A Review of Experimental Study of MIG Welding Process

"The effect of microstructure on tensile strength of low carbon welded steel using inert gas welding"

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***Abstract* - In this study Metal inert gas (MIG) welding also known as 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. A consumable electrode is used which also plays the role of conductor. MIG welding gives little loss of material and can be operated as semi as well as fully automated. The current work aims to study the effects of parameters in gas metal arc welding of AISI 1020 material. 10 mm thick AISI 1020 material plates are used as work material to be welded by gas metal arc welding process Detailed experiments are designed and performed on the basis of orthogonal array (OA) and welding strength measured and analyzed using trend graphs. An optimum combination of process parameters, finds out by Taguchi method. Optimization result has been used for identifying the most significant parameter effect on welding strength. I have studied the effect of various process parameters are voltage, Welding current, wire feed rate and welding speed of MIG Welding and the output parameter is tensile strength and microstructure. The aim of this work is the effect of microstructure on tensile strength of low carbon welded steel using inert gas welding.**

***Index Terms* - MIG Welding, Microstructure, Tensile Strength, Low Carbon Welded Steel.**

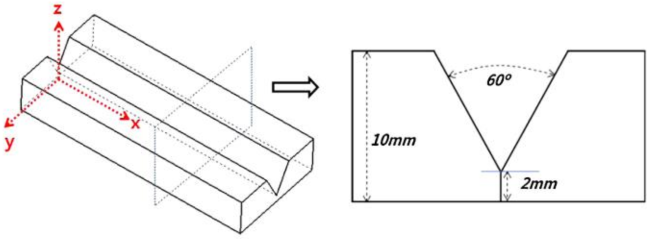
1. INTRODUCTION

Metal Inert Gas welding as the name suggests, is a process in which the source of heat is an arc formed between a consumable metal electrode and the work piece, and the arc and the molten puddle are protected from contamination by the atmosphere (i.e. oxygen and nitrogen) with an externally supplied gaseous shield of inert gas such as argon, helium or an argon-helium mixture. No external filler metal is necessary, because the metallic electrode provides the arc as well as the filler metal. It is often referred to in abbreviated form as MIG welding. The American Welding Society refers to the process as Gas Metal Arc Welding and has given it the letter designation GMAW. This term appears simpler because it to covers inert as well as active shielding gases. MIG welding process overcome the restriction of using small lengths o electrodes as in manual metal arc welding and overcomes the inability of the submerged arc process to weld in various positions. It is not surprising, therefore, that the 50/50 level of the relative weights of weld metal deposited by manual metal- arc and MIG processes was reached in 1973 in the USA and in 1978 in Europe. [1]

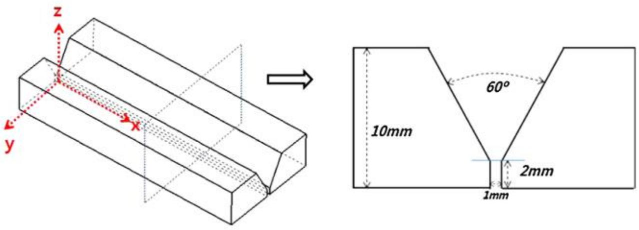
2. LITERATURE REVIEW

Mitsuhiro Okayasu et al. was investigated Mechanical properties of SPCC low carbon steel joints prepared by metal inert gas welding. To better understand the fatigue and tensile properties of SPCC steels welded by metal inert gas welding, the mechanical properties of the welded component in several localized regions, e.g., weld metal, heat affected zone (HAZ) and base metal, were investigated. The tensile and fatigue properties of the weld metals were high compared to the other areas (base metal and HAZ) due to the precipitated Ti containing oxide inclusions in acicular ferrite (bainite). Two typical microstructures were mainly observed in the heat affected zones (HAZ): (i) bainite in a ferrite matrix (HAZ-B) and (ii) a ferrite phase with low internal stress (HAZ-A). The hardness of HAZ-B was higher than HAZ-A because of the partially formed bainite structure and precipitated Ti containing oxide inclusions. The mechanical properties of the weld sample were further investigated using test specimens that included all regions, i.e., weld metal, HAZ and base metal (BHW). The tensile and fatigue properties of the BHW sample were found to be lower than those in all other regions, which was influenced by the high internal stress. The mechanical properties were analyzed using microstructural and crystal characteristics, as examined by TEM and EBSD analysis. The tensile strength of the WM samples is apparently higher than that for the other samples. Due to the bainite structure and precipitated Ti base inclusions, the weld metal (WM) of the sample showed higher hardness values compared to the other areas. The HAZ-A sample is softened, caused by the tempering process. This is slightly less than the softening in the BM sample, even though the micro-structural formation of HAZ-A is similar to that for BM. A relatively high hardness level of HAZ-B is measured, arising from the Ti base inclusion and partially formed bainite structure. A high fatigue strength (endurance limit) for theWMsample is observed, about twice as large as for the other samples. The fatigue strengths for the HAZ-B and BM samples are relatively high compared with BHW and AF. This would be affected by the different microstructural characteristics**.** [2]

