Research Paper on Automation of Gas Tungsten Arc Welding & Parameters of Auto-TIG for SS304L

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Abstract

Advances in technologies are necessary for every industry to survive in competition. The main factors by improving which the industry can survive in the market are productivity, quality & customer delivery date. In this paper I am going to present the scope of improvement in the manual Gas Tungsten Arc Welding (TIG) by replacing it with automated Gas Tungsten Arc Welding. The parameters also developed for SS304L by Auto-TIG welding for a pipe of SS304L with 8mm Thickness. After developing these parameters they applied on the standard job items and the penetration controlled within 1mm. Finally concluded with the implementation of these parameters on Auto-TIG productivity gets increased.

Keywords: Gas Tungsten Arc Welding, Welding Penetration, Welding Speed, Gas Flow

I. INTRODUCTION

A. Manual Gas Tungsten Arc Welding:

TIG Welding is a manual welding process that requires the welder to use two hands to weld that separates TIG welding from most other welding processes is the way the arc is created and the way in which the filler metal is added. When TIG Welding one hand is used for holding the TIG torch that produces the arc and the other hand is to add the filler metal to the weld joint. Because two hands are required to weld, TIG welding is the most difficult of the processes to learn, but at the same time is the most versatile when it comes to different metals. This process is slow but when done right it produces the highest quality weld. TIG welding is mostly used for critical weld joints, welding metals other than common steel, and where precise, small welds are needed.

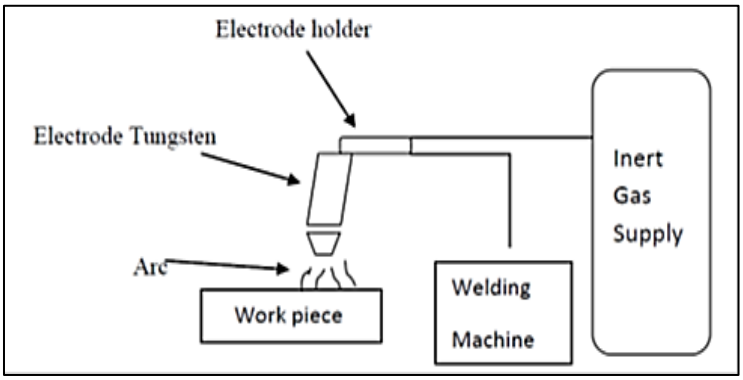

Fig. 1: Manual Gas Tungsten Arc Welding

TIG welding requires three thing, heat, shielding, and filler metal. The heat is produced by electricity passing through the tungsten electrode by creating an arc to the metal. The shielding comes from a compressed bottle of gas that flows to the weld area to protect it from air. The filler metal is just a wire that is dipped by hand into the arc and melted. First the welder turns on the gas flow, many times by a valve on the TIG torch itself. The gas begins to flow and starts protecting the weld area from the air. The torch is held over the weld joint just far enough for the torch not to touch the metal. Then the welder presses a foot pedal and the TIG torches tungsten electrode starts an arc. Once the arc is started the two pieces of metal begin to melt by creating a puddle of metal. Once the puddle is established the welder with the other hand starts filling the joint by manually dipping a welding wire into the arc to fill the joint. Ultimately this process creates a single piece of metal.

II. METHODOLOGY

A. Automation of Tungsten Inert Gas Arc Welding:

In Auto TIG before start of any welding the data is entered through Human Machine Interface regarding job diameter, start current, voltage ,speed of rotation, preflow period, postflow period etc. The data entered in HMI goes to PLC, PLC execute the sequence according to that. Initially the inert gas flow starts for a period of 5 sec to prevent any impurity over the welding joint. After that Tungsten develop an arc still the feed of filler wire not started directly but after span of 2-3 sec it starts and the rotation of chuck also started. As the welding pass comes to completion the welding current slows to zero gradually during that span before the current become zero the feed of filler wire stops. Then also the shielding gas flow continues for a period of 5 sec after which the flow stops and rotation also stops. In this way the Auto TIG cycle is executed.

