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Comparative Evaluation of Mechanical Characterization Features of Dissimilar Weldments

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ABSTRACT

An attempt has been prepared to join the two dissimilar materials AISI 310 and AISI 316 L by Tungsten Inert Gas (TIG) welding process. AISI 316L and 90 S was used as filler metal. The microstructures of AISI 316 L and AISI 310 were evaluated after the TIG welding. And also various mechanical tests were conducted on Weldments to evaluate the mechanical properties .In this paper, the focus is purely on characterization and analysis of the dissimilar metal welded joint. The chemical composition of base metals as well as filler metals was found to play an important role on mechanical properties. Mechanical tests such as SEM/EDS, optical micro-structure, micro-hardness, tensile test and fractrography are performed. And then a comparison is made between the results

Keywords: *Dissimilar metal weld, TIG welding, AISI 310 and AISI 316 L*

1. INTRODUCTION

Welding is one of the most effective joining process employed in wide range of industrial application for joining of materials [1]. The dissimilar metal welded joints have been emerged as a structural material for various metallurgical and industrial applications which provides improved combination of mechanical properties like corrosion resistance, strength with lower cost. Selections of joining process for such a materials are very difficult because of their physical and chemical properties [5]. Dissimilar metal Weldments are generally used in various industries such as power generation, metallurgical, chemical industry, electronics, boiler manufacturing and nuclear industries to take the benefit by combining the properties of different materials in a single component [2]

The reported work have been described that there are many parameters that control the weld ability of dissimilar metals such as their crystal structure , chemical composition, solubility in the liquid and solid state. Spreading of filler metal in the weld pool area frequently leads to the creation of inter-metallic phases. Many of these inter-metallic phases are brittle and hard and affect the ductility of joint, mechanical strength of the joint and toughness.

Tungsten inert gas welding is a joining process and it can be wildly used in modern industries for joining either similar or dissimilar metal Weldments. Tungsten inert gas welding is often known as gas tungsten arc welding (GTAW) .The advantages of tungsten inert gas welding like joining of similar and dissimilar metals at very high quality weld, low heat affected zone, absence of slag etc. Gas tungsten arc welding wildly uses a non-consumable tungsten electrode to produce the weld because it created a very high temperature to weld the metals. Weld zone is protected by a shielding gas (usually inert gas such as argon) from atmospheric air or gases and a filler material is normally used for fill the gap of metal [3].

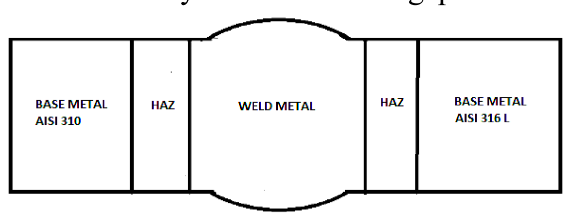


Fig:-1 Schematic diagram of welded joint.

2. Experimental:

In this research the dissimilar metal welding between AISI 310 and AISI 316 L was carried out by using TIG welding process with two different filler metals. The base metal used for dissimilar welding were AISI 310 and AISI 316 L and thickness of base metals were 4 mm. AISI 316L and 90 S was used as filler metal. The chemical compositions of base metal and filler metals are shown in Tables 1 and 2, respectively

Table 1: Crhemical Composition of Base Metal

Element / Material	C	S	P	Si	Mn	Ni	Cr	Mo
AISI 316L	0.040	0.010	0.025	0.520	1.79	19.010	24.700	---------
AISI 310	0.020	0.010	0.040	0.250	1.30	10.260	16.420	2.100

Table 2: Chemical Composition of Filler Metal

Element	C%	Mn%	Si%	Cr%	Ni%	Mo%	N%	V%	Cu%	S%	P%
316L	0.020	1.450	0.350	19.100	11.720	2.240	---	------	0.100	0.017	0.027
90S	0.084	0.520	0.460	2.420	0.020	0940	--	0.001	0.220	0.005	0.011

Metallurgical investigations of the joint were done after polishing the weld samples. The samples were prepared by first cutting in appropriate size by wire cut machine and then grinding using 80,120, 400, 800, 600, 1000, 1500 and 2000 grits of emery papers and final polishing is done by using 0.5μm diamond powder. Optical microstructure was measured along a straight line starting from first base metal, HAZ, weld metal, HAZ and ends at second base metal by an optical-microscope and a scanning electron microscope equipped with an energy dispersion X-Ray spectrometer (SEM/EDS). And micro hardness of all three specimens is measure by micro-vicker hardness testing machine. The mechanical properties of the welded joint were analyzed by conducting various tests. The tensile test was performed at a crosshead speed of 3 mm/min. The shape of the specimens which were used for performing tensile tests was dumbled shape and the length was 200mm and width was 20mm as shown in fig: 2.

