Adoptability Analysis of Water Plasma ARC Welding For Mild Steel Pieces

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Abstract: This paper is about the applicability of water plasma arc welding for the mild steel pieces and how the process will take place. This is done with an intension of knowing the parameters and how they will influence the rate and mechanism o welding especially if it compared with the conventional welding processes. There should be some specific reason for an action in the universe as like the usage of plasma arc welding too. This is been discovered for the making of intricate hole and in the high precise applications such as aerospace industry. With reference to that as the plasma arc welding can make to such an extent produce the high precise holes. Why can't it will produce the high strength welding and defects free welding. This is intension for this research and this is what exactly been carried out for by making the water plasma arc welding for the mild steel pieces of three sizes. While performing welding, the process parameters and decision variables were emphasized but recording the data, analyzing that and summarizing at the end finalizing them. After that the Non destructive and destructive testing's carried out for knowing the soundness of the weld.

Key words: Water plasma arc welding, Hardness, Testing

1 Introduction

This work as an integration of welding of mild steel plates using the water plasma arc welding and in comparison with the manual arc welding. It is often seen from the daily practice that the arc welding may be an efficient one [1] [2]. But in real practice efficient operation does not employee all the requirements. Hence it must to be analyzed further to find the interrelationships coupled with the decision to be made for the optimization of the process. In this arena three sets of mild steel pieces of each thickness 3mm, 5mm and 7mm of length 100mm and breadth 100mm. in each set of two similar pieces were put one is for manual arc welding and other is for the water plasma arc welding. And while doing the experiment the voltage, current, direction of weld, angle of weld, type of electrode, gas flow rate in case of water plasma arc welding etc were recorded. Based on the methodology that is used the results were analyzed for performance optimization. This is been illustrated in the below sections [3] [4].

2 Methodology

As described in Figure 1the work was carried out. From the inception of the work it was observed that the root source of welding is same that is thermal energy is the one which used to make the weld. And the cause behind this would be different.

Hence the analysis of decision variables that is the parameters involved in the welding would produce the right decision of opting the right one [5].

It is of prime importance for an engineer to opt the right method for right outcome. First mild steel plates have been taken into consideration for the welding by electric arc and water plasma arc welding. For that the surface and edge preparation is done such as providing the V groove for the weld between plates. The V groove is so made by 45^o to the tangential surface and is filed up to a thickness of $(¾)^{th}$ of the total thickness of the plate. And after that the mild steel electrodes were selected in both the electric and water plasma arc welding [6].

In the next step while doing the welding the voltage used, current used, length of weld, time for weld were recorded in both the welding processes for finding the dependency and inter relationship among the parameters. Next the surface roughness is been calculated by root mean square and center line average method in both the welding processes [7].

Then the hardness at various locations were found by brineell's hardness method. And the formula used in it is given in equation (1):

$$BHN = 2P / (\pi D (D - \text{sqrt}(D^2 - d^2)))$$

$$HBW = 0.102 (2P / (\pi D (D - \text{sqrt}(D^2 - d^2)))) \quad (1)$$

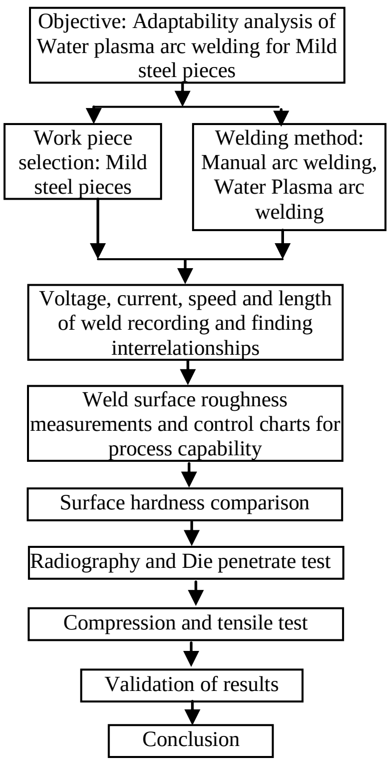

Figure 1: Methodology

Then the weld pieces have been tested for finding the soundness of the weld. This is carried out in two ways viz. Non destructive testing and Destructive testing [8]. In the earlier one Radiography and Die penetration tests were carried out and in the later Tensile and Compressive tests were carried out. At the end of the work the conclusions were made for the further research [9] [10].

