A Review on Parametric Optimization of GMAW Process

"Effect of Welding speed, Welding current, Arc voltage and Wire feed rate on Bead geometry & Bead hardness"

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***Abstract* – Gas Metal Arc Welding Process (GMAW) is also known as a MIG Welding, in this process different parameters play most important role for quality, productivity and cost of welding. This paper presents the influence of welding parameters like welding speed, welding voltage, welding current, wire feed rate, etc. on weld bead geometry and bead hardness of medium carbon steel material during MIG welding process. Depth of penetration, bead height and bead width will be considered as bead geometry in this paper. Taguchi technique has been used as acquire the data and Taguchi orthogonal array play most important role for minimize the experimental reading. So, also step of Taguchi method is included in this paper based on literature study.**

***Keywords* - GMAW process, MIG welding, Taguchi method**

I. INTRODUCTION

Gas Metal Arc Welding Process (GMAW) is an arc welding process that uses an arc between a continuous fill metal wire and weld pool. All commercial ferrous and non ferrous metal such can be easily welded in all positions using this process by choosing the proper condition of process. The production rate is higher compare to other shielded metal arc welding process because of continuous electrode feed and high filler metal deposition rate. Gas Metal Arc Welding also known as a MIG welding. In this process the wire feed is a continuous process, so we can achieve a long weld joint without stop and start condition. The current work aims to study the effects of various parameters in gas metal arc welding on medium carbon steel. This paper also contains information regarding steps of Taguchi method.

II. GAS METAL ARC WELDING (GMAW)

GMAW is an arc welding process where in coalescence is obtained by heating the job with an electric arc produced between work piece and metal electrode feed continuously. Gas metal arc welding (GMAW) process consists of heating, melting and solidification of parent metals and a filler material in localized fusion zone by a transient heat source to form a joint between the parent metals. The arc and molten weld are shielded by an inert gas like argon, helium, carbon dioxide or gas mixture hence flux is not used or required in this GMAW process/ GMAW also called metal inert gas (MIG) welding. Gas metal arc welding is a gas shielded process that can be effectively used in all positions [1].

The electrode in this process is in the form of coil and continuously feed towards the work during the process. At the same time inert gas is passed around electrode from the same torch. Argon, helium, or a suitable mixture of these is used as an inert gas to prevent the atmosphere from contacting the molten metal & Heat affected zone. When gas is supplied, it gets ionized and an arc is initiated in between work piece and electrode. Here, gas play role like flux. Heat is produced there and due to the heat electrode is starting melts and molten metal falls on the heated joint.

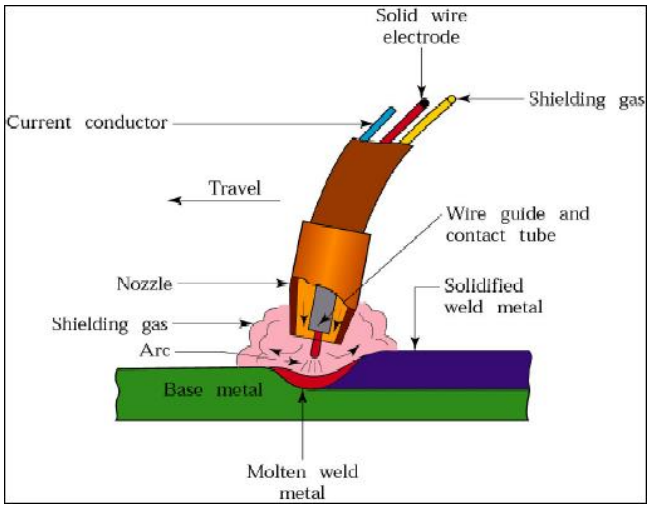


Figure 1.1 Working Principle of MIG Welding [1]

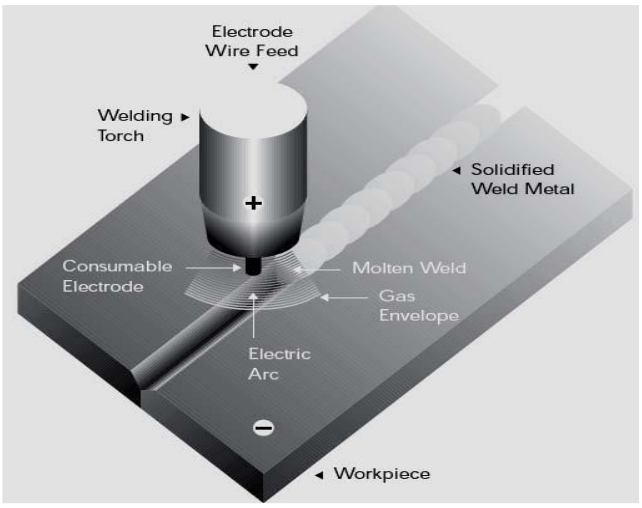


Figure 1.2 Basic GMAW Workpiece Welding [1]

