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The Effect of Welding Parameters in Micro Plasma arc Welding of Stainless Steel 304 Thin Sheets

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Abstract

These days welding of thin plate is prominent due to its importance in various field such as aerospace, medical science and industrial application etc., where welding of thin structure is required. Stainless steel is most widely used due to its corrosive resistance with high strength and ductility. Micro Plasma Arc Welding (MPAW) is one of the effective welding processes, for these structures, therefore optimum parameter for effective welding needs to be studied. In this work specimens for welding are prepared from stainless steel (SS 304) having sheet thickness of 0.5mm and welding is carried out using MPAW. The effects of welding parameters such as welding speed, and base current on the weld properties are considered.

Mechanical properties are evaluated by carrying out tensile test , hardness test and microstructure. These tests are carried out on different specimens which are obtained by micro plasma arc welding by varying the welding parameters for different specimen. The results obtained from the test are analyzed and optimum values of the welding parameter are determined.

Keywords:*MPAW, Stainless Steel 304, mechanical properties.*

1. Introduction

The effect of process parameter in micro plasma arc welding (MPAW) is on stainless steel thin sheet has greater influence on mechanical properties and good quality of welding. At the different input parameter such that welding speed, base current, peak current, nozzle distance etc. are varied their quality of welding and mechanical properties. To determine these optimum input process parameter visual inspection is used. Heat input is also important process parameter for welding thin sheets because in fusion welding process material is joined by melting of metals .In other arc welding process high heat produce than material melt throughout, burn throughout, greater tolerance are obtained. So micro plasma arc welding is good welding of thin sheet but it has high equipment cost compared to GTAW.

In the pulse current MPAW select the pulse frequency and optimize the base current, peak current welding speed and nozzle distance to maintain the arc and also material is melt at the peak current so narrower heat affected zone (HAZ) is obtained , greater to heat sink lower heat input is required and reduce residual stress are obtained.

From the literature review (Kondapali Siva Prasad et.al, Kaung-hung Tseng et.al, F.Karimzadeh et.al, Mohandas et.al.) it is under stood that maximum of work is reported the effect of welding speed, base current ,peak current, standoff distance, pulse frequency, gas flow rate are considered. Hence ultimate tensile strength, hardness values are obtained at the optimum process parameter. But here optimum values of the process parameter are obtained at visual inspection and varied base current, welding speed and standoff distance to obtained for the good quality of welding and then ultimate tensile strength and hardness values are obtained.

2. Experimental Procedure

Prior welding work piece was cut by shearing machine having dimension 100 mm x150mmx 0.5 mm. Cut samples were then cleaned by polishing paper and acetone such that no impurities were present on the welding edge. After edge preparation work piece was hold tight in the fixture in such a way that nozzle tip was able to move exactly on top of the butt line between the work pieces. Various welding conditions used in experiment. Different process parameter was adjusted to carry out the study of effect process parameters. Table 1 shows various welding conditions used for experiments.

TABLE- 1Welding condition

Power source	Micro plasma machine (model: MP 50)
Polarity	DCEN
Electrode	Tungsten
Plasma gas	Argon
Shielding gas	Argon
Copper nozzle diameter	1.2mm
Torch position	Vertical
Operation type	Semi automatic
Mode of operation	Pulse

Following two important process parameters were varied during micro plasma arcwelding of SS sheets. The other process parameters listed in Table 2 were kept constant.

Following process parameters were varied.

a. Welding speed

b. Base current

TABLE-2 Following process parameter remains constant

Plasma gas	0.9 LPM
Shielding gas	3.25 LPM
Sec pre flow	4 sec
Sec up slope	4 sec
Sec dn slope	3 sec

Sec post flow	6 sec
Pulse time	40 m sec
Standoff distance	2.5mm
Pulse frequency	40 pulse/sec

3. Optimization of process parameter for micro plasma arc welding of ss304 sheets of 0.5mm thickness

Variation in travel speed for determining optimum speed for sound of successful welding. As shown in the figure A,B,C,D,E. samples were found with defects increase in travel speed. Hence optimum values of travel speed was found to be for different current and other input parameter remain constant. Following graph are plotted of defect specimen for obtaining optimum welding speed at each current.

