



MECHANISM FOR AUTOMATION IN WELDING PROCESSES OF PRESSURE VESSELS

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Abstract: Welding is a major part in the manufacturing of reservoirs where the raw material that is the metal sheet is rolled and welded and then domes are attached to the rolled sheet and the whole thing is welded. Manual welding causes adverse effects on the health of the workers. To overcome such disadvantages along with the precision and accuracy of the weld in mind, the welding process is automated by building CNC machine like mechanism along with a Y-axis roller. The portable CNC has 3 degrees of freedom i.e., X, Y and Z directions. Three motors are connected to the Arduino CNC shield and can be operated by using GRBL software. The Y axis roller turns according to the speed set by the operator depending on the diameters of the pressure vessel. The linear welding is first done on the rolled metal sheet which is first tack welded. And with the help of Y-axis roller circumferential welding is also done. The main advantage is that this automation decreases health effects, increases precision and accuracy of the welding, and increases productivity rate.

Keywords: Automation, Welding, CNC machine, Y-axis roller, GRBL software

I. INTRODUCTION

Welding is the major part in manufacturing of reservoirs, reactors, pressure vessels etc. Welding is a fabrication process whereby two or more parts are fused together by means of heat, pressure or both forming a join as the parts cool. The mechanism of this automated welding system can be used to weld any type of reservoirs, cylinders, or vessels but here it is used to weld the pressure vessels used in the railways since these cylinders are welded manually. Automation of this increases the rate of production and decreases the time of welding and gives a cleaner weld. Welding torch will be moving with the help of a guideway that welds the cylinders whose dimensions are already provided to do the job. This system is like a CNC machine. The mechanism built will focus on motion the cylinder, motion of the welding torch with help of motors & fixtures and their orientation.



Fig.1: Mechatronic Welder

II. PROBLEM STATEMENT

As we all know that welding done by a human being is quite harmful for the health. Both acute and chronic health risks are associated with welding fumes. Occupational lung diseases are the most common health risks. But welding can also affect the eyes and skin. Welding in the manufacturing of reservoirs can only be performed by professional welders (welding accreditation certified welders). Now a days we do not find highly certified welders to perform this job. As accuracy is also a key aspect to be considered while welding, the welding bead might not be equal and precise even when a professional welder welds the parts. This is a tedious process and as it also has fewer workforces, it results in the decrease in productivity rate.



Fig.2: Certified Welder

The goal and purpose of this paper is to overcome these adverse health effects caused by manual welding, to increase the precision and accuracy of the weld, and increase the productivity by decreasing the time of welding.

III. WORKING OF THE SYSTEM

The general method that is followed is, the part that is fed into this cell will be a rolled sheet clamped to edges so that it maintains the cylinder shape. Once it is fed to the cell the welding begins lengthwise and the direction regarding to it. After this the shells/domes are placed to the sides of the cylinder, then the welding takes place throughout the curved surface of the reservoir. Then the welded cylinder is passed to the post processor unit where the finishing process can be added as per the requirements of the user.

The working of this mechanism is like that of a CNC machine. This has 3 degrees of freedom that is in 3 directions X, Y and Z respectively. The stepper motors are used for the 3-axis motion in the mechanism. The stepper motors are operated by the Arduino CNC shield. This Arduino CNC shield uses the GRBL software to operate everything.

A rotary roller to support the cylinder and revolve is mounted on top of the table. The rotary roller is also operated by a stepper motor that is operated using an Arduino board.

This mechanism makes the welding process easier to use. The rolled sheet is first tack welded and then placed on the rotary roller that is placed on the table of the mechanism. The guide block that supports the welding holder is adjusted along the X & Z axis and brought to the starting of the tack welding using the jog option in the GRBL control. This position is taken as the origin. The part programming using G codes and M codes is written and fed into the GRBL software.

With the help of the part programming where the dimensions are mentioned previously the guide block moves horizontally while welding that part.