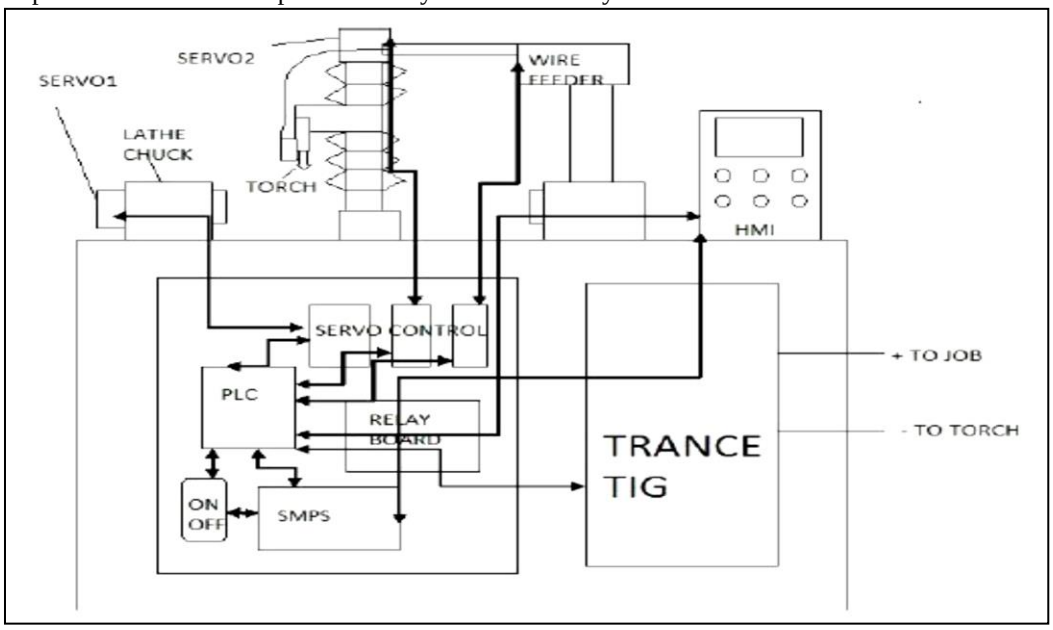

Fig. 2: Block Diagram of Auto TIG

1) Drive Mechanism:
In this automated TIG welding machine the drive mechanism basically consist of lathe chuck which is coupled with servomotor. Servomotor helps to give the digital output. Servomotor provides the speed variation as per the programmable logic controller as it is coupled with lathe chuck the variation in speed can be observed in lathe. Servomotor transmits its rotation to the lathe gear drive through belt drive mechanism.
2) TIG Torch:
TIG torch is mounted on a square block which is supported with the bellows. On the same square block there is arrangement of feeding of feeler wire. The feeler wire is fed from front side of the tungsten. Panasonic 200watt servomotor is provided at the top of arrangement for TIG torch assembly. Due to the servomotor the height of the TIG torch is adjustable, according to the requirement of job. Also one separate pipe is provided over the TIG Torch mechanism; through that pipe 2 tubes are passed one for wire cooling of TIG Torch and another for shielding gas flow through ceramic cup. TIG torch assembly also capable to move horizontally i.e, along x-direction.
3) Wire Feeding Unit:
Wire feeding unit consist of spool of feeler wire of over which feeler wire is wounded. The feeler wire of the spool is passed through the bevel gear arrangement. The rotation of that bevel gear train is provided by the Techo servomotor .As the welding starts then initially we can't start the feed of feeler wire directly. There is definite time span of time after which we can start feeding the feeler wire. Also during the completion of welding the feeler wire feed needs to stop before the end of arc, so these start and stop of feeding of feeler wire is controlled by servomotor through PLC.
4) Human Machine Interface:
The Human Machine Interface (HMI) includes the electronics required to signal and control the state of industrial automation equipment. These interface products can range from a basic LED status indicator to a 20-inch TFT panel with touch screen interface. In this Auto TIG it consists of a touch screen with alpha numeric keypad provided over it so as to change the parameters as per the requirement. HMI is connected with Programmable logic controller So the data which is entered in the HMI gets directly saved in PLC. In the HMI we have to enter the values for gas pre flow time, job circumference, time of

rotation etc. In the Auto TIG at the base of HMI some buttons are provided which directly control gas flow, rotation of chuck, Start & Stop of machine.

