Design of Portable TIG Welding RIG

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Abstract— Welding is the process of joining two or more similar or dissimilar metals by mode applying heat and pressure. TIG welding is the most commonly used method of welding process, this type of joining process is accustomed with Steel, stainless steel, Aluminum, etc. Manual TIG welding is inefficient as welding parameters like Stand-off distance, Arc travel speed and work angle which plays a vital role in overall quality of the weld, which cannot be controlled manually and leads to poor quality of weld. Even though if the welder has a lot of experience, the percentage of accurate weld is not as much. In this case study, we designed a Portable TIG welding RIG that can reduce the human contact with the weld specimen during the welding process with the help of servo motors, lead screw and nut mechanism and Arduino.

Keywords: TIG welding, welding parameters, TIG welding RIG

I. Introduction

There are certain standards which needs to be followed while joining metals based on the nature of material and thickness of the specimen to be joined. The main problem in any type of welding process is the control over parameters. The appropriate use of parameters creates a good quality weld. Some of those parameters are voltage (V), Type of current (DC/AC), current (A), Gas flow rate (m/s), Travel speed (m/s), Stand-off distance (mm) and Torch angle (°). Among all these parameters Stand-off distance, Arc travel speed and work angle cannot be controlled manually which may leads to the following problems.

1) Lack of fusion
2) Craters
3) Poor colour on stainless steel

Lack of fusion, craters, poor colour on stainless steel occurs because of not maintaining the Stand-off distance uniformly throughout the joint. If the welding torch is hold far away there is chance of lack of fusion in the weldment. Holding the torch too close to the joint leads to poor colour on the weldment because of overheating. Not placing the torch at a perfect angle and frequent stops while welding, leads to improper accumulation of filler and craters respectively.

In order to remove all these barriers, Automation of the TIG welding has become the necessity in the world of production [1][2]. It is the only best possible way to increase the quality of the weld as the human interference is very less. Apart from the quality of the weld, productivity is also important in mass production. Productivity plays important role in manufacturing industries due to competitive market conditions. The main objective of industry is the production of better-quality products at minimum possible cost and time.

II. Literature review

In a study conducted on "Study The Effects Of Welding Parameters On Tig Welding Of Aluminium Plate" by prakash mohan for his M.Tech research work [3], it is observed that with the help of automated TIG welding process uniform welding of the aluminium plates was done and it is very clear by looking at the results that, not only welding current but also travel speed is responsible for good welding strength.

"Pulse TIG welding: Process, Automation and Control" was studied by P. K. Baghel et al[4] it is observed that a customized setup for TIG welding is built with stepper motor along with single axis driven mechanism and Custom-built wire feed system. Defect free weld is produced because of the automation of the Pulsed TIG welding process. The weld quality of the weldment using customized setup is as same as that of setup available in the market.

III. Methodology

A. Selection of Working Mechanism

There are so many possible ways in solving the problem which is raised during welding process. The main movement of the TIG torch is linear motion along the direction of the joint. This type of movement can be achieved by Rack and Pinion, slider crank, spiral groove, belt driven, lead screw and nut mechanisms, etc. Every rotary to linear mechanisms is studied, lead screw and nut mechanism is chosen because of its ease of manufacturing, readily available market and more over the accuracy which can be drawn from this mechanism is high. Accuracy of 1mm can be achieved by customizing the lead screw.

B. Selection of Motors to Drive the Mechanism

Servo and Stepper motors are the most commonly used type of motors when it comes to conversion of nonlinear to linear motion. The main difference between these two are the way they are constructed and controlled. Stepper motor is basically a 50-100 pole brushless motor, where as a servo is typically a 4-12 pole brushless motor. Stepper motor doesn't have any kind of encoder for feedback sometimes we can add it as an option where as a servo is always built with some kind of feedback device whether it can be encoder or resolver in order to tell its drivers the position of the motor shaft. When it comes to precision, stepper motor beats the servo motor. The special feature of stepper motor is that it can control the angular position of the shaft without the closed feedback loop, it is simple and accurate open loop system. This is the reason for selecting stepper motor for this project.