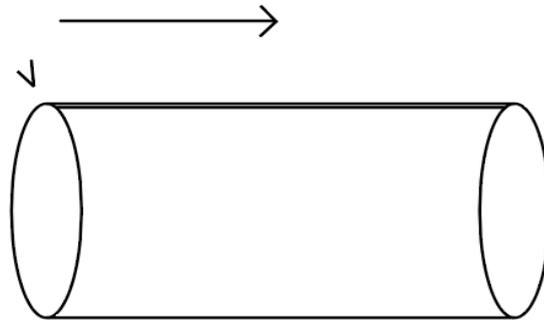


Fig.3: Welding takes place in the longitudinal direction i.e., lengthwise.

Now the rotary roller is operated and switched on according to the speed required. High speed for lesser diameters and low speed for greater diameters. The shells of the cylinders are now placed, and tack welded or clamped. The guide block(Y-axis) is brought back to the starting position where the shells are fixed. The rotary roller is now switched on and the cylinder starts revolving, hence the welding is done circumferentially. This is carried out on the other side as well.

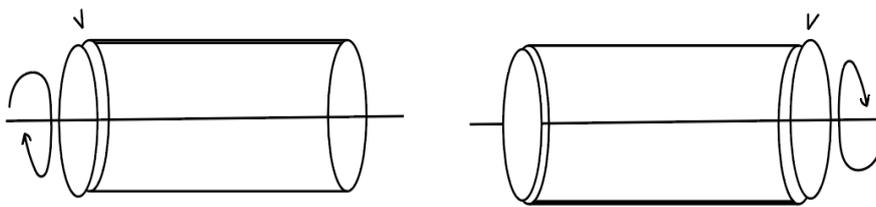


Fig.4: Welding takes place in the circumferentially.

The method can also be understood by the following flow chart:

