

Experimental Investigation on AISI 304L & AISI 310 Alloys Welded by Gas Metal Arc Welding (GMAW) Process

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Abstract - In this research is to study the influence parameters affecting the mechanical property (microhardness) and optical investigation (microscopy) of austenitic stainless steel grade (AISI-304L& AISI-310) with Gas Metal Arc Welding (GMAW). The research was applying the different values of wire speed and current for experiment, which have following interested parameters: welding current at (180, 250 and 320 Amps), welding wire speeds at (2, 3, 5 m/min), shield gas pure CO₂ and (24V)Welding Voltage. The study was done in following aspects: microhardness and optical investigation. A research study investigate the maximum value of micro hardness for welding joint is 444.9 Hv at wire speed 3m/min and 250 Amps welding current. From the microscopy that HAZ has finer grain and interdendritic austenitic phase at wire speed 3m/min & 250 Amps current which may cause the high tensile strength & micro hardness.

Keywords: Austenitic stainless steel; microhardness, microscopy.

I.INTRODUCTION

Welding is a process for joining two similar or dissimilar metals and alloys. Coalescence of different metals and alloys is carried by either with the help of processes in which heat is supplied either electrically or by means of a gas torch, or pressure may be executed for making the joint.[1] Austenitic stainless steel possesses austenitic

structure at room temperature. They possess the highest corrosion resistance of all stainless steels. They have greatest strength and scale resistance at high temperatures so these steels are used at elevated temperatures.[2] 310 Stainless Steel is a highly alloyed austenitic stainless steel used for high-temperature applications. The high chromium and nickel contents give the steel excellent oxidation resistance as well as high strength at high temperatures. 310 grade is very ductile, and has good weld.[3] Alloys 304 are also resistant to moderately aggressive organic acids such as acetic and reducing acids such as phosphoric.[4] MIG is an arc welding process wherein coalescence is produced by heating the job with an electric arc established between a continuously fed metal electrode and the job.[5] GMAW are used to weld the metals such as carbon steel, high-strength low alloy steel, stainless steel, aluminum, copper, titanium and nickel [6]. Dissimilar metals (like 310 & 304) are widely used in different areas of applications like power generation plants, food processing and chemical industries.[7]

II.EXPERIMENTAL PROCEDURES

The experiments were carried on AISI-304L and AISI-310 Austenitic stainless steel rod having diameter 1.5 cm and length 8cm of size is selected.

TABLE 1 CHEMICAL COMPOSITION OF AISI-304& AISI-310

AISI	C%	SI%	Mn%	P%	S%	Cr%	Ni%	MO%	N%
304L	0.04	0.75	2.0	0.035	0.015	17-19	9.5-11.5	0.20-0.50	0.10-0.18
310	0.04-	0.75	2.0	0.030	0.030	24-26	19-23	-	0.15-0.000.030

TABLE 2 SELECTION OF PARAMETERS LEVEL

Specimen	Wire speed (m/min)	Current (Amps)	Voltage (Volts)	Gas pressure (kg/cm ²)
1	2	180	24	3
2	2	250	24	3
3	2	320	24	3
4	3	180	24	3
5	3	250	24	3
6	3	320	24	3
7	5	180	24	3
8	5	250	24	3
9	5	320	24	3

The chemical compositions of AISI-304L & AISI-310 are presented in Table 1. The filler Welding wire AISI-304L with copper coated which specifies requirements for classification of wire electrodes for gas shielded metal arc welding of non-alloy and fine grain steels 8 mm diameter with copper coated are presented was used in this study. The distance between the nozzle tips to electrode tip (electrode extension) is maintained as 15 mm. The selection of the best shielding gas is based on consideration of the material to be welded and type of metal transfer that will be

used. Accordingly, 100% CO₂ considered as a shielding gas is selected for the experiments. Co₂ is widely used as the base gas in most of the shielding gases used for stainless steel welding. Before welding Specimen of AISI-304 & AISI-310 rod of diameter 1.5cm was cut in the shape of smaller section, having 8cm length of each piece. Each specimen was machined to obtain v groove, having angle of 20°.