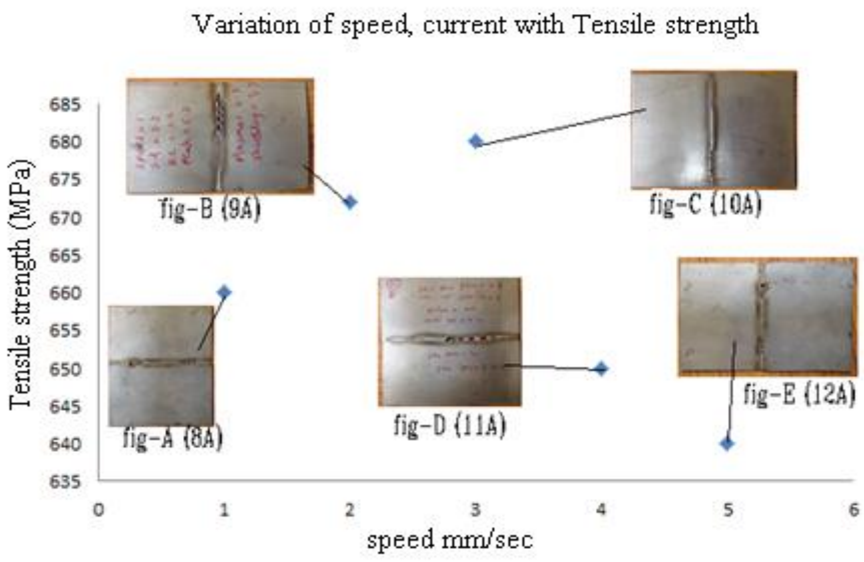

Fig-1 Defected specimen for optimizing welding speed

TABLE-3 Optimum speed for each current.

Current	8Amp	9Amp	10Amp	11Amp	12Amp
speed	3mm/sec	4mm/sec	5mm/sec	6mm/sec	7mm/sec

Experiment with different average current and speed were carried out. Average current was varied from 8 A to 12 A with the interval of 1 A. Welding speed of 3 mm/sec to 7 mm/sec with interval of 1 mm/sec. Fig 4.1 shows the photo graph of welding samples carried out process parameters (a) 8 A & 3 mm/sec (b) 9 A & 4 mm/sec (c) 10 A & 5 mm/sec (d) 11 A & 6 mm/sec (e) 12 A & 7mm/sec of current & travel speed .

For determining optimum speed at various current values visual inspection of weld bead was considered. Welding at various travel speed & various current values were carried out for obtaining successful defect free welds. The various type of defect and their respective tensile strength Vs travel speed is presented in pictorial from in fig 4.1. thus optimum values of process parameters are determined fo MPAW of ss 304 sheets &summarised in table 3. In fig -1 fig E & D shows spatter , burring during MPAW to high values of currents

11 & 12 A & low travel speed. Fig. A,B& D shows incomplete fusion & burning of sample due to low values of speed at different current values of 8,9,10,11,12 A respectively.