5) Programmable logic Controllers:

A programmable logic controller, PLC or programmable controller is a digital computer used for automation of typically industrial electromechanical processes. The

Functionality of the PLC has evolved over the years to include sequential relay control, motion control, process control. The data handling, storage, processing power and communication capabilities of some modern PLCs are approximately equivalent to desktop computers. It is heart of an Auto TIG welding machine. The data from HMI is compiled in PLC and all the operations are controlled through it from the start of welding till the end.

6) Servomotor:

A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed loop control system. In this Auto TIG there are 3 servomotors are used one for drive mechanism, one for TIG torch motion and last for wire feeding unit. As it can provides variation in the speed during the operation according to the requirement that why it is more useful.

7) Trans:

TIG :Trans-TIG is a power source which is used to supply power to the welding machine. Trans-TIG 3000 used in Auto TIG welding machine. The negative terminal of which is connected to the electrode while the positive terminal is connected to the workpiece. It is connected to PLC to control the welding as per the programming in it. It has digital display screen over which we can see the voltage and current during the welding .Automatic cooling shutdown is also available in it. Also it is able to calculate post flow gas time depend on the welding current.

III. STAGES OF DOE

Designed experiments are usually carried out in five stages planning, screening, optimization, robustness testing and verification.

A. Planning:

It is the process of testing and data collection. The factors or the parameters of the welding machine, which affects the overall productivity of the machine, are found out. Those parameters will be then replaced with the new parameters. These new parameters are collected from the experiments done on Mock-up jobs. New parameters will be then implemented on the new job items. Trail done on 5 number of mock up, different results were obtained by variation in the parameters.

Following are the parameters of TIG Welding

1) Voltage
2) Current
3) Welding speed
4) Gas flow
5) Preflow time
6) Postflow time
7) Arc length

B. Screening:

Screening experiments are used to identify the important factors that affect the process under investigation out of the large pool of potential factors. These experiments are carried out in conjunction with prior knowledge of the process to eliminate unimportant factors and focus attention on the key factors that require further detailed analyses. Screening experiments are usually efficient designs requiring few executions, where the focus is not on interactions but on identifying the vital few factors.

The vital few factors which are found after screening are

1) Current
2) Arc Length
3) Welding seed
4) Gas flow

By considering these important parameters changes done in their values and the penetration during each experiment is observed.

1) Current:

Current has direct influence on weld bead shape, on welding speed and quality of the weld. Most GTAW welds employ direct current on electrode negative (DCEN) because it produces higher weld penetration depth and higher travel speed than on electrode positive (DCEP) (reverse polarity). Besides, reverse polarity produces rapid heating and degradation of the electrode tip, because anode is heated more than cathode in gas tungsten electric arc Reverse polarity may be of interest in welding

aluminium alloys because of the cathode cleaning action of negative pole in the work-piece, i.e. the removal of the refractory aluminium oxide layer. However alternating current is better adapted to welding of aluminium and magnesium alloys, because it allows balancing of electrode heating and work piece cleaning effects.

2) Arc Length:

The arc length is the distance between the electrode tip and the work-piece. The arc length in TIG welding is usually from 2 to 5 mm. If the arc length increases, the voltage to maintain the arc stability must increase, but the heat input to work-piece decreases due to radiation losses from the column of the arc. Consequently, weld penetration and cross section area of melted material decrease with increasing arc length.

3) Welding Speed:

The effect of increasing the welding speed for the same current and voltage is to reduce the heat input. The welding speed does not influence the electromagnetic force and the arc pressure because they are dependent on the current. The weld speed increase produces a decrease in the weld cross section area, and consequently penetration depth (D) and weld width (W) also decrease, but the D/W ratio has a weak dependence on travel speed. These results suggest that the travel speed does not influence the mechanisms involved in the weld pool formation, it only influences the volume of melted material. Normal welding speeds are from 100 to 500 mm/min depending on current, material type and plate thickness.