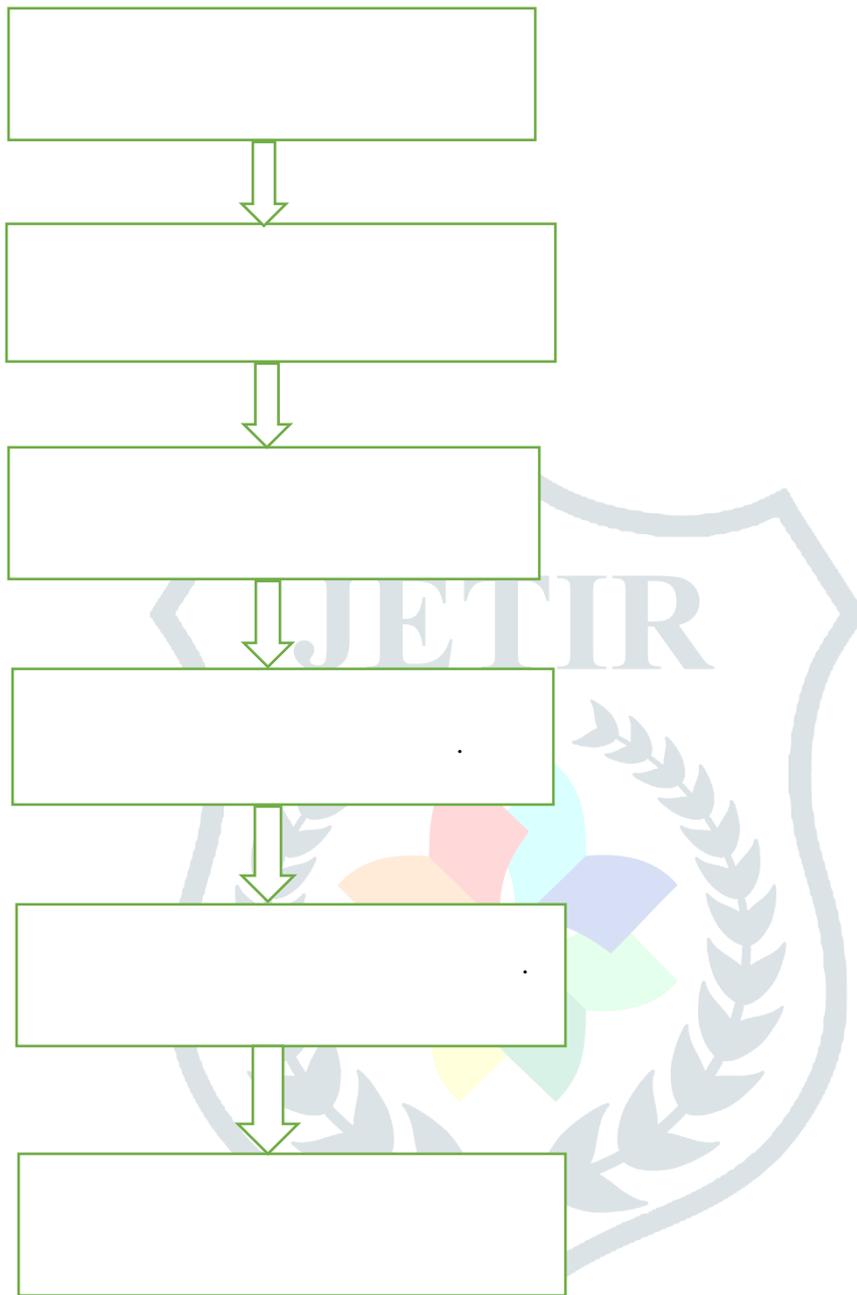


Fig. 5: Flow of the process

IV. DESCRIPTION OF ALL COMPONENTS USED IN THIS SYSTEM

A. ALUMINIUM RAILS:

Aluminium rail can be purchased as components or as pre-fabricated and ready-to-install rail systems. Aluminium non-welded series 500 pipe railing is especially designed to utilize all the advantages of aluminium where strength, durability and no-paint maintenance is a key factor.



Fig.6: Aluminium Extrusions

B. SWITCHED-MODE POWER SUPPLY:

This power module converts AC power to 12V 15A DC. It is highly efficient and robust to use. It is used in servers, power stations, PCs, equipment in railway and security systems and so on.



Fig.7: LRS 12-15 SMPS

C. ARDUINO UNO R3:

The Arduino UNO R3 is the perfect board to get familiar with electronics and coding. This versatile microcontroller is equipped with the well-known ATmega328P and the ATmega 16U2 Processor. This board will give you a great first experience within the world of Arduino.

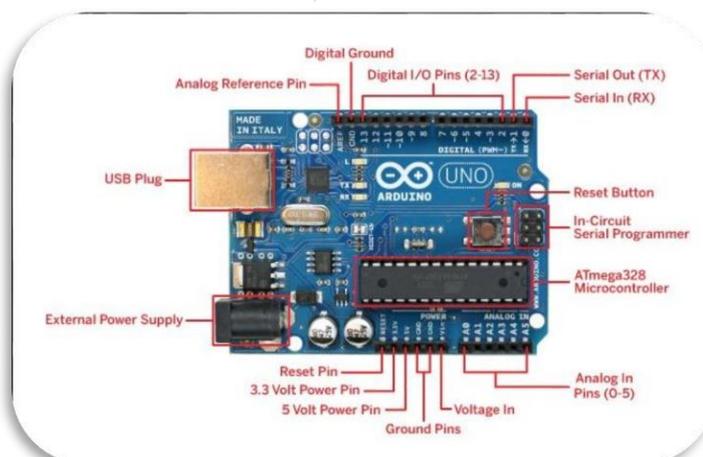


Fig.8: Arduino UNO R3

D. CNC SHIELD:

This expansion board as a driver expansion board, can be used for engraving machines, 3D printers, CNC. It is a total of four slots, can drive four stepper motors. Each stepper motors only need two IO ports. The CNC shield V3 driver expansion board is very convenient to use. After inserting CNC Shield V3.0 into Arduino UNO, install GRBL firmware and use it.