Fig: 2: Tensile Tested specimens

RESULT AND DISCUSSIONS:

For microstructure observations, the welded samples were cut right angle to the welding direction from the welded joints and after cutting the samples in small pieces then polished and etched by using a kroll solution. Optical micro-scope was used to observe the microstructure of the weld interface. Scanning electron microscope (SEM) was used to observe the microstructure, element distribution and fracture analysis.

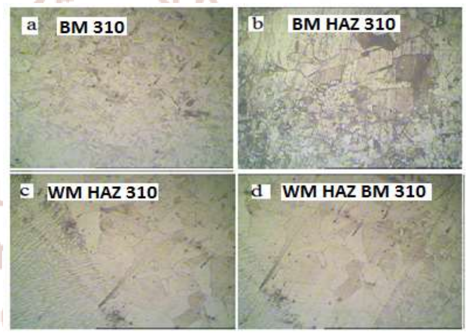


Fig 3. Optical micro-structure of sample 1 AISI 310 and AISI 316L welded by filler Metal AISI 316 L

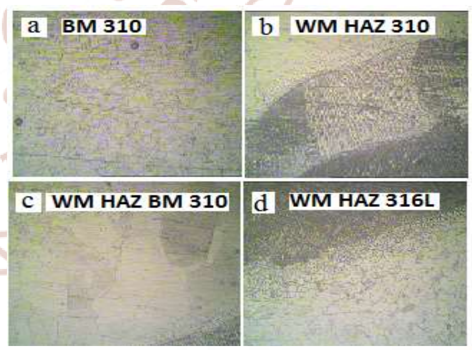


Fig 4. Optical micro-structure of sample 2 AISI 310 and AISI 316 L welded by filler metal 90 S

MICROHARDNESS: Hardness measurements of specimens were performed by means of Vickers method along the straight line starting from first base metal, haz, wm, haz, and then second base metal. Hardness results of all the samples are shown in table 3. In sample 1 the hardness values are lies in the range of 145–160, for sample 2 hardness values lies in the range of 152-458.

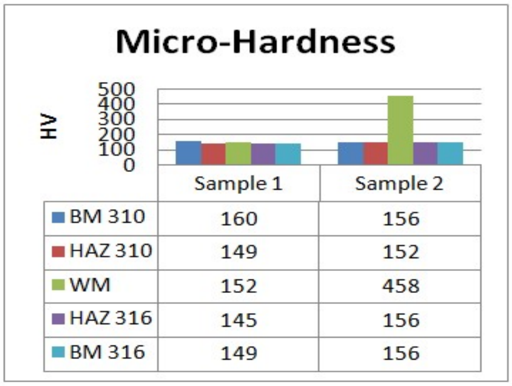


Table: 3. Shows comparison of micro-hardness of samples

TENSLIE TEST: A tensile test is the most common type mechanical test we can perform to predict the ultimate tensile strength of specimen. A tensile test is fully standardized, simple and less expensive. By pulling on something, you will very quickly determine how the material will react to forces being applied in tension. By pulling material, you will find its strength along with how much it will elongate. One of the properties you can determine about a material is its ultimate tensile strength. This is the maximum load the specimen sustains during the test. The ultimate tensile strength may or may not equate to the strength at break. This all depends on what type of material you are testing brittle, ductile or a substance that even carries both properties. The test process involves placing the test specimen in the machine and applying tension to it until it fractures. [4]

Tensile test of the samples were done on universal testing machine and the ultimate tensile strength of samples are shown in the fig: 6

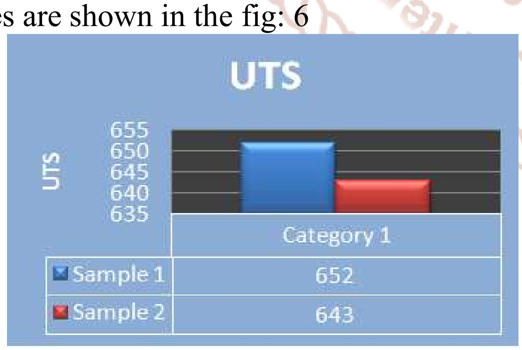


Table: 4.Ultimate tensile strength of samples.

