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The effect of CO_2 welding process parameter on the microhardness of structural steel

In the present work, bead-on -plate welds were carried out on 304L austenitic stainless steel using synergic MIG process. In this present investigation 304L having 1.2 mm diameter was used as an electrode with direct current electrode positive polarity. Argon and CO_2 was employed for shielding purposes. The fusion zone is defined by a few geometrical characteristics, such as bead width, bead height, and penetration depth. A number of factors influence the configuration of the fusion zone, including gas flow rate, voltage, travel speed, and wire feed rate. Micro hardness measurements were done over the weld bead base material to better understand the Knoop micro hardness.

Keywords: Gas metal arc welding (GMAW), fusion zone, regression analysis, bead geometry

1.0 Introduction

Because best inert gases had been employed to protect the molten puddle, GMAW turned into the beginning called MIG welding. Aluminum, deoxidized copper, and silicon bronze were the best substances that could be used on this technique. Later, technique was successfully utilised to weld ferrite and austenitic steels, as well as mild steel, by using active vapours instead of inert gases, earning the name MIG welding [2]. Carbon steels, low alloy and HIGH alloy steels, stainless steels, aluminium, and copper, in addition to titanium, zirconium, and nickel alloys, can all be welded using the GMAW (MIG/CO_2) method [3]. If the process parameters are set accordingly, connections with a thickness of 1-13 mm can be welded at all welding positions. Several researchers have looked into the influence of different process variables on weld bead geometry and metal transport. Weld distortion, mechanical strength, and weld quality are all indicators of a good weld process.

Shape and characteristics of weld beads: The weld bead geometry is the simplest of these characteristics to measure and control. All welding parameters could be controlled by a signal dial thanks to the synergic capability, which optimised the current peak pulse and background values, as well as the voltage and wire feed speed. Many researchers are interested in the influence of various parameters of the welding process on weld bead production and weld bead shape, which prompted them to further study, Jin Yi et al. [4]. The influence of welding process parameters on the weld penetration of gas arc welding (GMAW) was studied. The welding process includes variables such as wire diameter, gas flow rate, welding speed, arc current and arc voltage. The penetration depth of the weld increases with the increase of the wire diameter, arc current and voltage. Ganjigatti J. et al. [5] used group regression analysis and global regression analysis to predict the weld bead geometry during MIG welding.

Welding current, arc voltage and welding speed are selected as variables measure the penetration of each sample after welding, and check the influence of these parameters on penetration. According to the data obtained, increasing the welding current can increase the penetration. Pires R.M. et al. [7] described the effect of gas on the stability of the joining process and the movement of molten metal in the arc. The influence of factors such as gas type and welding speed in the welding process was investigated. Check the convexity, colour, gloss, smoothness and pore formation on the cord surface, paying special attention to the influence of gas on the appearance and shape of the cord, Murugan N et al [8]. It was found that when stainless steel is applied to structural steel, there is a secondary correlation between welding parameters and weld bead geometry.

2.0 Experimentation

The goal of the design process is to come up with a product that fits all of the requirements for the least amount of money. Welding is a crucial design strategy since it is the greatest joining method. The most popular processes for bonding materials are fastening, welding, and casting. Welding, on the other hand, is less expensive and more flexible than casting. Welding takes much less overall material because it is 3 to 4 times stronger than other procedures. Castings are also more rigid, ductile, and less prone to cracking than other materials. Finally, when it comes to impact resistance, welding beats castings out.

During the test run, the process parameters are changed one by one. A work area has been defined in previous

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research publications. +2 and 2 are used for the upper and lower limits, respectively. The ratio can be used to calculate the encoding value of the intermediate value.

$$X_i = \frac{2[2X - (X_{\max} + X_{\min})]}{(X_{\max} - X_{\min})}$$

Among them, X_i is the code value required by the X variable, X is any variable value between X_{min} and X_{max}; X_{max} and X_{min} are the maximum and minimum values of the variable. Table 1 lists the specified process parameters and their upper and lower limits, as well as names and measurement units.

TABLE 1: THE LIMITATION OF DESIGN PARAMETERS

Parameters considered	LEVELS				
	1(-2)	2(-1)	3(0)	4(1)	5(2)
Plate thickness (mm)	4.0	6.0	8.0	10.0	12.0
Gas flow rate (lit/min.)	5	9	12	15	20
Current (A)	140	180	220	280	320
Travel speed (cm/min.)	22	29	31	38	43

The weld beads were placed on stainless steel plate (304L) utilising a semi-automated welding station and the bead on plate procedure. The experiment used five different variables: plate thickness, gas flow rate, travel speed, and current. In response, 30 plates measuring 6 inches in length and five various thicknesses were cut:

Following the cutting of all plates, each plate was individually welded according to the conditions provided. A 304L filler wire with a diameter of 1.2 mm was used for the welding experiment. All experiments were conducted at five different flow rates with a contact tip to work distance of 20 mm and a shielded gas mixture of Argon and CO_2. The bead on plate was created using a direct current power supply and a synergic MIG method. The welded components are depicted in the diagram. 1 Synergic MIG is a cutting-edge welding technique that incorporates both spray and pulse transfers. Optimal conditions can be set and simply duplicated by the welder for a range of applications. All welding parameters could be controlled from a single signal dial, which optimised the current peak pulse and background values, as well as the voltage and wire feed.