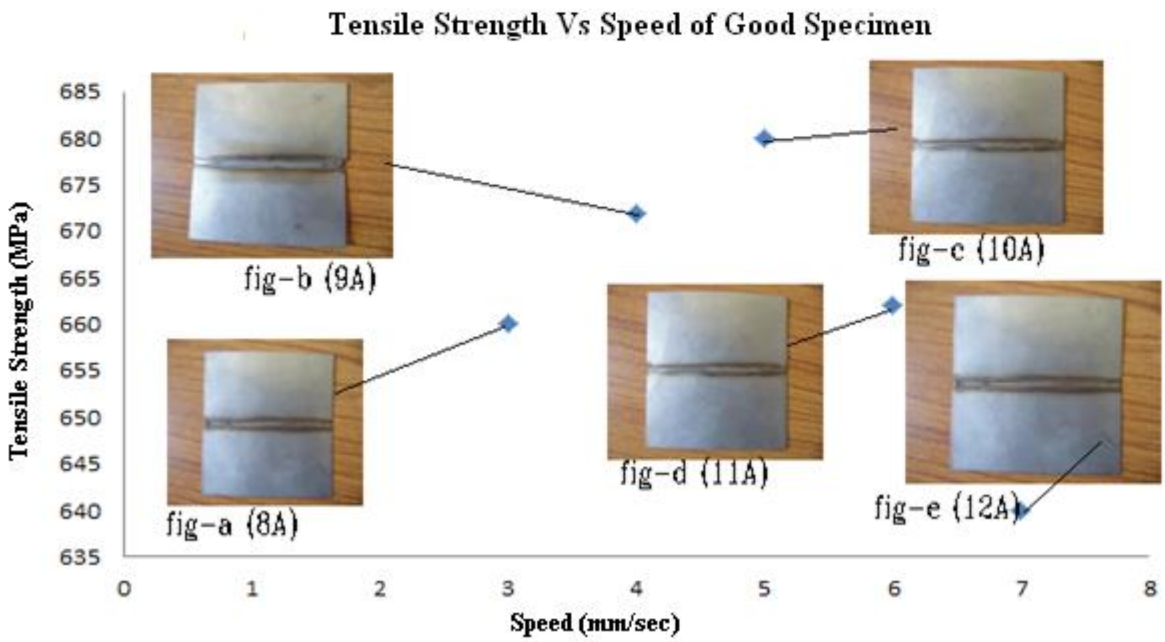

Fig-2 Good specimen for optimizing welding speed

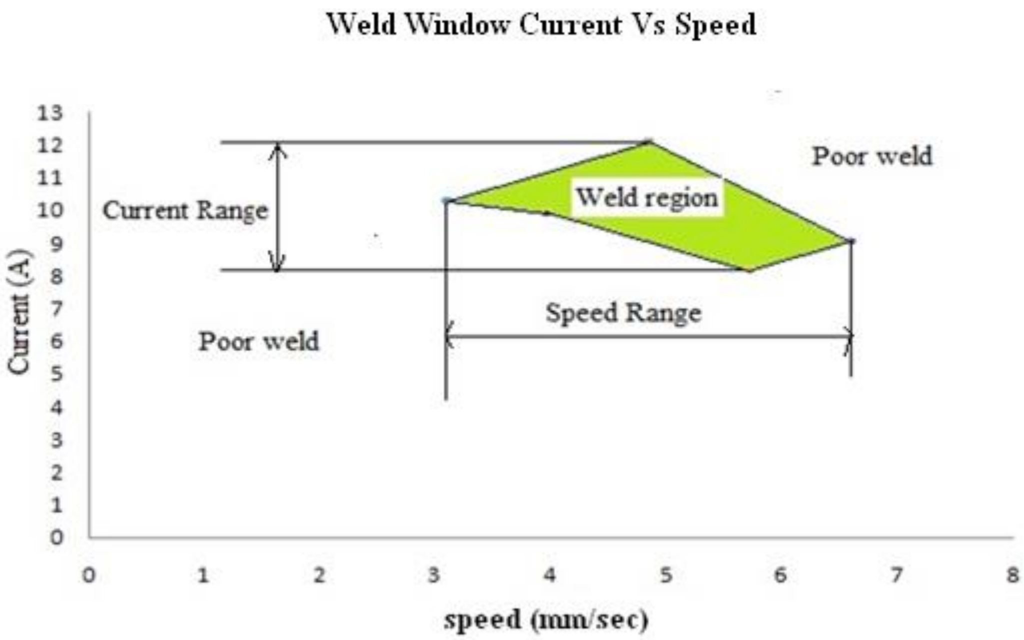

Fig:-3 Weld window

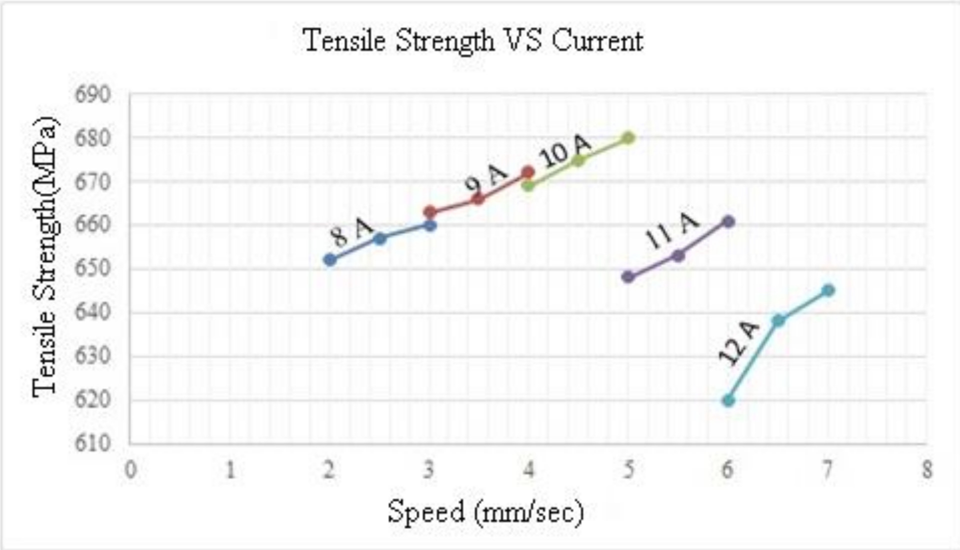

Fig-4 Tensile strength VS speed

For optimizing the speed at each average current first we tried a particular speed for welding than we get poor weld and this specimen are tested to obtained strength of welding than we increased welding speed and get better welding and this sample is also tested And get better tensile strength than previous welded sample and then again increase welding speed and get poor weld. So this type of experiment is repeated for each current and current range and speed are finalized. Fig 3 and 4 shown speed range, current range at a particular input parameter.

4. Mechanical Testing of Welds

4.1 Tensile Testing of weld

After many experiments at different process parameter specimen are prepared for different testing. For tensile testing specimen were cut by Co_2 laser cutting machine (ORION-3015) as per ASTM D-1708 specification. Tensile test were carried out in 5 KN computer controlled micro test machine (model no-MT 10081), so that specimen undergoes deformation. Fig.5 shows photograph of samples prepared for tensile testing.