The arc may be produced between the work and feed wire. Continuous welding with coiled wire helps high metal depositions rate & high welding speed. The filler wire is connected to the positive (+) polarity of DC source forming one of the electrodes. The base material is connected to the negative (-) polarity. The power source could be constant voltage DC power source, with electrode positive and it yields a stable arc & smooth metal transfer with least spatter for the entire current range. The gas shield around it does not ionized, which prevents weld against atmospheric contamination and surface oxidation. Some torch has water cooling systems.MIG welding is also called Gas Metal Arc Welding. The filler metal is transmitted from electrode to joint by different type's methods. It is dependent on the current passing through the electrode & voltage.

III. PROPERTIES OF MIG WELDED BUTT JOINT

A) BEAD GEOMETRY:

Automated robotic welding systems have received a great deal of attention, since they are highly appropriate both to increase Production rate and quality and to decrease cost and production time for a desired product. In order to obtain them, a complete Control over the relevant process parameters to get the required bead geometry and which is also based on weld ability is Indispensable.

Erdal Karadeniz [2], has investigated the effects of various welding parameters on welding penetration in Erdemir 6842steel Having 2.5 mm thickness welded by robotic gas metal arc welding were investigated. He chooses welding current, arc voltage and welding speed as variable parameters. In his research, depths of penetration were measured for each specimen after the welding operations and the effects of these parameters on penetration were researched. He chooses range of welding current is 95, 105, 115 A, Arc voltages range is 22, 24, and 26 V and the welding speeds were chosen as 40 cm/min, 60 cm/min and 80 cm/min for all Experiments in his research. As a result of this study, he found that increasing welding current increased the depth of penetration. In addition, arc voltage is another parameter which affect on the depth of penetration. However, its effect is not as much as current's. The highest penetration was observed at 60 cm/min welding current in his research.

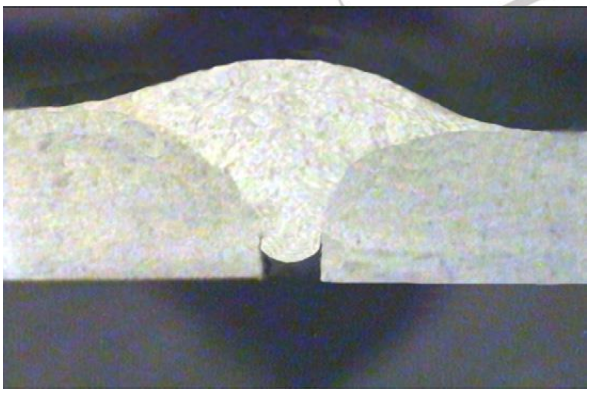


Fig. 2.1.1. 95 A, 22 V, 80 cm/min condition. P = 2.36 mm. lack of penetration in root pass.[2]

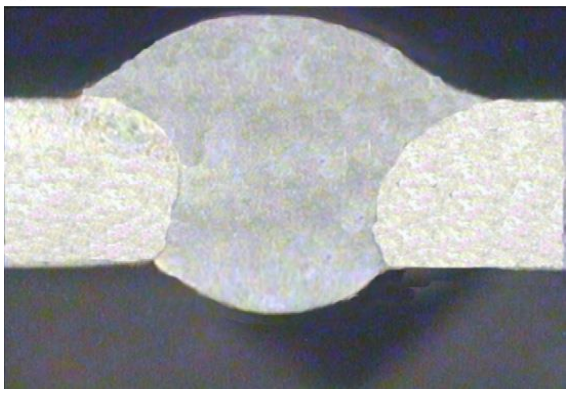


Fig.2 .1.2 115 A, 26 V, 40 cm/min condition P = 3.19 mm. An over penetrated weld joint.[2]