Fig. 1 Stainless Steel specimen with single v groove

Prior to welding, the groove was thoroughly cleaned with wire brush, followed by cleaning with acetone, to remove the oxide layer, if any dirt or grease adhering to the groove surface after proper preparation rods of steel are placed on the workbench. In each placement, distance between the nozzle and work piece and the electrode extension were 19 and 10 millimeters, respectively. The orientation of the

welding electrode with respect to the weld joint was 55°.-60° after checking the pressure of shielding gas cylinder, which was set to 3 kg/cm², welding was started. One piece of AISI 304L and one piece of AISI 310 having 8cm length for one and 8cm length for other piece can be welded with GMAW. Both rods were welded at single pass.

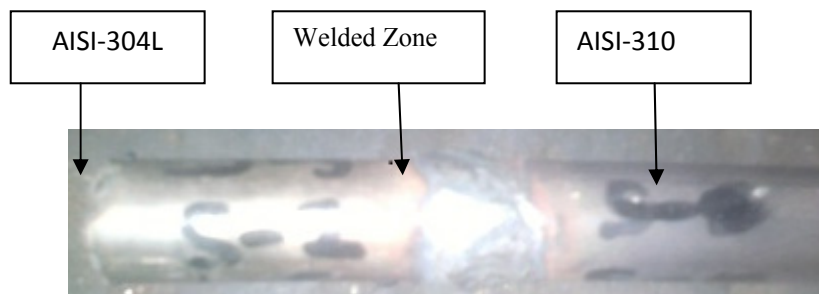


Fig. 2 of welded specimen

Specimen Preparation For Testing of Micro Hardness:

Micro Hardness test are carried out to check the hardness of material. Micro Hardness test can be done by applying the load on specimen. The specimen were initially polished with various grades of emery papers having grade 200, 300, 400, 600, 1000 from coarse to fine respectively on disc polishing machine. Then lapping with velvet cloth by using polishing grade alumina powder on a disc polishing. After polishing specimen ready for testing.

- ❖ Micro hardness test was conduct on three specimen of welded by three different speeds.
- ❖ Micro hardness test was carried out Vickers pyramid number (HV) at 100 gram force.
- ❖ The micro hardness test was carried out in institute for MMT, Batala (Punjab).

- ❖ Model- MVK- H11, MITUTOYO, Made in USA. Loading up to 50g to 200g

III.RESULTS

Experiment were conducted at different value of AC current (180,250&320 Amps) keeping gas flow rate 3kg/cm² at three different values of welding wire speed(2,3&5 M/Min). micro hardness were measured and tabulated.

Result of Microhardness Test:

Table 3 to 18 shows the variation of Micro hardness at different value of input current for AISI- 304L & AISI-310 welded alloys.