Fig-5 Specimen for tensile test

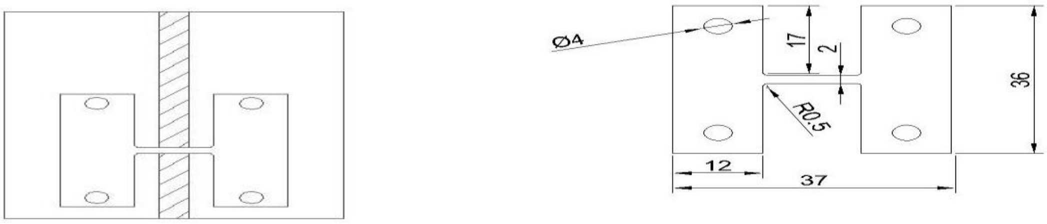

Fig-6 Dimension of specimen for tensile test

3 set of samples were prepared for each set of process parameters for tensile testing. Three samples were tested for tensile testing and results are plotted in graph shown in figure 7

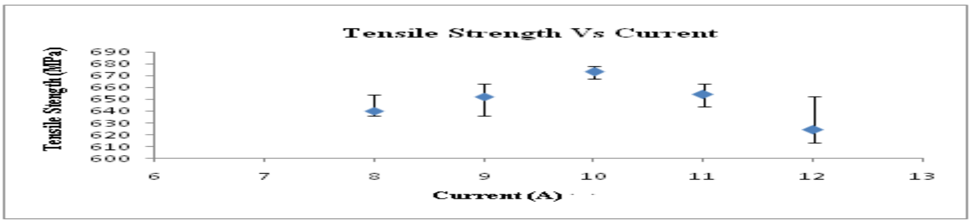

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Fig-7 Current Vs Ultimate tensile stress

It is found from the graph above that samples welded at 9 and 10 A current show better tensile strength as compared to others. At lower value of current the heat generated was not sufficient to weld the samples and create defect weld. Weld defects are anticipated and will be confirmed with metallographic study. At higher values of current 11 and 12 A the excess current amplitude is leading to spatter of weld pool and again reducing the strength of the weld. The optimum value of current is found to be 10 A. After tensile and hardness test it is found that maximum tensile strength is concluded at average current 10 A (650 MPa) at input parameter and maximum hardness value at average current 8 A (268 HV) at input parameter.