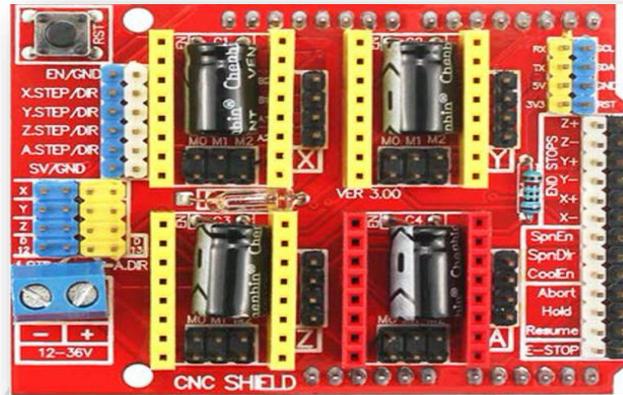


Fig. 9: CNC Shield V3

E. TMC2209:

The TMC2209 is a popular stepper motor driver designed and manufactured by Trinamic Motion Control GmbH. It is part of the StealthChop2 family of drivers, which utilizes advanced technology to provide silent, smooth, and precise motor control. The TMC2209 is widely used in various applications, including 3D printers, CNC machines, robotic systems, and automation equipment.



Fig.10: TMC2209

F. NEMA 17 Stepper Motor:

NEMA 17 is a stepper motor with a 1.7 x 1.7-inch (43.18 x 43.18 mm) faceplate. It is widely used in various industries due to its high precision, reliability, and versatility. The stepper motors move in precisely repeatable steps; hence they are the motors of choice for the machines requiring precise position control. The motor's position can be commanded to move or held in one position with the help of Stepper Motor

Drivers. They are very useful in various applications, especially which demand low speed with high precision.



Fig.11: Nema17 Stepper motor

G. LEAD SCREW:

Lead screws are used to convert rotary motion to linear motion. Lead screws are used as a component within various linear motion control systems. They are well suited to instrument grade applications, where smooth and precise operation is required.



Fig.12: Lead Screw

H. ROTARY ROLLER

A Rotary Roller is used to revolve cylindrical objects.



Fig.13: YRR2.0

V. RESULTS AND DISCUSSIONS

This automated welding mechanism is used to ease the process of welding in the manufacturing of pressure vessels. The welding is done accurately and precisely. The chronic effects caused due to the manual welding on the skin and the eyes can be prevented and avoided. Any skilled worker with basic knowledge in the CNC field can operate the system and perform welding. Hence this automation saves time and increases the productivity rate. The following 3D models of the mechanism is achieved during the research.

