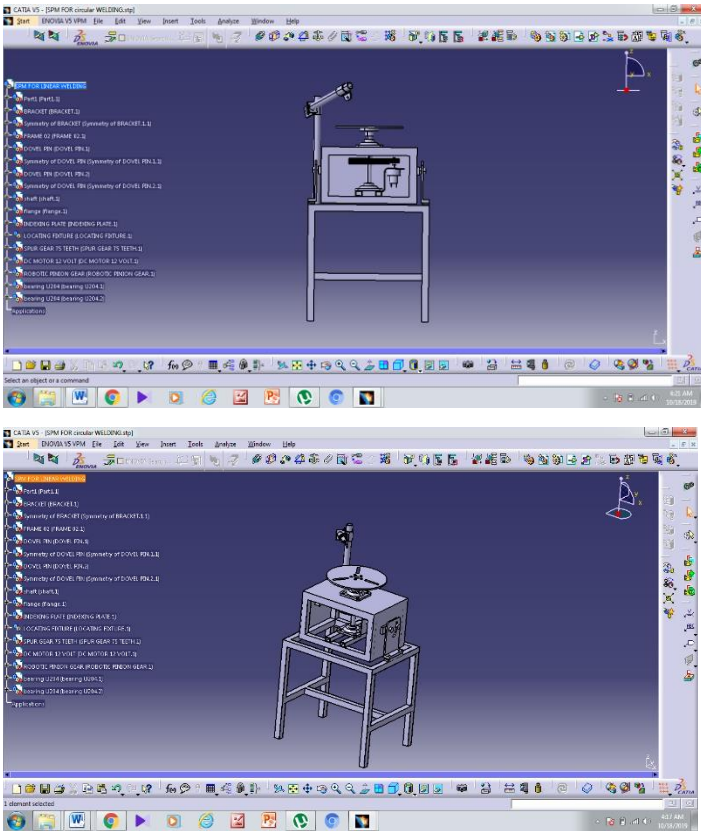


Fig. 5.1 CAD MODELS

6. RESULTS AND DISCUSSION

MANUAL WELDING PRODUCTION RATE				
DATE	2 INCH JOB	QTY	TIME (HRS)	
05-11-2023		144	11	
05-12-2023		137	11	
05-01-2024		142	11	
05-02-2024		147	11	
05-03-2024		146	11	

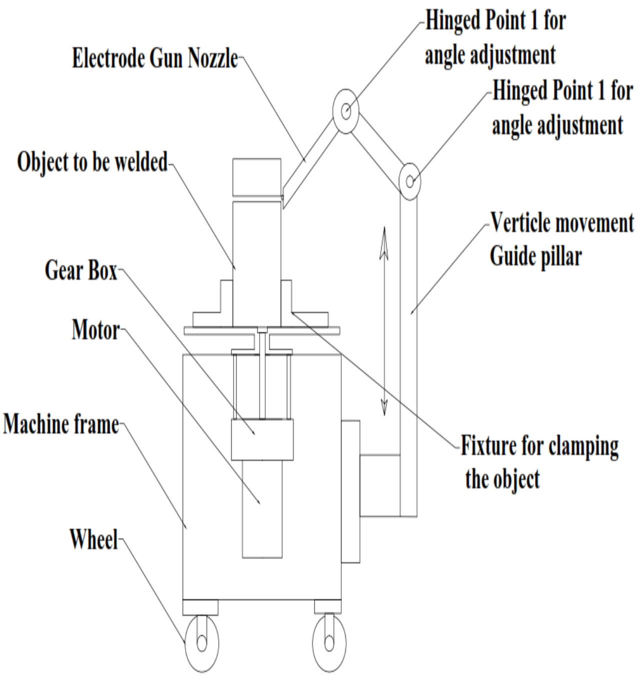
AUTOMATION WELDING PRODUCTION RATE				
DATE		QTY	TIME (HRS)	
06-11-2023	2 INCH JOB	264	11	
06-12-2023		262	11	
06-01-2024		261	11	
06-02-2024		259	11	
06-03-2024		263	11	