3 Analysis

In the initial step a set of two 3mm thickness mild steel plates have been welded, one by electric arc welding and another by water plasma arc welding. The Voltage, Current, Length and Time of cut been recorded as follows. The same is been carried out for 5mm and 7mm thickness plates.

Electric ARC welding is shown in Table 1:

TABLE 1
ELECTRIC ARC WELDING

S No	Voltage	Current	Length of weld	Time for weld
1	220	68.1	0	0
2	230	67.2	20	20
3	245	66.3	40	35
4	252	65.8	60	55
5	258	65.2	80	80
6	262	64.9	100	105

Water plasma ARC welding is shown in Table 2:

TABLE 2
WATER PLASMA ARC WELDING

S No	Voltage	Current	Length of weld	Time for weld
1	220	88.6	0	0
2	230	84.1	20	100
3	235	83.2	40	150
4	240	81.2	60	200
5	245	80.5	80	250
6	252	78.9	100	300

The comparison graphs were discussed in the results section.

3.1 Surface Roughness test:

In the surface roughness test the surface image will be taken for the RMS and CLA calculations. The below formulae shown in equation (2) used for calculation of roughness.

$$H_{r.m.s.} = \text{sqrt}((h_1^2 + h_2^2 + h_3^2 + h_4^2 + \ldots\ldots h_n^2)/n)$$

$$C.L.A = ((h_1 + h_2 + h_3 + h_4 + h_5 + \ldots\ldots h_n)/n) \quad (2)$$

For 3mm ms plates (by RMS method):

The observations were made as follows: h1 = 2.1mm, h2=2.4mm, h3=3.1mm, h4=4.2mm, h5=2.3mm, h6=2.1mm, h5= 2.3mm, h6= 3.8mm, h7 = 3.2mm , h8=2.1mm, h9 = 3.2mm, h10= 3.1mm, h11=3.2mm, h12=3.3mm, h13=2.8mm, h14=3.1mm, h15=2.4 mm and number of observations made= 15. By substituting these values in the above equation the hardness found is = 2.85mm

For 3mm ms plates (by CLA method):

The observations were made as follows: h1 = 3mm, h2=2.5mm, h3=2.5mm, h4=4mm, h5=3.5mm, h6=2.2mm, h5= 3.5mm, h6= 4mm, h7 3mm , h8=2mm, h9 = 2.5mm,h10= 3mm, h11=2.5mm, h12=3mm, h13=1.2mm, h14=1.5mm, h15=2.5mm and number of observations made= 15. By substituting these values in the above equation the hardness found is = 3.12mm

3.2 Hardness (Brinell's hardness test)

TABLE 3
FOR 3MM THICKNESS

Sl no	Place	Hardness	
		WPAW	EAW
1	On weld	145	144
2	2.5mm from weld	140	138
3	5mm from weld	133	131
4	7.5 mm from weld	127	126
5	10 mm from weld	124	123
6	12.5mm from weld	122	122
7	15mm from weld	120	120

TABLE 4
FOR 5MM THICKNESS

Sl no	Place	Hardness	
		WPAW	EAW
1	On weld	147	142
2	2.5mm from weld	141	139
3	5mm from weld	134	132
4	7.5 mm from weld	126	124
5	10 mm from weld	123	121
6	12.5mm from weld	121	122
7	15mm from weld	118	118

TABLE 5
FOR 7MM THICKNESS

Sl no	Place	Hardness	
		WPAW	EAW
1	On weld	146	144
2	2.5mm from weld	142	140
3	5mm from weld	136	135
4	7.5 mm from weld	128	126
5	10 mm from weld	124	122
6	12.5mm from weld	121	120
7	15mm from weld	119	119

X- ray testing of 3mm thick ms weld piece by water plasma arc welding (WPAW)

Figure 2: x- ray testing of by WPAW

X- ray testing of 3mm thick ms weld piece by electric arc welding (EAW)

Figure 3: x- ray testing of by EAW

From the above figure it can be evident that the weld penetration rate is more in EAW compare with the WPAW.