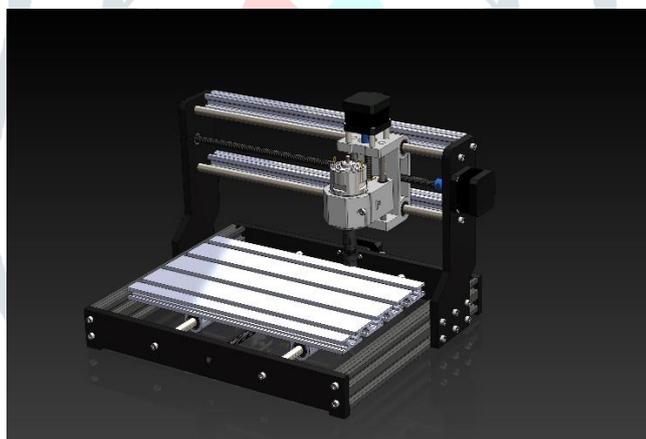


Fig.14: 3D model of Mechatronic welder V0

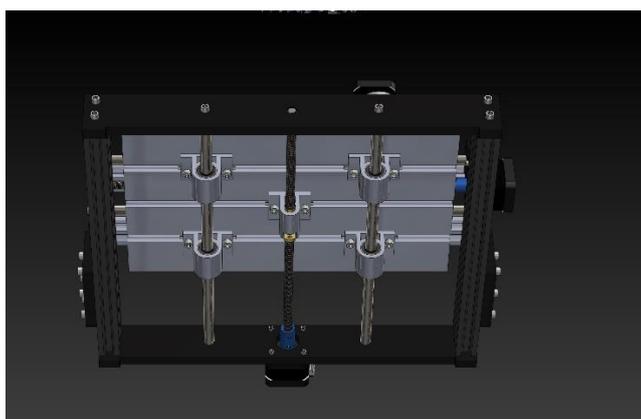


Fig.15: 3D model of Mechatronic welder V0

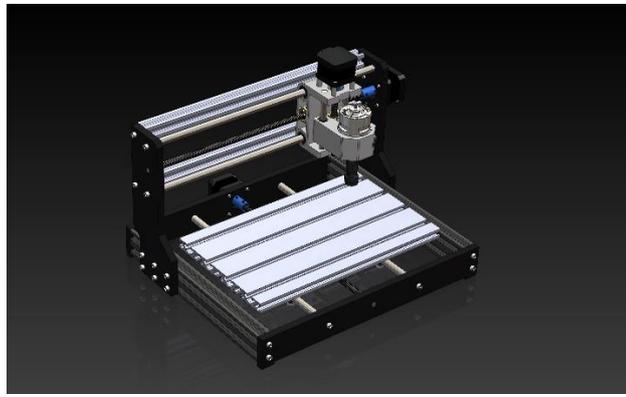


Fig.16: 3D model of Mechatronic welder V0

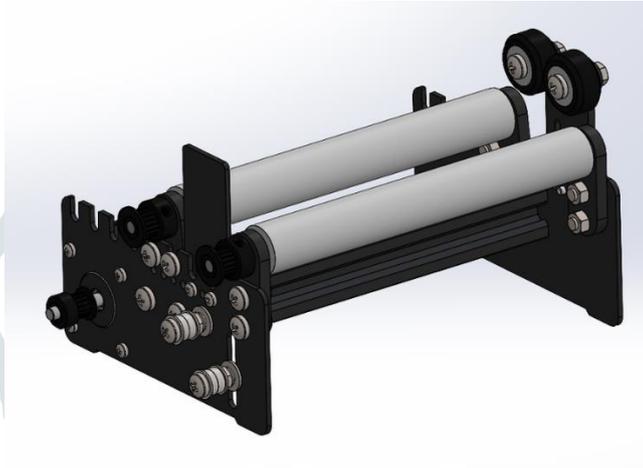


Fig.17: 3D model of YRR2.0

And later all the materials are sourced from different materials. The electronic components are first tested openly to check the running of motors. The mechanical components are cut and assembled according to the design. Then both electronics and mechanical components are integrated, and the Arduino CNC shield is connected to the GRBL software which is used to operate the CNC. The part programs are written using G-codes and M-codes and fed into the software interface application.