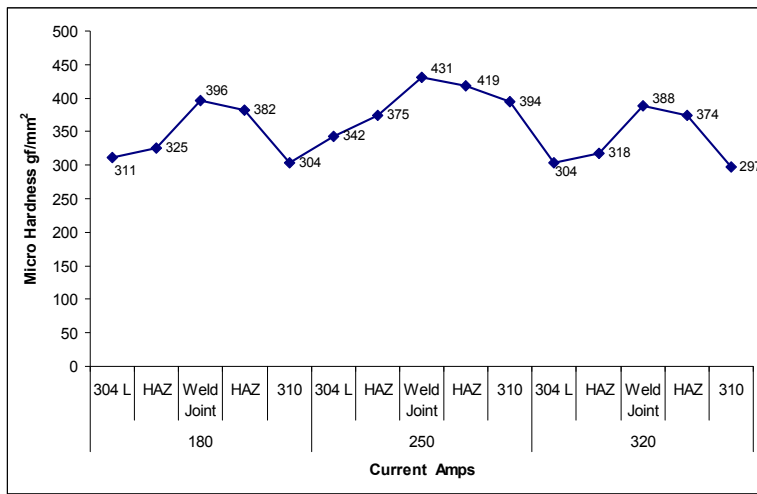


Fig. 3 Micro hardness v/s current at wire speed 2m/min

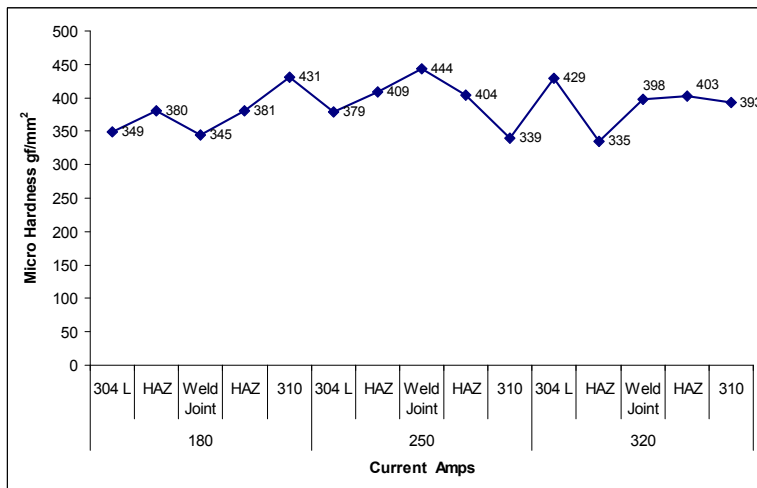


Fig. 4: Micro hardness v/s current at wire speed 3m/min

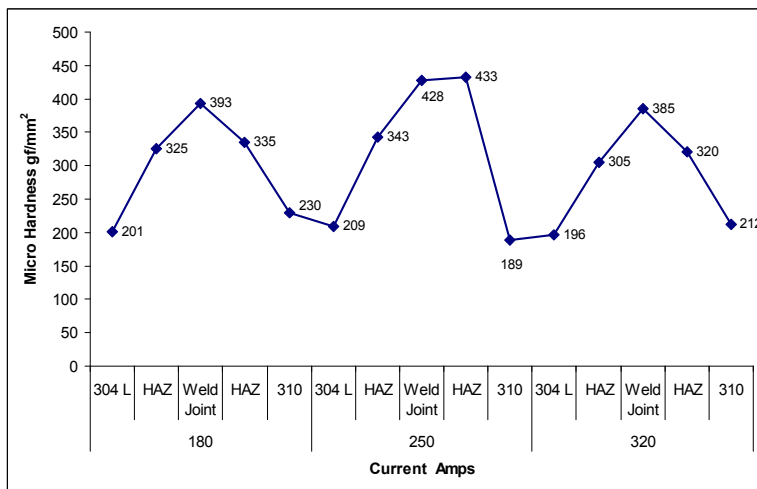


Fig. 5: Micro hardness v/s current at wire speed 5m/min

Result of Microstructure

Fig. 6 to 8 Show the various SEM images and Edax analysis for tensile specimen test at wire speed (2, 3 & 5 m/min) and (180,250 & 320amps) current.

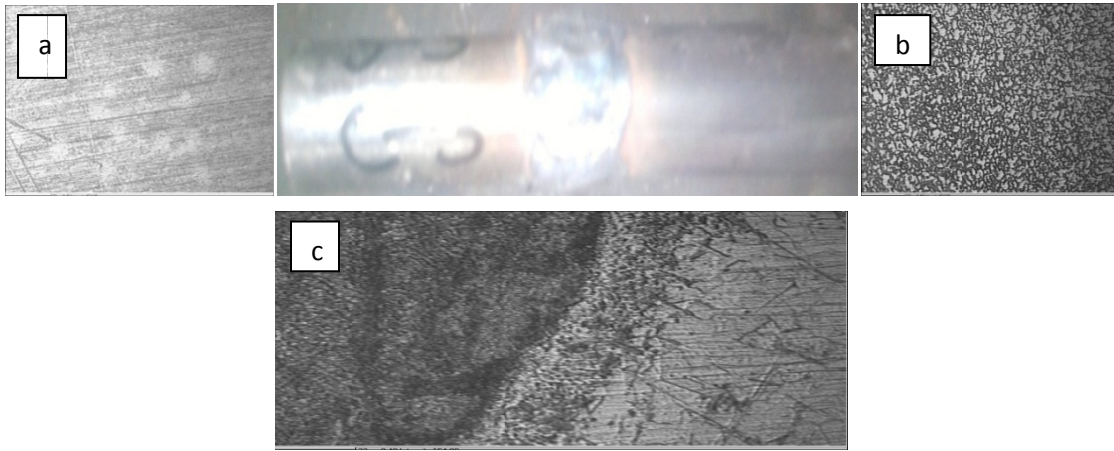


Fig. 6: a,b,c Microstructure of specimen after welded at wire speed 2m/min and 180 Amps current.