Die penetrate results

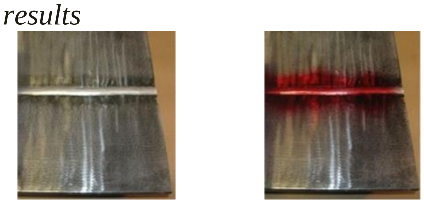

Figure 4: (a) Before test (b) After test

TABLE 6
RESULTS OF EAW AND WPAW

Sl No	Plates	No of holes observed
1	3mm of ms plate 1 (WPAW)	0
2	3mm of ms plate 2 (EAW)	0
3	5mm of ms plate 1 (WPAW)	0
4	5mm of ms plate 2 (EAW)	1
5	7mm of ms plate 1 (WPAW)	1
6	7mm of ms plate 2 (EAW)	2

From the above test it is found that for low thickness plates the probability of getting defects is less but as the thickness is gradually increasing the number of defects per plate were increasing more in EAW compared to WPAW.

TABLE 7
MECHANICAL TESTING RESULTS

Sl no	Thickness	Tensile strength	Compressive strength
1	3mm (WPAW)	362 MPa	260 MPa
2	3mm (EAW)	358 MPa	255 Mpa
3	5mm (WPAW)	370 Mpa	259 MPa
4	5mm (EAW)	365 MPa	255 Mpa
5	7mm (WPAW)	369 Mpa	264 MPa
6	7mm (EAW)	368 MPa	262 Mpa

4 Results

The following results were made after the analysis of the welding of ms plates by EAW and WPAW.

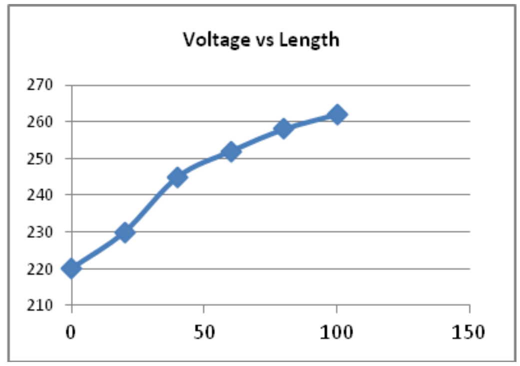

Figure 5: The analysis of the welding of ms plates by EAW and WPAW

The above graph (Fig 5) depicts the voltage vs. length graph of 3mm ms weld plate made by EAW process. The voltage consumption is rapid for half of the way and gradual in the next half of the welding. For the same process made by the WPAW is shown below (Figure 6).

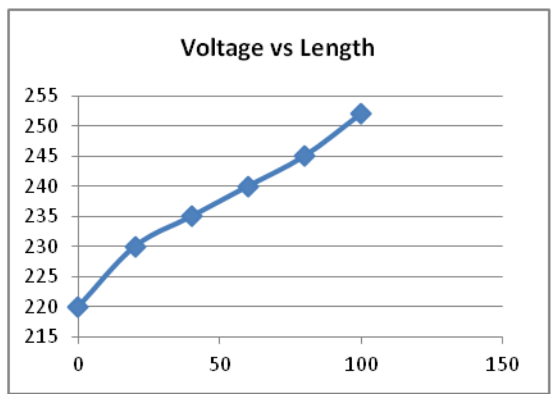

Figure 6: WPAW Results

By observation the voltage consumption is more gradual and consistent. This is an important aspect for the soundness of the weld. In addition the surface hardness variations are shown below. This shows how much change that would matter if the welding mechanism changes.