C. Selection of Circuit Board

Microcontrollers are integrated circuits that are basically tiny computers which can run small and simple software programs. They are low powered enough which can be powered by battery for days, but they are very fast enough to process the data much faster than humans can ever think of. In this project Arduino is used as the circuit board along with Arduino SHIELD, which are basically circuit boards that plug into the main Arduino circuit board. Arduino SHIELD

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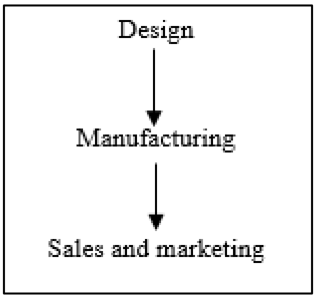
controls the stepper motor without necessity of design motor control circuits.

D. Selection of G-Code Software

This project uses GRBL which is an open-source software that controls the motions of the machine by generating G-codes form the given design. This software can be installed easily to an Arduino. The software uses G-codes as input and output motion control via Arduino.

IV. DESIGN AND ASSEMBLY

Designing is the first step of product development. A typical product development process consists of three stages. As shown below flow chart.



Flow chart 1: product development procedure

Design and assembly of the RIG is done in "SOLIDWORKS 2017". The Portable TIG Welding RIG consists of the following parts.

1) Foldable table
2) Rails with guide
3) Side supports
4) Sliders
5) Torch holder
6) L-staps
7) Lead screw
8) Stepper motor
9) Arduino
10) Hing
11) Coupler

Main parts of the RIG are explained below.

A. Table:

The dimensions of table are 700 mm length, 680 mm width and height of 70 mm. This part of the RIG is important because it can be folded into 350 mm length, 680 mm width and 140 mm box that can accommodate all other parts of the RIG. Below figure show how the table looks when it is folded and unfolded.

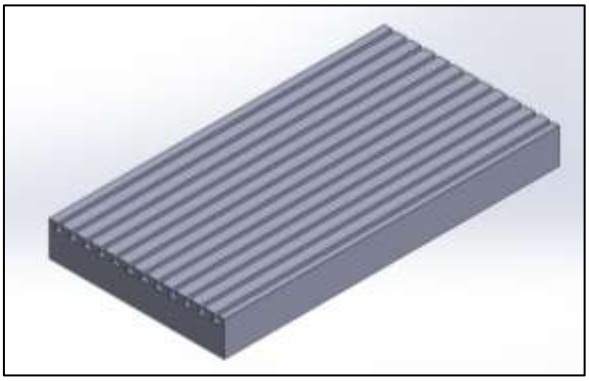


Fig. 1: Isometric view of the half table

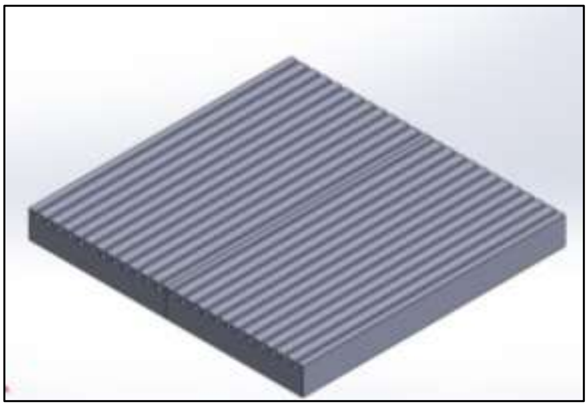


Fig. 2: isometric view of the table before folding

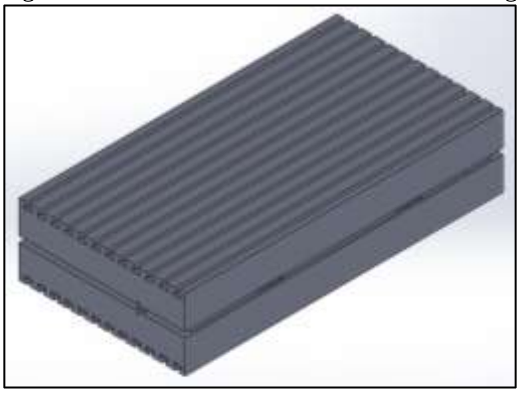


Fig. 3: isometric view of the table folded into half

B. Lead Screw:

Before going directly into designing the lead screw some basic calculation and assumptions were made.