Microstructure of HAZ showed in fig 4.53 (c) show the Microstructure HAZ having columnar and rough austenite grains

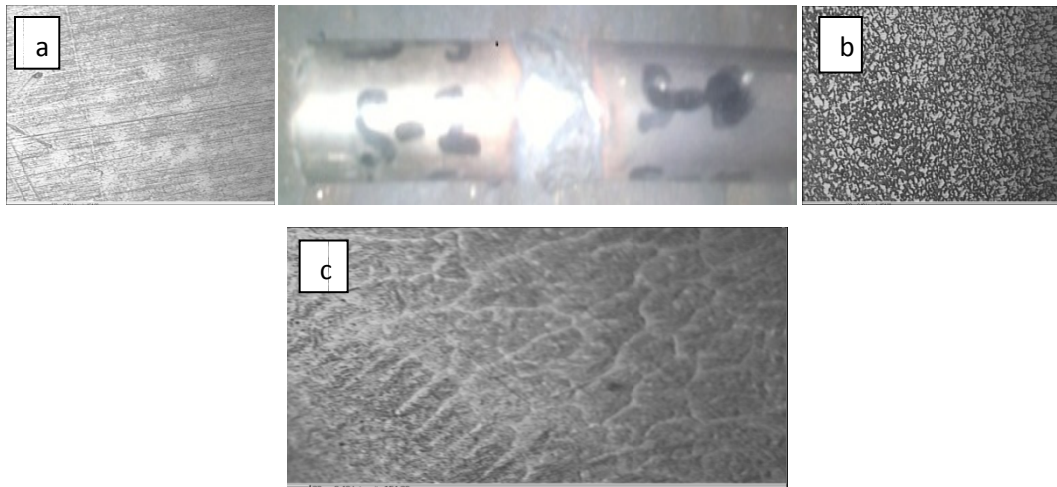


Fig. 7 a,b,c Microstructure of specimen after welded at wire speed 3m/min and 250 Amps current.

Microstructure of HAZ showed in fig. 4.54 (c) shows that equiaxed austenite grains and columnar grains. equiaxed austenite grains are fine and interdendritic austenite phase.

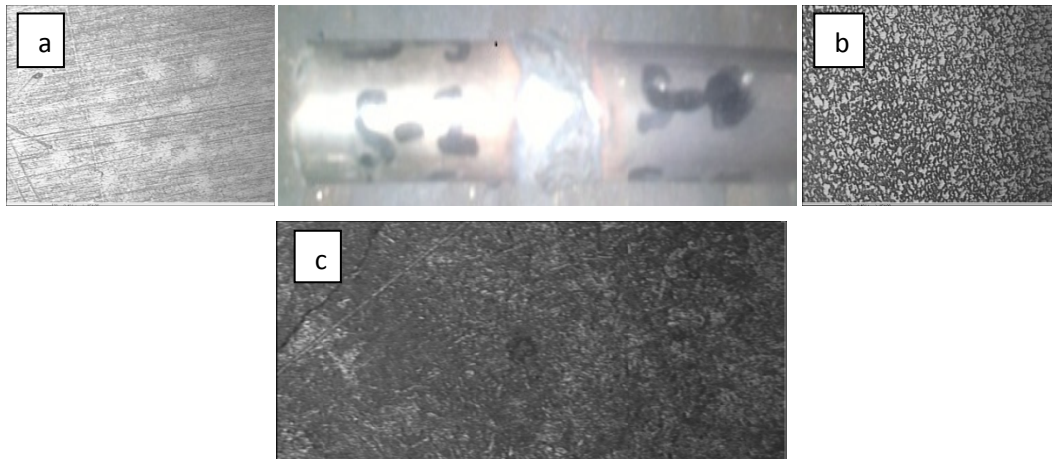


Fig. 8 a,b,c Microstructure of specimen after welded at wire speed 5m/min and 320 Amps current.