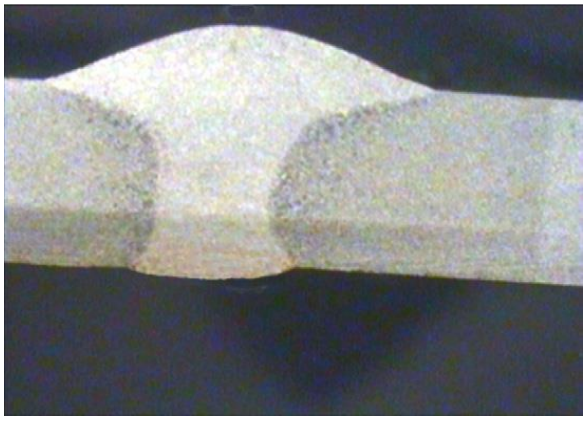


Fig. 2.1.3. 95 A, 24 V, 60 cm/min condition. Depth of penetration, P=2.67mm.[2]

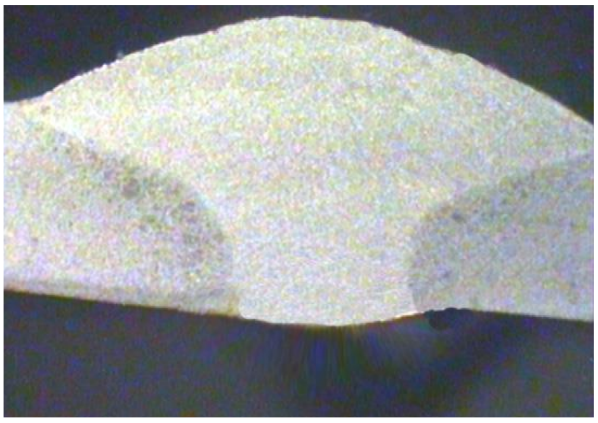
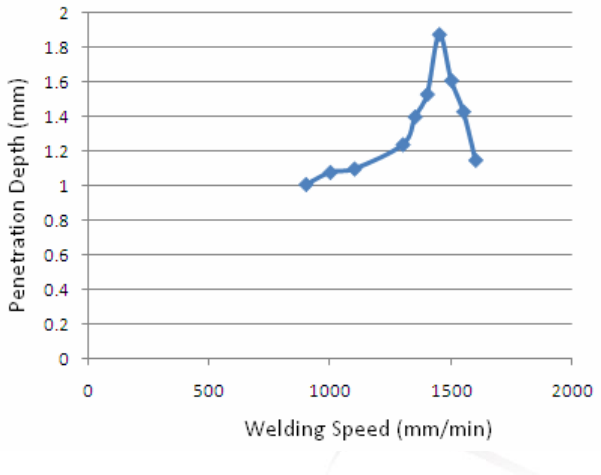


Fig. 2.1.4 95 A, 26 V, 40 cm/min condition P = 2.64 mm.[2]

Stated that, The depth of penetration increases with increasing welding current between range of 95A to 115 A and the avg. penetration rise was measured as 0.0225 mm for each 1 A current increment. In addition to welding current, arc voltage also increases the penetration value by 0.02–0.12 mm for 22–26 V, respectively. However, its effect of voltage is not as much as welding current's. When they taken welding speed as a parameter, the deepest penetration was obtained in 60 cm/min one. The depth of penetration values increases from 0.03 to 0.08 mm between 40 to 60 cm/min. Its value decreases after that top point.[2]
K. Abbasi [3] has investigated the effect of MIG welding parameters on the weld shape factor and weld bead characteristic of bright drawn mild steel specimen of dimensions 144*31*10 mm. The welding current, arc voltage, welding speed, heat input rate are chosen as welding parameters in his investigation. The depth of penetration and weld width were measured for each specimen after performing welding operation, a effect of welding speed and heat input rate parameters on depth of penetration and weld width were investigated.[3]



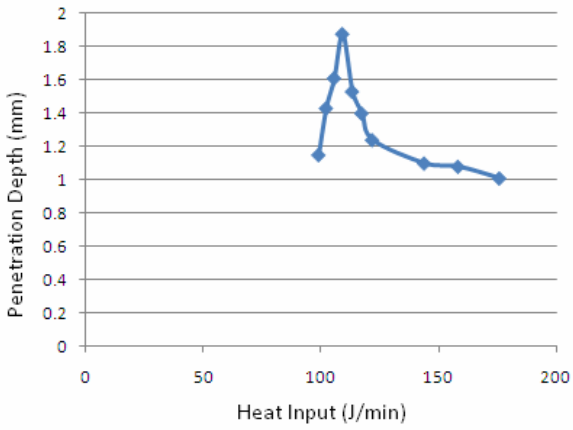


Fig.2.1.5 Penetration depth as a function of welding speed [3] **Fig. 2.1.6 Penetration depth as a function of heat input [3]**

