Application of Taguchi Method to Determine MIG Welding Parameters for AISI 1020

Sahil Garg*[*], *Nitin Bhati*[*], *Chandra Vikram Singh*[*], *Dr. Satpal Sharma*[*]

Abstract

Mild Steel alloy 1020 is a Mn-S-P alloy employed in simple structural applications. MIG welding is used in this study for welding AISI 1020. The effect of three parameters namely welding current, groove angle and gas flow rate was selected for making the welding joint using MIG welding process. These parameters were varied simultaneously using Taguchi method in order to investigate the effect of single factor effect and interactions on the tensile strength of the welded joint. The hardness of the welded joint will be discussed in order to correlate with the tensile strength of welded joint.

Keywords: Microstructure, MIG, Taguchi Method, Gas Flow Rate.

Introduction

The Gas metal arc welding (GMAW) process is preferred joining technique and mostly chosen for welding large metal structures such as bridges, automobiles, aircraft and ships due to its joint strength, reliability, and low cost compared to other joining processes.

A Metal Inert Gas (MIG) also called GMAW is the process that includes heating, melting and solidification of parent metals and a filler material in restricted fusion zone by transient heat source to form a joint between the parent metals. The continuous wire electrode from an automatic wire feeder and fed through the contact tip inside the welding torch is melted by the internal resistive power and heat transferred from the welding arc. Heat determined from the end of the melting electrode to molten weld pools and by the molten metal that transferred to weld pools.

The GMAW welding parameters influence the quality, productivity and cost of welding joint. The perfect arc will be achieved if all the welding parameters like arc welding current, arc voltages, welding speed, torch angle, wire feed rate, nozzle distance, welding position and direction and lastly the flow rate of gas are in conformation with the welding material.

The relationship between the bead geometry and process parameters began investigation in the mid 1900s and the regression analysis was applied in the welding geometry research in 1987. The best possible welding conditions are determined by combination the factors like the types of base metal, the geometry of welded parts and the welding process.

The investigation of GMAW process and relationship between process variables and bead geometry was carried and the results showed the arc current has the greatest effects on bead geometry. Investigation in the weld deposit area presented that the effects of electrode polarity, diameter and extension, arc voltage, welding current, power source setting, travel speed and flux on the weld deposit area.

In the present investigation, attempts have been made to study the influence of bevel angle in bevel- groove butt joints on strength & impact hardness and analyzing these results. In this investigation, experiments were conducted on different specimens by varying bevel angle for zero root openings and different welding parameters.

Methodology

Material Selection

The AISI 1020 DOM is a low carbon steel selected for experimentation. The chemical composition of the base material is given in table 1. The 11.0 mm thick samples of material 1020 DOM were cut into the standard sizes of 254 x 76 mm. All samples and filler rods were cleaned for removing the dust, oil, grease and thin oxide coating before welding. These welded samples were used to analyze microstructure and hardness.

[*]Mechanical Engineering Department, Gautam Buddha University, Greater Noida, UP, India.
E-mail Id:sahilgarg12@yahoo.com, nitinbhati73@gmail.com, chandu.vikram1310@gmail.com,satpal78sharma@gmail.com

Material	C	Si	Mn	Cr	Ni	Cu	Mo	V	Al	S	P
1020 DOM	0.2073	0.1693	0.5470	0.0504	0.0897	0.0224	.0111	0.001	0.0304	0.0106	0.0131

Table 1.Chemical Composition of AISI 1020 DOM

Process and Parameters

MIG welding operations were performed by means of an EWM alpha Q 351 welding machine. The welding was carried out in the 100% CO_2 shielding gas protect, 1.2mm diameter of electrode wire, the torch angle is 45 degree, nozzle to work distance is 12mm and only one pass on weld plate.

Selections of significant input process parameters are very important to obtain good bead geometry, which represents the strength of weld and its quality. But the underlying mechanism connecting then (welding parameters and quality characteristics) is usually not known. One of the most widely used methods to solve this problem is the Taguchi approach which uses orthogonal array method in which the experimenter tries to approximate the unknown mechanism with an appropriate empirical model.

A standard Taguchi L9 orthogonal array is chosen for this investigation as it can operate up to three parameters each at three levels. Three parameters-Current, Gas Flow rate and Groove Angle were chosen for this study which affects the strength, microstructure and hardness. Sufficient details of the effect of different parameter values on experimental results can be obtained by choosing three levels for each parameter to investigate.

	Units	**Level 1**	**Level 2**	**Level 3**
Current	A	110	140	170
Gas Flow Rate	L/Min	8	10	12
Groove Angle	Degree	50	60	70

Table 2.Welding Parameters

Trial No.	**Current**	**Gas Flow Rate**	**Groove Angle**
1	110	8	50
2	110	10	60
3	110	12	70
4	140	8	60
5	140	10	70
6	140	12	50
7	170	8	70
8	170	10	50
9	170	12	60

Table 3.L9 Matrix with Actual Parameters

Testing

After done with the welding process for all those of experiment trials, the specimens will be cut perpendicular to the welding direction by using a cut- off machine. The tensile test of the specimen was carried out on the INSTRON UTM of 1000KN. The ASTM E8 standard was followed to do the tensile strength of the welded joints. Lastly, for the hardness values for the welded area, it was calculated by the Izod impact test.