4.2 Hardness Test

After Micro plasma arc welding at different process parameter 3 specimens at each parameter are prepared and hardness is measured at five different points on specimen and average hardness value is measured. . Vickers hardness testing is carried out with 300kgf load for getting the indentation.

Following points are considered at the specimen. -2, -1, 0 , 1, 2 are indicating only different points on the specimen.

Base material Zone (-2)	HAZ (-1)	Weld Zone (0)	HAZ (1)	Base material Zone (2)

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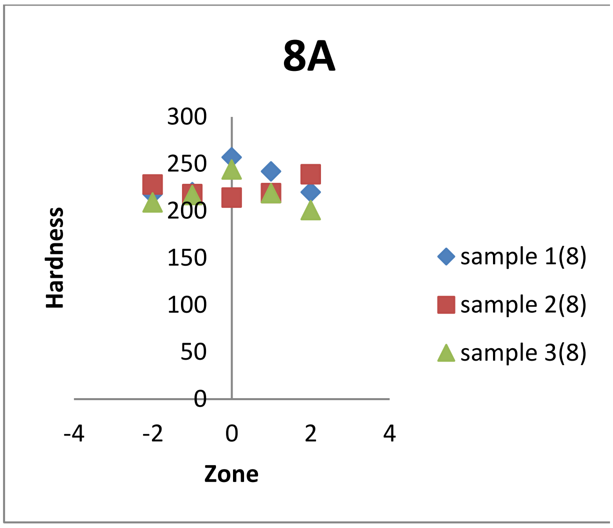