TABLE 2: PLATE DISTRIBUTION

Thickness (mm)	No. of plates
4.0	01
6.0	08
8.0	13
10.0	07
12.0	01

In this sample preparation method, the sample cut from the sheet is ready to be inspected under a metallurgical microscope. The ultimate goal is a smooth, scratch-free mirror surface.

3.0 Microhardness

The micro hardness varies by region. The micro hardness is measured using an Omnitech MVH automatic micro hardness tester with a load of 100 g and a holding time of 20 seconds.

Fig.1: Welded plates

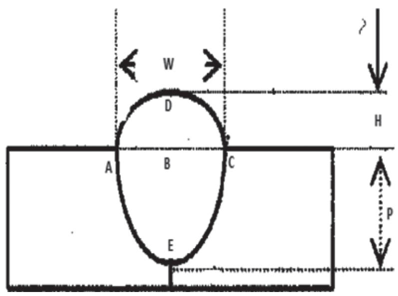

Fig.2: Samples after etching

Calculation done with the microhardness value at each point. These points are located in two areas from point A to point E. These points are shown in Fig.3. The microhardness of Koop is indicated by the given number. The polished surface of the test material of known strength is measured with a microscope for a certain exposure time. Table 3 shows the calculated microhardness values.

Fig.3: Microhardness of a bead vary the points on the bead

TABLE 3: MICRO HARDNESS NUMBER

Trial	A	B	C	D	E
2	1432	1410	1433	1339	1478
5	1289	1255	1318	1214	1323
19	1739	1658	1723	1434	1777
24	1619	1538	1689	1623	1818
30	1378	1325	1416	1299	1445

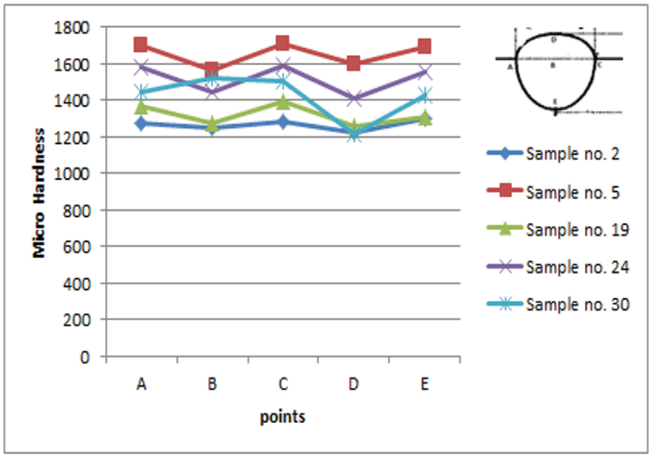

Fig.4: Microhardness varies in different parts of the body

Microhardness levels are calculated at different places. Base metal has a microhardness of 1125 KHN. The graph shows the relationship between each point and the microhardness. The hardness test is carried out at a depth of 2 mm below the surface of the base metal. In the above table, the KHN values of the weld zone and the base metal are comparable. The maximum hardness is indicated at points A, C and E. These locations are in the high-risk zone (HAZ). Therefore, HAZ has the highest microhardness value. The presence of pearlite and the size range of the microstructure can explain this finding. The pearlite concentration and size distribution range of the base metal and the weld zone are approximately equal. Compared to the weld zone and the base metal, HAZ shows a higher concentration of pearlite and more crystal grains, which indicates that its structure is finer. Due to the higher pearlite content and finer structure, HAZ has a higher microhardness. The microhardness of the fine-grained area is also higher, which contains the most perlite and the finest grains.

3.0 Conclusion

The mixed mode was created by high welding current and high welding voltage, however it was mostly axial spray with some short circuiting. The weld bead ripples were quite consistent, and the bead's overall appearance was excellent. HAZ has the highest microhardness value. As a result, the HAZ has the smallest grain sizes. Starting at the bottom, the microhardness value rises. The impacts of wire feed rate (W), arc voltage (V), and welding speed (S) on dilution are all increasing, whilst gas flow rate and welding speed (S) are decreasing. While the gas flow rate has little effect on dilution on its own, when combined with other parameters to boost weld dilution, it has a significant impact.

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