Microstructure of HAZ showed in 4.55 (c) shows that coarse equiaxed austenite grains

IV. DISCUSSION

Fig. 3 to 5 shows the different values of micro hardness Hv at different values of current (180,250,320) at different points. Fig 3 it may be observed that maximum value of micro hardness for base metal AISI 304L is 342.3 Hv, for the HAZ of AISI 304L is 375.4 Hv, weld joint of AISI 304L & AISI 310 is 431.3 Hv, for HAZ of AISI 310 is 419 Hv, for base metal of AISI 310 is 394 Hv at 250 Amps current when wire speed is 2m/min. Fig 4 it may be observed that maximum value of micro hardness for base metal AISI 304L is 380 Hv, for the HAZ of AISI 304L is 431 Hv, weld joint of AISI 304L & AISI 310 is 444 Hv, for HAZ of AISI 310 is 429 Hv, for base metal of AISI 310 is 403 Hv at 250 Amps current when wire speed is 3m/min. Fig 5 it may be observed that maximum value of micro hardness for base metal AISI 304L is 209 Hv, for the HAZ of AISI 304L is 343 Hv, weld joint of AISI 304L & AISI 310 is 428 Hv, for HAZ of AISI 310 is 433 Hv, for base metal of AISI 310 is 189 Hv at 250 Amps current when wire speed is 5m/min. The micro hardness has best value at 250 Amps current for 3m/min speed because of smooth grain structure and from the EDAX analysis the presence of alloy element (Fe, Ni and Cr) cause the large value of Hardness where as the micro hardness of 310 & 304 alloy is less than the H. Naffakh [et.al] [8], this is because of the surface is obtained during welding is do not have equally axis grain and also because of impurities and variation of alloy elements.

Fig 6 (a) show the micro structure of test specimen (AISI-310) having columnar and equiaxed grain and fig 6 (b) show the test specimen (AISI-304) having fine grain structure. While that of fig 6 (c) show the Microstructure HAZ having columnar and rough austenite grains, because of the columnar and rough grain bonding between the grain is not very much high so when the specimen tested under tensile test as the result tensile strength low as compared to the structure of equiaxed columnar grain and more over the upper surface structure of the HAZ is rough in appearance because the columnar and rough grain structure which cause the micro hardness is not so high when compared with equiaxed grain structure. fig 7 (a) show the micro structure of test specimen (AISI-310) having columnar and equiaxed grain and fig 7 (b) show the test specimen (AISI-304) having fine grain structure. While that of fig. 7 (c) show the Microstructure HAZ having equiaxed austenite and columnar grain, because of the equiaxed columnar grain bonding between the grain is quite high, so when specimen tested under tensile test, the tensile strength appear is very high and more over the upper surface structure of the HAZ is quite fine, because the grain is equiaxed which cause the micro hardness is also high at wire speed 3m/min and 250 Amps current. In earlier investigations (Bonollo *et.al*)[9]

equiaxed austenite grains are fine and interdendritic austenite phase. fig 8 (a) show the micro structure of test specimen (AISI-310) having columnar and equiaxed grain and fig 8 (b) show the test specimen (AISI-304) having fine grain structure. While that of fig. 8 (c) show the Microstructure HAZ having coarse equiaxed austenite grains, because of the coarse equiaxed grain bonding between the grain is quite low when compared to equiaxed grain structure so when the specimen tested under tensile test as the result tensile strength low as compared to the structure of equiaxed columnar grain and more over the upper surface structure of the HAZ is rough in appearance because the coarse grain structure which cause the micro hardness is not so high when compared with equiaxed grain structure.

V. CONCLUSIONS

- 1) The maximum value of micro hardness for the base metal & HAZ of AISI 304L is 380.6 & 431.2 at wire speed 3m/min when current is taken at 250 Amps.
- 2) The maximum value of micro hardness for the Weld joint of AISI 304L & AISI 310 is 444.9 at wire speed 3m/min when current is taken at 250 Amps.
- 3) The maximum value of micro hardness for the base metal & HAZ of AISI 310 is 429.4 & 403.7 at wire speed 3m/min when current is taken at 250 Amps.
- 4) It has been observed from the microscopy that HAZ has finer grain and interdendritic austenitic phase at wire speed 3m/min & 250 Amps current so for increase the microhardness and tensile strength.

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