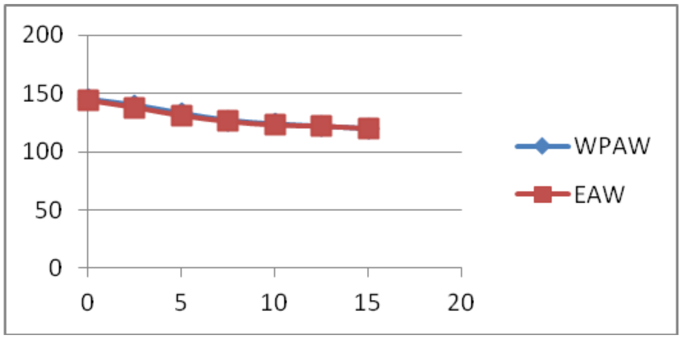

Figure 7: 3mm MS plate hardness comparison with WPAW & EAW

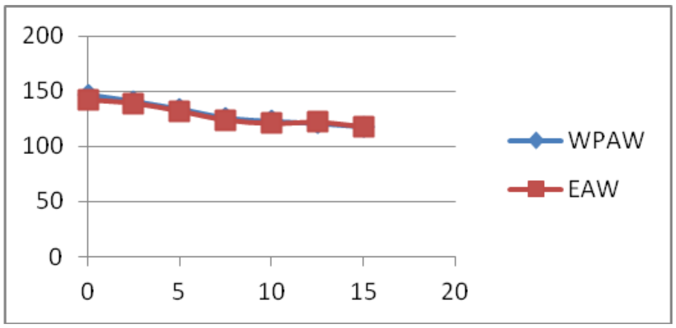

Figure 8: 5mm MS plate hardness comparison with WPAW & EAW

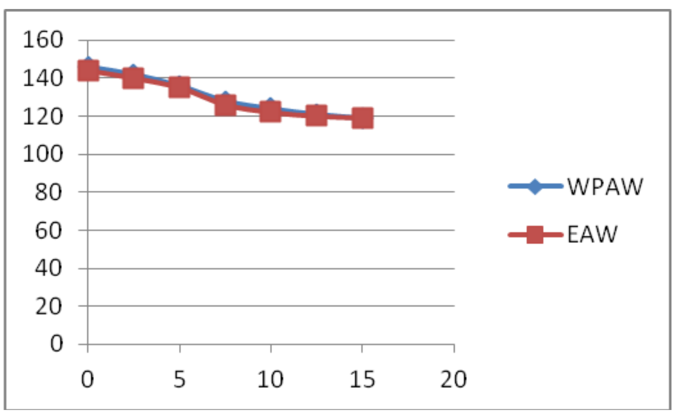

Figure 9: 7mm MS plate hardness comparison with WPAW & EAW

With reference to the above graphs it is evident that the hardness has not changed significantly. So it has less effects on the welding by both the said processes.

Now one of the few important parameters to be considered is surface roughness and weld defects.

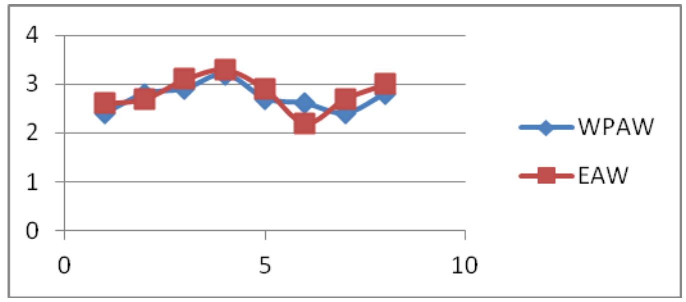

Figure 10: 3mm MS weld plate surface roughness

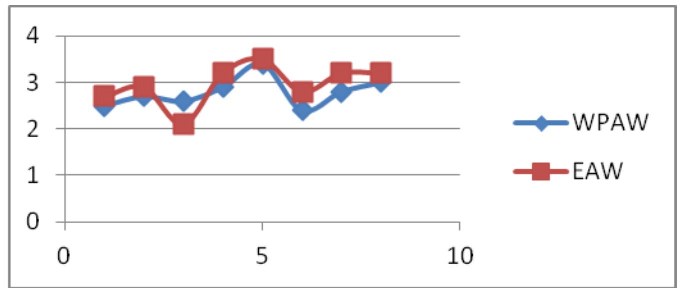

Figure 11: 5mm MS weld plate surface roughness

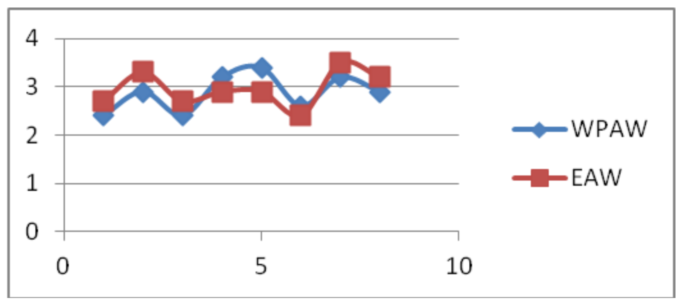

Figure 12: 7mm MS weld plate surface roughness

From the above figures it is evident that the surface roughness is more dependent on type of welding being carried out. And the weld consistency is good with the WPAW process.

At the end the surface defects if any are been developed while the welding process is carried out analyzed and recalling them again the EAW process is more prone to defects compare with WPAW.

5 Conclusion

This work concludes that the EAW welding is preferable for the usage of low priority and of less importance but for accurate and sound welds WPAW is a better choice. However from the point of consideration of economical feasibility EAW is a choice of alternative.

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