4) Shielding Gases:

Shielding gases are used in TIG welding in order to prevent atmospheric contamination of the weld metal. This contamination can produce porosity, weld cracking, scaling and even change in the chemical composition of melted material. Further, shielding gas also has a large influence on the stability of the electric arc. Gases with low ionization potential facilitate the ignition of the electric arc and those with low thermal conductivity tend to increase the arc stability. Argon is the most used TIG welding shielding gas. It has low ionization potential and is heavier than air, providing an excellent shielding of the molten weld pool. Furthermore it is less expensive than helium, the other inert shielding gas used in the process. Argon is sometimes used in welding of carbon and stainless steels and low thickness aluminium alloy components.

IV. OPTIMIZATION

A. Parameters of Auto-TIG for SS304L:

Experiments conducted on SS304L pipe of diameter 76mm with 8mm thickness. The scope of this experiment is to identify the best suitable parameter by using Auto-TIG to control the penetration within 1mm.Five trials taken on the specified size mock-ups to identify optimum parameter for Auto-TIG . After carrying out these trails at the 5th trail the penetration controlled within 1mm as per the requirement. Current & Voltage plays an important role in penetration of welding, if we go on increasing the current the penetration goes on increasing .Most of welding machines are constant current power source welding machines. So the current remains constant during the welding and the voltage goes on changing with respect to the arc length. In the Manual TIG we can't keep the arc length constant as it is controlled by the hand of the welder so it is much difficult to maintain constant arc length, But with the Auto-TIG as the arc length remain constant so we can easily maintain uniform welding quality for the entire weld run. Weld quality consists of two factors: weld integrity and repeatability. Automate welding systems ensure weld integrity through electronic weld process controllers. Combining mechanized torch and part motions with electronic recall of welding parameters results in a higher quality weld than can be accomplished manually. Furthermore, because a weld is made only once, defects are readily visible and detectable. Humans tend to do mistake with the torch, hiding lack of penetration or a possibly flawed weld. In some cases, leak testing and vision systems can be integrated into fully automated systems to provide additional quality control. Repeatability is a function of the quality of the weld process controller and of the engineering of the machine motions. Mechanized welding provides repeatable input parameters for more repeatable output.

Table - 1
Parameters for Auto –TIG Welding

Parameters	*Trial1*	*Trial2*	*Trial3*	*Trial4*	*Trial5*
Voltage(v)	*13*	*12*	*11*	*10*	*10*
Current(A)	*120*	*110*	*100*	*95*	*90*
Speed(mm/min)	*60*	*58*	*55*	*55*	*55*
Gas Flow(Lit./hr)	*7-10*	*7-10*	*7-10*	*7-10*	*7-10*
Penetration(mm)	*4mm*	*3mm*	*2mm*	*2mm*	*1mm*

V. CONCLUSION

In this paper the various factors on which the productivity depends are discussed and the most suitable parameters are implemented on the new Auto-TIG. For increasing productivity of the TIG welding machine the important factors are Current, Voltage, Arc Length, Gas Flow & welding speed. Thus, by doing the trail on SS304l workpiece, optimum parameter to control

the penetration within 1mm is found out. With the Automation the quality & the quantity of the production also increases. As the quality of the welding with the automation is much higher than the manual TIG so the scrap gets reduced & productivity improved.

REFERENCES

[1] P. N. Rao - Manufacturing Technology - McGraw Hill Education (2013)
[2] C.B. Shaw - Diagnostic Studies of GTAW arc – Part 1 Observational Studies
[3] R. C. Voigt & C. R. Loper Jr. - Tungsten Contamination during GTAW – Supplement to welding Journal, April 1980
[4] V. P. Kujanpaa - Role of Shielding Gases in GTA Welding Of Stainless Steel strips – 64th Annual AWS Convention, Philadelphia
[5] [5] Construction Technologies for Nuclear Power Plants-International atomic energy agency
[6] M. Lu & S. Kou - Power & Current Distribution in Gas Tungsten Arc – Supplement to welding Journal, February 1988
[7] J.S .Chain, X.R.LI and Y.M. Zhang -Gas Tungsten Arc Welding using an Arcing wire
[8] Ulrich Kruger, Schweibtechnishe Lehr –Arc welding process TIG, Plasma& MIG
[9] American Welding Society (2004). Welding handbook, welding processes Part 1.
[10] ASM International (2003). Trends in welding research. Materials Park.