Results and Discussion

Total 9 experiments with different variables parameters which are current, gas flow rate and groove angle were performed, and hardness and ultimate tensile strength were measured.

The Effect of Groove Angle on Tensile Strength

The value of variable process parameters current, flow rate and groove angle corresponding to the maximum ultimate tensile strength was noted. These values were the optimized values of input process variables, to obtain the maximum yield strength in welded plates of AISI 1020.And the optimum result values are shown in table 4. The highest value of tensile strength of 229.2562 MPa was obtained at gas flow rate of 10 L/Min and current of 140A for groove angle of 70 degree.

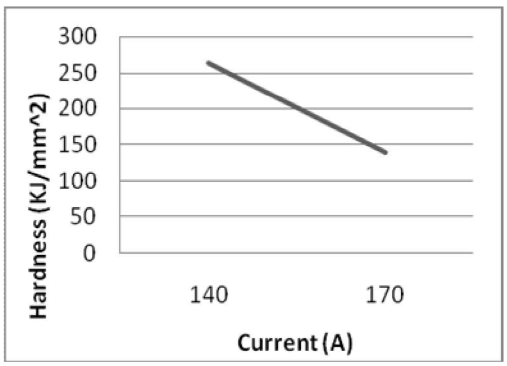
Experiment No.	Current (A)	Gas Flow Rate (L/Min)	Groove Angle (Degree)	Tensile Strength (MPa)	% Elongation
1	110	8	50	73.7576	.9558
2	110	10	60	63.1575	.7277
3	110	12	70	115.384	.6599
4	140	8	60	65.1705	.5922
5	140	10	70	229.2562	2.0485
6	140	12	50	51.1189	.6170
7	170	8	70	169.5722	1.6735
8	170	10	50	30.3636	.5581
9	170	12	60	27.0303	.3064

Table 4.Result for Tensile Strength

Hardness

The hardness test of the welded specimen was carried out using the IZOD impact test. The samples were cut with the dimension of 100mm x 10mm x 10mm. The maximum hardness of 264.023 KJ/mm^2 was achieved for the parameters 140A current, 10 L/Min gas flow rate and 70 degree groove angle.

(a)



(b)

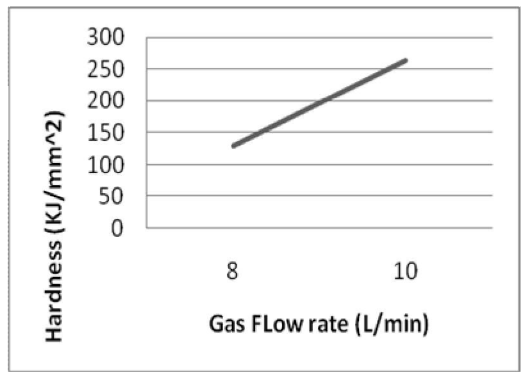


Figure 1.(a) Effect of current on Hardness, (b) Effect of gas flow rate on hardness

Conclusion

The mild steel 1020 was used for the present study to explore the different input process parameters on the tensile strength and hardness of the weld samples. The L9 orthogonal has been used to assign the identified parameters and current is the most significant parameters that influenced the tensile strength and hardness of the weld. The highest tensile strength obtained in the research is 229.2562 MPa at current (140 Amp), gas flow rate (10 L/min) and groove angle (70 degree).

References

1. Benyounis KY, Olabi AG. Optimization of Different Welding Processes Using Statistical and Numerical Approaches—A Reference Guide. *Advances in Engineering Software* 2008; 39: 483-96.
2. Juang SC, Tarng YS. Process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel. *J Mater Process Technol* 2002; 122: 33-37.
3. Cary HB. Modern welding technology. *AWS*, 2nd ed, 1981: 82-85.
4. Ross PJ. Taguchi Techniques for Quality Engineering. *McGraw Hill, New York*, 1988.
5. Taguchi G. Introduction to Quality Engineering. Asian Productivity Organisation, Tokyo, 1990.
6. Peace GS. Taguchi Methods: A hand-on Approach. *Assison- Wesley, Reading, M. A.*, 1993.
7. Haragopal G, Reddy PVRR, Reddy GCM et al. Parametric design for MIG welding of Al-65032 alloy using Tagauchi Method. *Journal of Scientific and Industrial Research* 2011; 70: 844 – 50.
8. Sapakal SV, Telsang MT. Parametric Optimization of MIG Welding Using Taguchi Design Method. *International Journal of Advanced Engineering Research and Study* 2012; 1: 28-30.
9. Parmar RS. Welding Process and Technology. *Khanna Publishers*, 2010: 126-62.