D.W. Choa, S.J. Naa et al. studied on performed three-dimensional transient numerical simulations using the volume of fluid method in a gas metal arc V-groove welding process with and without root gap for flat, overhead, and vertical welding positions. Without the root gap, it is difficult to form a fully penetrated weld bead in the flat and overhead positions, while humping and melt-through beads are formed in the vertical-upward position under the same welding condition. With a 1-mm root gap, the molten pool overflow patterns can be described for various welding positions under the given welding conditions. The overflow patterns in some welding positions do not induce the weld defects, while a weld bead with incomplete penetration can be formed in the vertical downward position. Thus, it is necessary to avoid the overflow patterns in such a case by increasing the welding speed. [3]



(a) without root gap



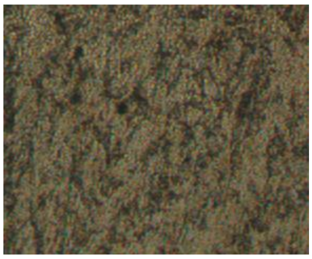
(b) with 1-mm root gap

Figure 1.1 Schematic sketch of V-groove shapes (a) without root gap and (b) with 1-mm root gap. [3]

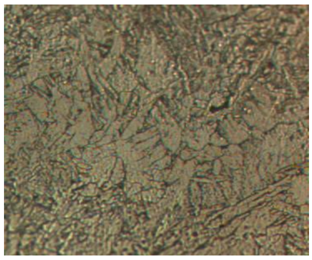
Ehsan Gharibshahiyan et al., was investigating the effect of welding parameters and heat input on the HAZ and grain growth in Gas metal arc welding process. The role of grain size on hardness and toughness of low carbon steel has also been studied. It was observed that, at high heat input, coarse grains appear in the HAZ which results in lower hardness values in this zone. High heat input and low cooling rates produced fine austenite grains, resulting in the formation of fine grained polygonal ferrites at ambient temperature. One of the major factors affecting the toughness of the welded Metal is the formation of a local brittle zone (LBZ). The degree of brittleness in this zone varies with material chemistry and welding conditions [2]. The elevation of heat input and welding speed, can lead to the formation of equiaxed grains [6]. The microstructure of the HAZ depends on chemical composition and the peak welding temperature and welding voltage. The energy transfer per unit length of weld is a function of heat input. It was also observed that high heat input and rapid cooling. [4]

Izzatul Aini Ibrahim, Syarul Asraf Mohamat was worked carried out on The Effect of Gas Metal Arc Welding (GMAW) processes on different welding parameters. In this study, the effects of different parameters on welding penetration, microstructural and hardness measurement in mild steel that having the 6mm thickness of base metal by using the robotic gas metal arc welding are investigated. The variables that choose 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 was chosen as 20, 40 and 60 cm/min. The penetration, microstructure and hardness were measured for each specimen after the welding process and the effect of it was studied.

210 A, 22V, 20cm/min



210 A, 22V, 40cm/min



210 A, 22V, 60cm/min

Figure1.2. Microstructure of welded parts [5]

The value of depth of penetration increased by increasing the value of welding current 90, 150 and 210 A. Welding current is factor that will determine the penetration. Penetration also influence by the factors from welding speed and arc voltage. At the graph, the good 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 good value for penetration happened is 26 V at 210 A.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. The grain boundaries of microstructure changes from bigger size to smallest size when the variables welding parameters changed. [5]