	WELDING CYCLE TIME	LOADING	UNLOADING	TOTAL TIME
MANUAL	135	10	5	150SEC
AUTOMATED	79	5	5	89SEC

MANUAL	AUTOMATED
144	264
3137	262
142	261
147	259
146	263
148	260
149	251

147	267
144	249
149	247
152	251

Table. 6.1 Results and discussion



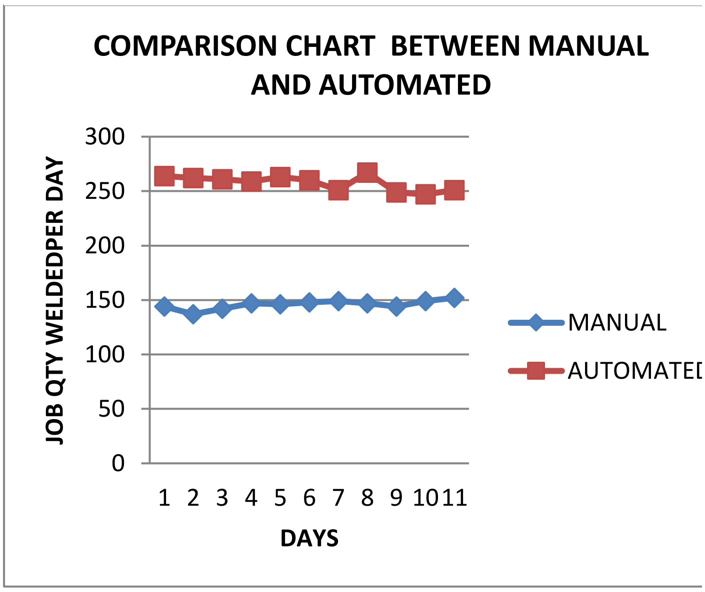


Fig. 6.2 Comparison Chart

7. EXPERIMENTAL SETUP

The spot to be welded is placed on the indexing table and the speed controller is adjusted to achieve the desired table speed, taking into account the welding process and the electrode feed speed. There are indexing knobs on the table for the number of weld seams and their position. The table is switched to the first stop position. If you now press a single switch, all processes are carried out simultaneously. Such as,

1. Griping work piece
2. Location the welding nozzle.
3. Initiating the welding.
4. After 360 angle completion, relay off machine off the welding process .Welding gun moves to its initial position.
5. Job ready to unload.
6. Buzzer blinks for 2 sec.
7. Process completed.

8. FUTURE SCOPE

It plays an important role in mass production and in the following processes: painting, air washing, wire winding, circular marking, welding of any geometric shape, as an indexer, CO_2 welding of circular or offset welds, arc welding of circular or offset welds, plastic moulds for multi-position moulds, bottling lines. Etc.

9. LITERATURE SURVEY

1. **Fu-senRen Xiao-zehad** developed a new type of special welding robot, which mixed design method of series and parallel and realized the integrated design of organization for robot and anchor. The robot kinematics is build and realized the real time control of welding torch position, orientation and welding speed during welding process.
2. **A.M. Vaidya and P. M. Padole** had calculated the flexibility of the limbs and the stiffness of the joints.
3. **Zhao Yang** has investigated the effects of the scanning frequency of the plasma torch on the temperature. Distribution at molten pool surface. In simulation plasma torch power is 750 kW, melting rate is 300kg/hr the torch scanning frequency changes from 0.0833 Hz to 0.5 Hz.
4. **ION Lucaciu** had worked on welding head enables vertical positioning of welding wire relative to electrode position, adjusting the lead angle when entering into metal bath or turning device to bring the welding rod in front of or behind the torch, depending on the welding direction
5. **Irfan Sheikh,** Studied the MIG welding parameters are the most important factors affecting the quality, productivity and cost of welded joint, Weld bead size, shape and penetration depend on number of parameters. The quality of a weld seam is directly influenced by the input parameters of the weld.
6. **Mithari Ranjeet,** Describes the welding positioner with automatic indexing, which is most important for mass production in the circular welding industry.
7. **Ganguly Arghya**, Describes a PLC based Control System for Hardening and Tempering Furnace in Heat Treatment Plant as implemented at the Siddheshwar unit for Mahindra Automobiles Limited, which is one of India's largest vehicle manufacturing corporation. The proposed system deals with the design of a PLC-based control system for a hardening and tempering furnace This article describes the components implemented for the control system and the workflow of the various components required. The system is controlled using a measurement PLC.
8. **Prof. Sawant P.R**, Discuss the case study and compare the productivity of a component drilled and tapped using a conventional radial drilling machine and a special purpose machine (SPM).

10. CONCLUSIONS

Heavy load capacity of table is 80 kg safe load Adjustable table speed (0 to 75 rpm) Auto stop feature, to start and end process operational precise positions. Multiple indexer positions, enables to make overwhelmed welded joints. Simple operation, as the table stops automatically depending on the position of the indexer button and the next operation is started by simply pressing the jog switch. Compact, as the entire drive unit is mounted under the table and the controls are located at the front in ergonomic positions. Low power consumption (50 watts) The above report shows that both complete circular welding and spray painting at the desired angle can be carried out perfectly and efficiently in mass production.

11. ACKNOWLEDGEMENT

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