1) Calculations:

Square thread with single star is used
Pitch (P) = 4 mm
Co efficient of friction (μ) = 0.15 (lubricated lead)
Mass (m) = 50kg
Outer diameter (Do) = 20 mm
Core diameter (Dc) = Do-P
= 20- 4
= 16 mm
Length (L) = P× no of start
= 4×1
= 4 mm

$$\text{Pitch circle diameter (Dp)} = \frac{\mathbf{Do+Dc}}{\mathbf{2}}$$

$$= \frac{\mathbf{20+16}}{\mathbf{2}}$$

$$= 18 \text{ mm}$$

$$\text{Helix angle } (\alpha) = \mathbf{tan^{-1}}\left(\frac{\mathbf{L}}{\boldsymbol{\pi}\times\mathbf{Dp}}\right)$$

$$= \mathbf{tan^{-1}}\left(\frac{\mathbf{4}}{\boldsymbol{\pi}\times\mathbf{18}}\right)$$

$$= 4.046^{o}$$

$$\text{Torque (T)} = W\times\frac{\mathbf{Dp}}{\mathbf{2}}\left(\frac{\boldsymbol{\mu\pi}\mathbf{Dp+L}}{\boldsymbol{\pi}\mathbf{Dp}-\boldsymbol{\mu}\mathbf{L}}\right)$$

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$$= 50 \times 9.81 \times \frac{18}{2}\left(\frac{0.15 \times \pi \times 18 + 4}{\pi \times 18 - 0.15 \times 4}\right)$$

$$= 984.88 \text{ N.mm}$$

According to the values obtained from the calculations, the designing of lead screw is done.

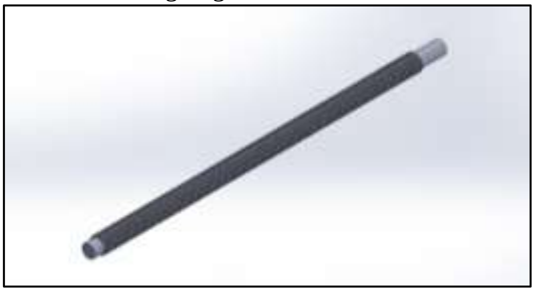

Fig. 4: lead screw

C. Rails with guide:

Two types of rails used in this project. They are, side rails and top rail as shown in the below figure.

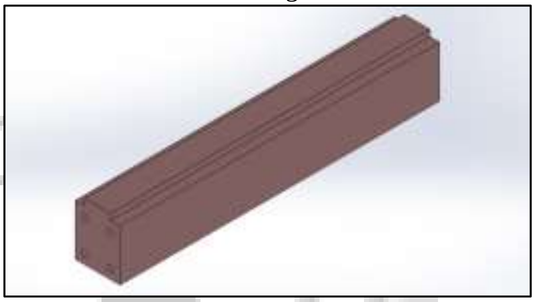

Fig. 5: Side rail

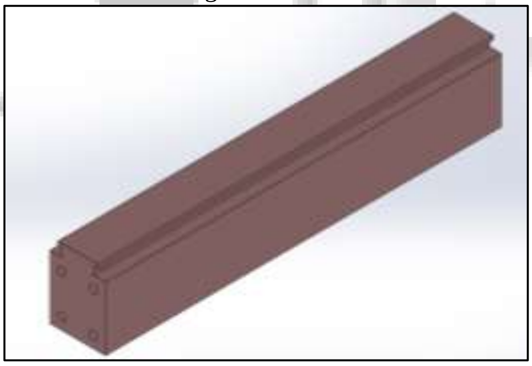

Fig. 6: Top rail

The main difference between the two rails is, the top rail designed in T shape on the top side of the rail which not only guides the slider on it but also prevents the lead screw getting bend while the welding process taking place.

1) Slider:

It acts as the nut in the lead screw and nut mechanism. This part is responsible for converting the rotary motion of the lead screw to linear motion. A groove is proved to the part which sits right on top of the side rails.

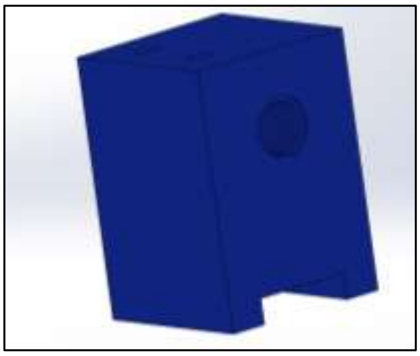

Fig. 7: Slider

2) Torch holder:

Torch holder holds the TIG torch firmly in the correct position at any required angle. This part has a curvature which helps the operator to fix the torch on the holder easily.