Fig 8-Hardness values at 8A of three sample at different zone

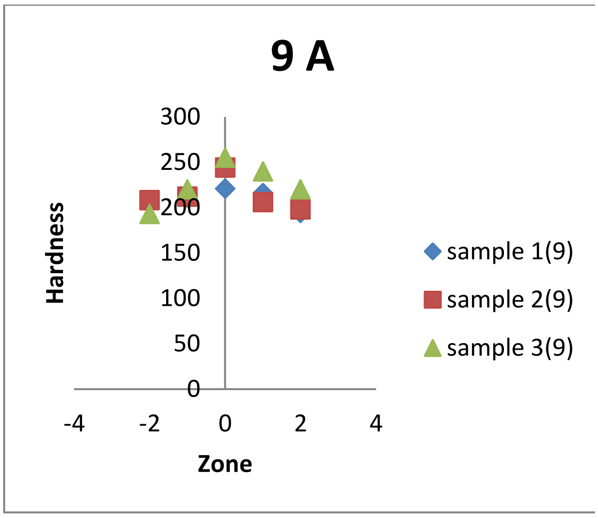

Fig -9 Hardness values at 9A of three sample at different zone

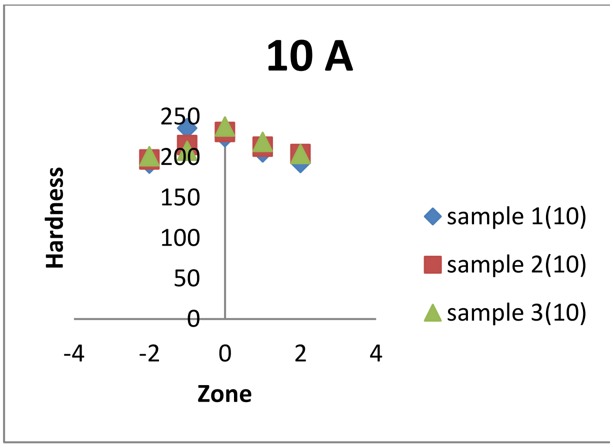

Fig-10 Hardness values at 10A of three sample at different zone

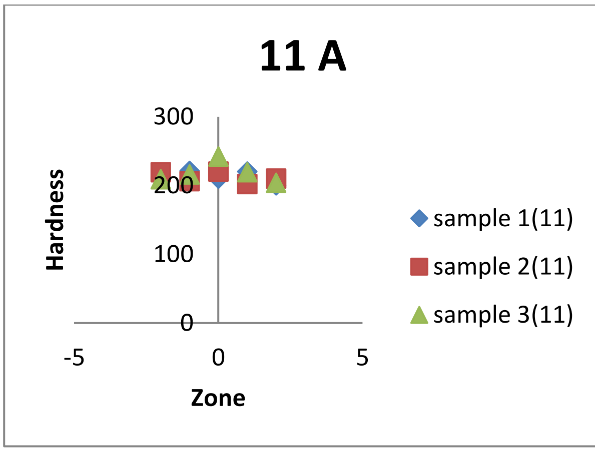

Fig-11 Hardness values at 11A of three sample at different zone

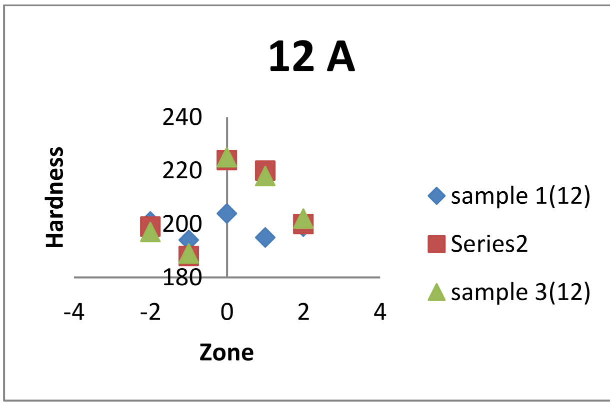

Fig-12 Hardness values at 12A of three sample at different zone

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TABLE 4 Average surface hardness at different process parameter and at different points.

Average current	Base metal	HAZ	Weld Zone	HAZ	Base metal
8 Amp	220	236	268	248	230
9 Amp	207	210	202	216	194
10 Amp	192	211	225	206	193
11 Amp	214	213	215	210	205
12 Amp	198	191	213	207	200

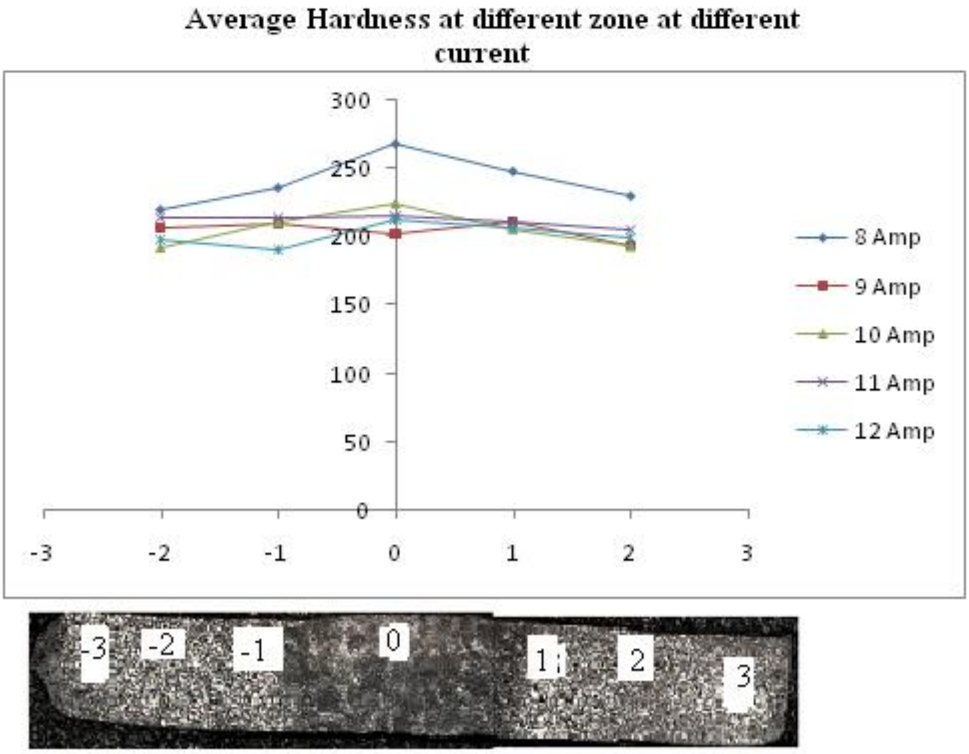

Fig-13 Hardness values at different currents

4.3 Microstructure

For grain size inspection specimen is cut in transverse direction of 20 mm length such that welding region remain center of the specimen and mounted this sample by phenolic powder. Specimen are mounted by Hydraulic press machine. The samples are polished by using polish paper having (320, 400, 600, 800,1000,and 1200) grade. These sample are further polished by aluminum oxide and velvet cloth in a polishing machine. These polished sample are etched by using 100ml water , 100 ml hydrochloric acid and 10ml HNO_3.