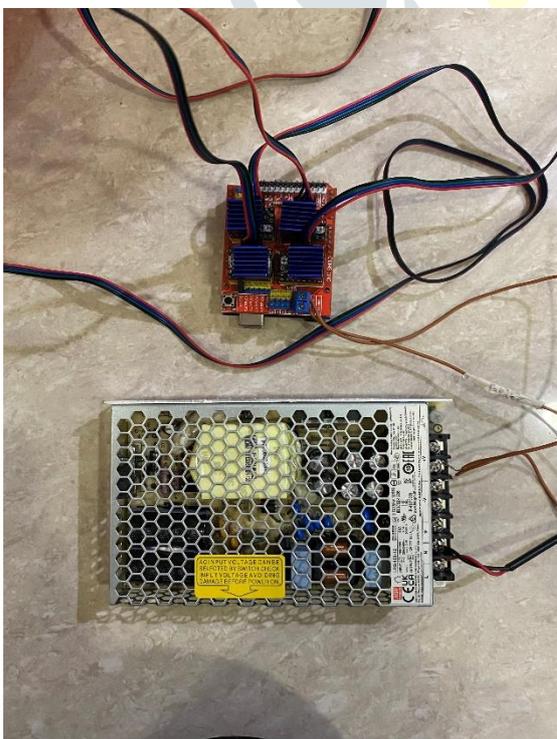


Fig.18: Electronic connections.

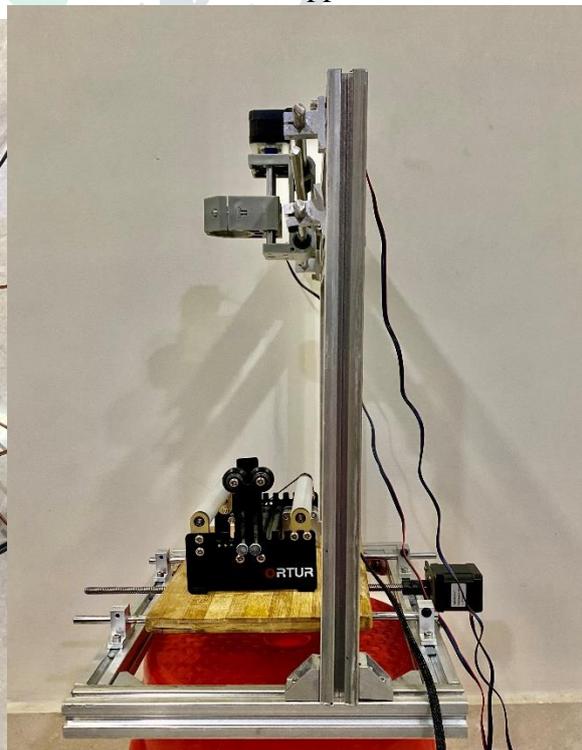


Fig.19: Side view of the AWSM

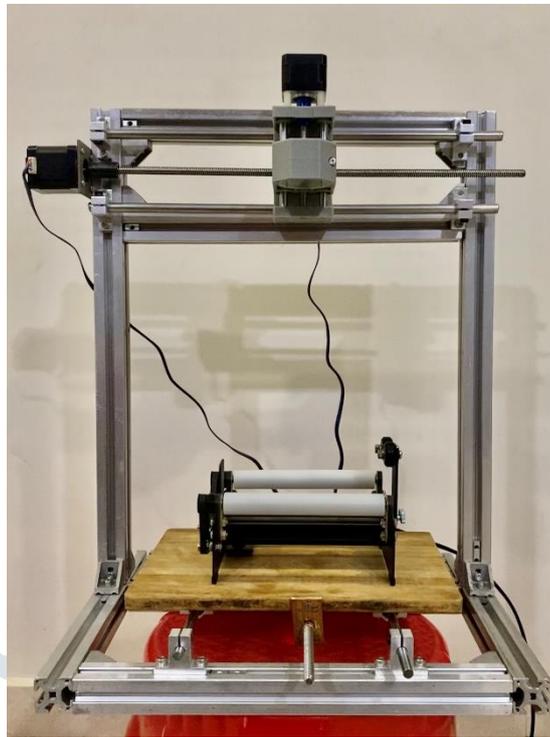


Fig.20 Front View of AWSM.

VI. CONCLUSIONS

This mechanism is quite helpful for the welding industry to decrease the adverse health effects of the welding processes. It can be scaled according to the manufacturing industry's requirement and can be used for different applications. It is user friendly and can be used by an operator with minimum knowledge in CNC operations and part programming.

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