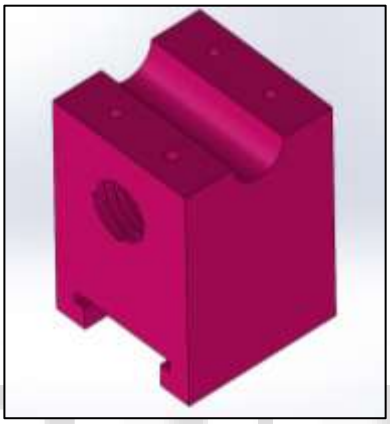

Fig. 8: torch holder

D. Figures of other parts:

Fig. 9: coupler

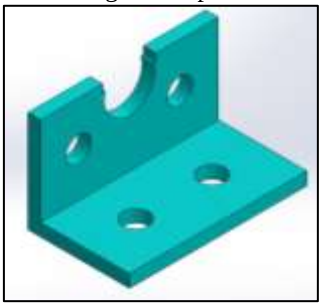

Fig. 10: L-strap

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Fig. 11: Hexagonal Bolt

Fig. 11: L-strap screw

E. Assembly figures:

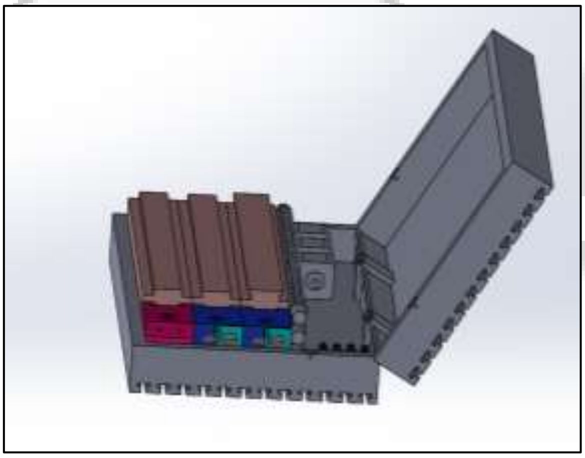

Fig. 12: Box containing all parts

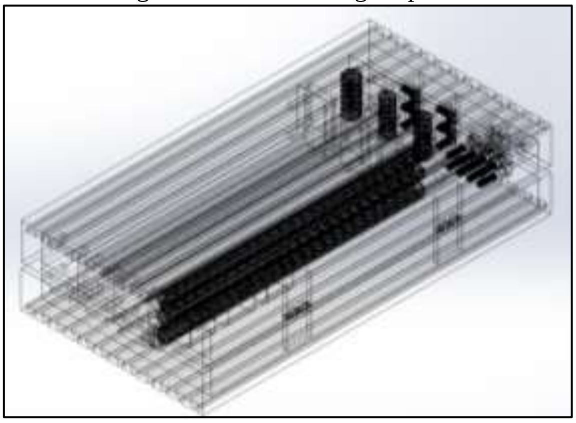

Fig. 13: Wireframe display style

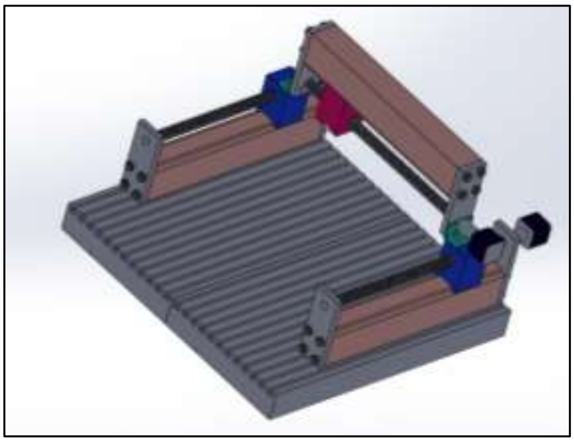

Fig. 14: TIG welding RIG

V. CONCLUSION

Building a proper customized welding RIG is another alternate for setup available in the market. This type of setups is useful for research work because sometimes there will a need of producing a good quality weld in order to test the weldment. Accurate results can be obtained by using this kind of welding RIG.

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