Micrograph are taken using optical microscope (Carl zeiss 10001208) at 100x magnification. The micrograph of parent metal zone and weld fusion zone shown in fig:-14 below.

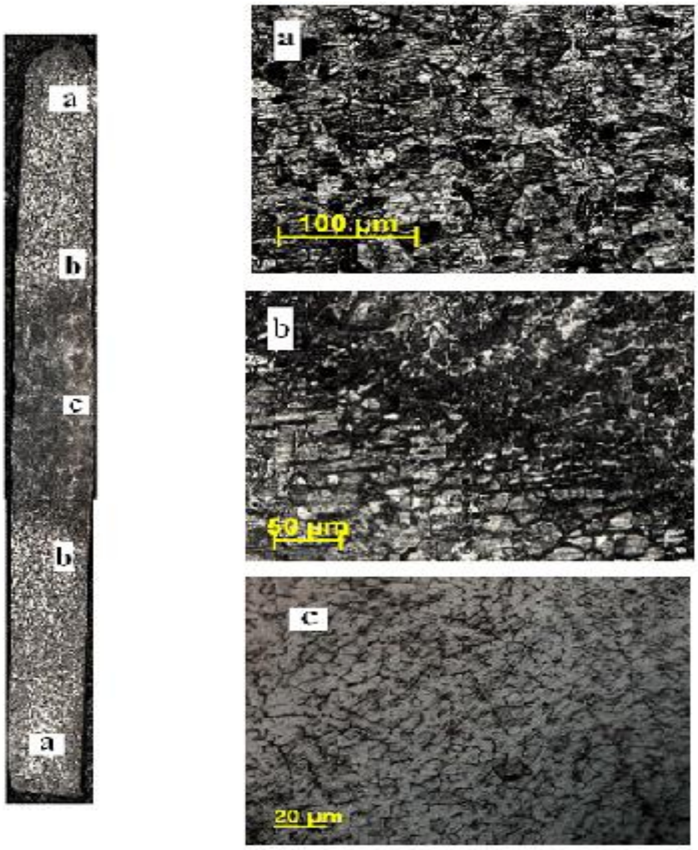

Fig-14Microstructure at different zone

Results and discussion

After tensile and hardness test it is found that maximum ultimate tensile strength is concluded at average current 10 Amp (650 MPa) at input parameter and maximum hardness value at average current 8 amp (268 HV) at input parameter. And microstructure is refinement than base zone HAZ.

It is found the weld bead increases with current up to a certain limit after which burn out of the material occurs. Tensile testing and Vickers micro hardness testing and micro structure are conducted to estimate the best quality weld under the stimulated region. The ultimate tensile strength is found to be comparable to the base metal. But with increase in current more brittle components are formed. Thus proper shielding device has to be provided to protect the molten zone to prevent formation of the brittle components. Hardness is increased due to martensitic transformation taking place during welding. In micro plasma (pulse) arc welding process work piece is remain at high temperature for melting at a very short period of time so solidification rate is high. And also hardness is increased due to refinement of grain structure.

Conclusion

(1) Optimum values of welding current , travel speed at constant parameter such as plasma gas , pre flow gas , secondary flow gas nozzle tip distance ,nozzle diameter are determine based on tensile strength.
(2) Optimum values of travel speed is determined to be 5 mm/sec & optimum values of current is determined to be 10 A based on Tensile testing of samples at various values of current and speed
(3) Variation in Hardness values is found at HAZ, FZ & base zone for all MPAW samples welded at different process parameters. Maximum values of HV are found at FZ at 8A. Reduce HV are obtained at 9 , 10-11,12 A. Thus Optimum current based on Hardness can concluded to be 9 A.
(4) MPAW samples at 10 A shows maximum Tensile strength and good ductility.

(5) Fig 4.15 shows the microstructure of base zone , HAZ , and welded zone. This is a single- phase austenitic microstructure with equiaxiad grain.

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