In his research he also found that, penetration depth increases with increase in speed up to an optimum value of 1450 mm/min, beyond that speed penetration starts decreasing. When the heat input is taken into consideration the depth of Penetration increases with increase in heat input up to a rate 109 J/min, beyond which the penetration depth starts decreasing.[3]
Amalina Amir [4], has studied the effects of different parameters on welding penetration, micro structural and hardness measurement using mild steel that have 6mm thickness of base metal. Using the automatic gas metal arc welding research are investigated. The variables that chosen in this study are arc voltage, welding current and welding speed. The arc voltage and welding current were chosen as 22, 26 and 30 V and 90, 150 and 210 A respectively. The welding speed range was chosen as 20, 40 and 60 cm/min. The penetration, microstructure and hardness were measured for each specimen after the welding operation and the effect of it was studied. As a result, they found that increasing the value of welding current increased the depth of penetration. Other than that, arc voltage and welding speed is another factor that also affects the value of depth of penetration.

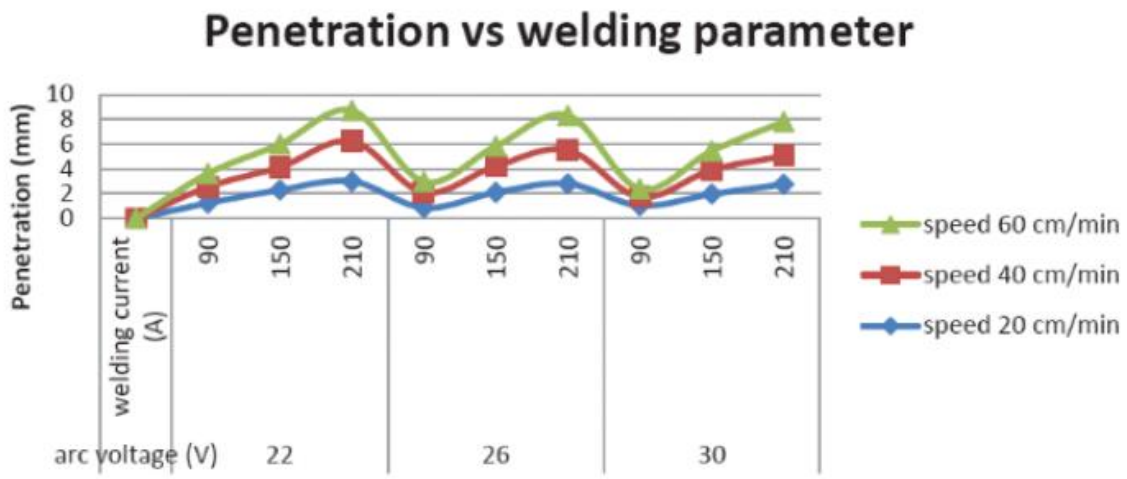


Figure 2.1.7 Penetration vs. Welding Current diagram for 20 cm/min welding speed [4]

Depth of penetration increased with increasing the value of welding current 90A, 150 A and 210 A. Welding current is factor that will determine the penetration value. Penetration value also affected by the factors from welding speed and arc voltage. At the graph, the best value of penetration for three various welding speed is 22 V at 210 A. It plotted the highest values of penetration than others. At the welding speed 60 cm/min, the best value for penetration happened is 26 V at 210 A. [4]

B) BEAD HARDNESS

Amalina Amir [4], has studied the different parameter effect on bead hardness. In this study base plate will cut perpendicular to the direction of welding by using a cut-off machine to cut the plate and polished with different grades of emery sheets. Then, the plates will etched using 2% nital to clearly the metal zone of welding joint. The Vickers Hardness values for HAZ, The 1kg load applies up to 20sec.on the base plate. The hardness values are determined and performance is shown in figure. Normally, the material will loses its strength by strain hardening effect in the fused zone area during the solidification. In the carbon steel or low alloy steel, at the fusion zone that content the formation of marten site or bainite phase and that were increased the hardness of metal [4].