Dinesh Mohan Arya, Vedansh Chaturvedi, Jyoti Vimal studied to search out the optimum process parameters for Metal inert gas welding (MIG). The optimization of MIG welding process parameters was carried out for alloy steel work piece using grey relational analysis method and Taguchi method. The effect of welding parameters like wire diameter, welding current, arc voltage, welding speed, and gas flow rate were optimized based on bead geometry of welding joint. The objective function was chosen in relation to parameters of MIG welding bead geometry Tensile strength, Bead width, Bead height, Penetration and Heat affected zone (HAZ) for quality target. The signal to noise ratio (S/N ratio) is also applied to identify the most significant factor and predicted optimal parameter setting. Optimal parameters collection of the MIG operation was obtained via grey relational analysis for this study.
In the present study, Taguchi optimization technique pair with grey relational analysis has been adopted for evaluating parametric complex to carry out acceptable. Tensile strength and Penetration higher is better. Bead width, Bead height and Heat affected zone (HAZ) lower is better of the alloy steel element to acquire by using Metal inert gas welding. After identify the predict optimal parameter setting with the help of signal to noise ratio (S/N ratio) the most significant factor also found the results closer to the optimize results.. So it is most significant factor in this result. [6]

S.V.Sapakal, M.T.Telsang was investigated on GMA welding parameters are the most important factors affecting the quality, productivity and cost of welding. Influence of welding parameters on penetration depth of MS C20 material during welding. A plan of experiments based on Taguchi technique has been used to acquire the data. Taguchi optimization method was applied to find the optimal process parameters for penetration. A Taguchi orthogonal array (L9), the signal-to-noise (S/N) ratio and analysis of variance (ANOVA) were used for the optimization of welding parameters. Finally the conformations tests have been carried out to compare the predicated values with the experimental values confirm its effectiveness in the analysis of penetration. [7]

3. RESEARCH GAP & ANALYSIS

- From literature review, I found that The influence of microstructural characteristics on the mechanical properties of low carbon steel joints prepared by metal inert gas welding
- The dynamic molten pool behaviors such as humping, melt-through, and overflow for various welding positions in V-groove GMAW.
- High heat input led to grain coarsening which was more pronounced in the HAZ, as well as reducing the impact energy and toughness.
- The grain boundaries of microstructure changes from bigger size to smallest size when the variables welding parameters changed.
- Taguchi optimization technique pair with grey relational analysis has been adopted for evaluating parametric complex to carry out acceptable Tensile strength and Penetration higher is better.
- A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance were used for the optimization of welding parameters.

4. CONCLUSION

In V-groove GMAW With a 1-mm root gap, the molten pool overflow patterns can be described for various welding positions under the given welding conditions. Welding current, arc voltage, welding speed, type of shielding gas, gas flow rate, wire feed rate, diameter of electrode etc. are the important control parameters of Metal Inert Gas Welding process. They affect the weld quality in terms of mechanical properties and weld bead geometry. The value of depth of penetration increased by increasing the value of welding current and the grain boundaries of the microstructure are varied when the welding parameters are changed. Design of Experiments with optimization of control parameters to find best results are attained in the Taguchi Method. "Orthogonal Arrays" (OA) gives a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions in optimization, help in data analysis and The purpose of the analysis of variance (ANOVA) is to examine which design parameters significantly affect the quality characteristic and estimation of optimum results. MINITAB software is a useful aid for the above purpose. To better understand the mechanical properties of our samples, microstructural characteristics etched in 2% nital solution and fracture mechanism will investigate using an optical microscope and a scanning electron microscope (SEM).

5. REFERENCES

[1] Welding Handbook Volume 4, “Metals and their Weldability”, American Welding Society (ASM), Seventh, Chep-1.
[2] Mitsuhiro Okayasu,Yuki Ohkura et al.” Mechanical properties of SPCC low carbon steel joints prepared by metal inert gas welding”, Materials Science & Engineering A 560 (2013) 643–652
[3] D.W. Choa, S.J. Na et al.” A study on V-groove GMAWfor various welding positions”, Journal of Materials Processing Technology 213 (2013) 1640–1652
[4] Ehsan Gharibshahiyan, Abbas Honarbakhsh Raouf etal.” The effect of microstructure on hardness and toughness of low carbon welded steel using inert gas welding”, Materials and Design 32 (2011) 2042–2048
[5] Izzatul Aini Ibrahim , Syarul Asraf Mohamat et al.” The Effect of Gas Metal Arc Welding (GMAW) processes on different welding parameters”, Procedia Engineering 41 (2012) 1502 – 1506
[6] Dinesh Mohan Arya, Vedansh Chaturvedi and Jyoti Vimal, “Application of Signal to Noise Ratio Methodology for Optimization of MIG Welding Process Parameters”, International Journal of Engineering Research and Applications, Vol. 3, Issue 4, Jul-Aug 2013, pp.1904 1910.

[7] S. V. Sapakal, M. T. Telsang," Parametric Optimization of Mig Welding Using Taguchi Design Method" International Journal of Advanced Engineering Research and Studies, Vol. I/ Issue IV/July-Sept., 2012, pp.28-30.