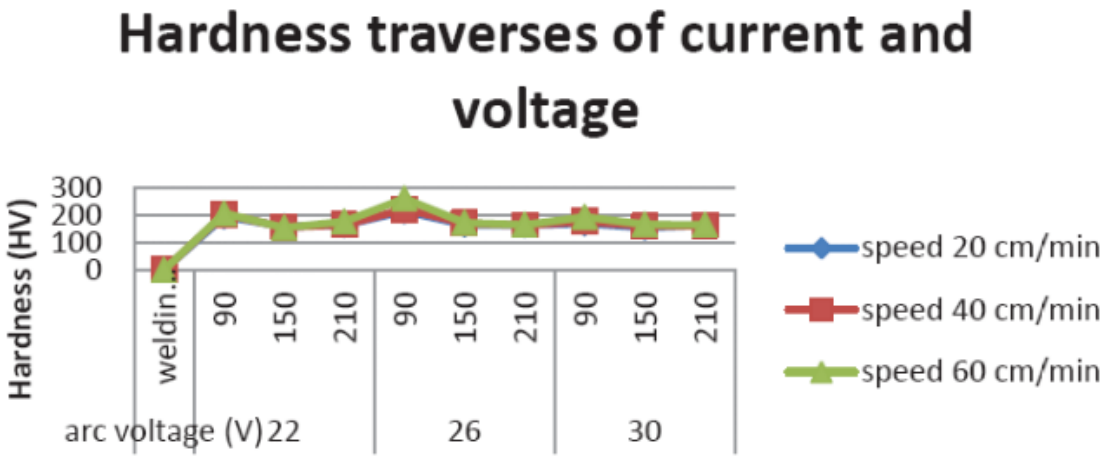


Figure 2.2.1 Hardness vs. Welding Current and arc voltage diagram [4]

Hardness values under the different welding parameters are plotted in figure. In that Figures, it represents the welding current versus hardness value at weld bead joint. In studying the hardness graphs that produced from different welding parameters, it noticed that hardness is increase at 90 A and slowly decrease to 150 A but at 210 A it is greater than 150 A. Hardness at speed of 60cm/min, voltage of 26V expose the highest hardness because of the faster the speed at medium voltage reveals the good formation of marten site grain.[4] Final conclusion in his study is The hardness at weld bead it is higher value at point 90 A and it slowly dropped to 150 A and at 210 A it small increased than 150 A. The higher value of hardness is 26 V at 90 A at welding speed 60 cm/min.[4]

IV. OPTIMIZATION TECHNIQUE

Steps of Taguchi method for implementation: -

1. Define the process objective
2. Identify test conditions
3. Identify the control factors and their alternative levels
4. Create orthogonal arrays for the parameter design
5. Conduct the experiments indicated in the completed array to collect data on the effect on the performance measure.

6. Complete data analysis to determine the effect of the different parameters on the performance measure.
7. Predict the performance at these levels.
8. Confirmation experiments.

V. RESEARCH GAP & ANALYSIS

- From literature review, I found that welding quality is mostly depend on bead geometry and also hardness is most important factor for welding quality.
- Arc voltage, Welding speed, Welding current, Heat input, Wire diameter, Wire feed rate mostly affect on the weld bead hardness and bead geometry.
- Most of the researches reported are focused on welding current, welding speed, arc voltage as a input parameter, we can introduce wire feed rate as input also.
- Limited studies have been reported for effect of various parameters on bead hardness in GMAW Process. Hardness play most important role for welding quality in GMAW Process.
- Welding speed 40 cm/min is best while considering penetration factor but not shown the relation to the bead hardness.
- Most of paper focused on individually characteristics bead geometry or bead hardness, not give relation between each other.

VI. CONCLUDING REMARK

Gas metal arc welding is most widely used in industry. It has found widespread applications in diverse industries. This paper has clearly demonstrated the properties such as bead hardness, depth of penetration, bead height and bead width in butt joint weld. In addition, it has optimization will be on experimental reading value. The main conclusions can be summarized as follows:

- Bead hardness is increase with increment of current up to certain level after that it is start decrease within some range of current.
- Depth of penetration increase with welding current increment up to 210 A nearly around after that point it start again decrease of penetration.
- Weld joint or bead hardness is always change compare to base or filler metal due to heat affected zone.HAZ play most important role for that.
- Heat input also play role for depth of penetration. so, indirectly it affect on bead geometry also.
- Taguchi Technique is most important tool for improving output of research & using Taguchi technique also helpful for improving quality of product at minimum cost.
- Orthogonal Arrays is useful for minimization of experiment for reading.

VII. REFERENCES

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