Ultimate tensile strength of all the samples is lies in the range of 643-652.

SEM/EDS: Figure 5 shows an SEM (Scanning electron micro-scope) images at the joint interface of the sample 1 and 2 at magnification level of x33, x33 and x35 respectively. The composition of Cr, Fe and Ni were observed in interface by EDS.

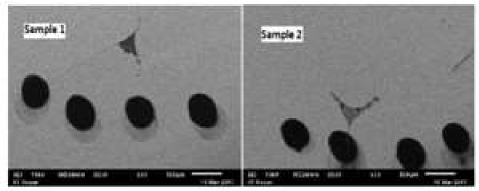
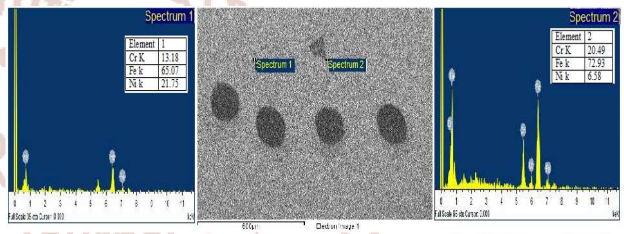


Figure 5. SEM of sample 1 and 2

Sample 1 AISI 310 AISI 316L AISI 316L.

Table: 5. EDS of sample 1

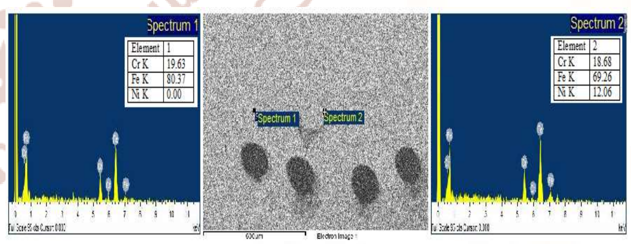
Element	1 BM	2 BM	3 HAZ	4 HAZ	5 WM	6 WM	7 HAZ	8 HAZ	9 BM	10 BM
Cr K	13.18	20.49	17.39	27.72	26.09	25.41	22.49	25.55	26.78	29.35
Fe k	65.07	72.93	68.60	59.75	60.27	61.85	64.59	55.27	56.07	53.20
Ni k	21.75	6.58	14.01	12.53	13.63	12.74	12.92	19.17	17.15	17.45



Sample 2: AISI 310 90 s AISI 316L

Table: 6. EDS of sample 2

Element	1 BM	2 BM	3 HAZ	4 HAZ	5 WM	6 WM	7 HAZ	8 HAZ	9 BM	10 BM
Cr K	19.63	18.68	26.80	8.76	8.47	12.44	9.07	9.98	26.72	27.31
Fe K	80.37	69.26	73.20	91.24	91.53	87.56	90.93	90.02	53.88	59.64
Ni K	0.00	12.06	0.00	0.00	0.00	0.00	0.00	0.00	19.40	13.05



Fracture surface examination: Scanning electron microscopy (SEM/EDS) photographs of fractured surface of tensile tested samples normally show the overall micro-cracks, the striation, as well as beach marks in the fractured region, and the dimples in the ductile fracture region. SEM/EDS photos of samples are shown below in fig. 8.

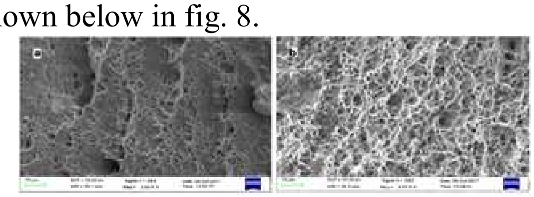
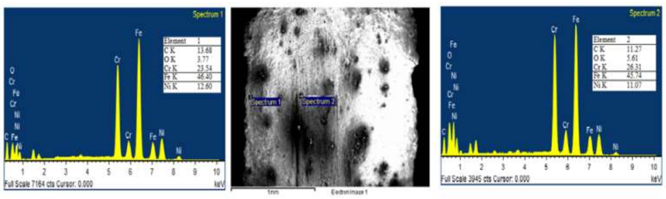
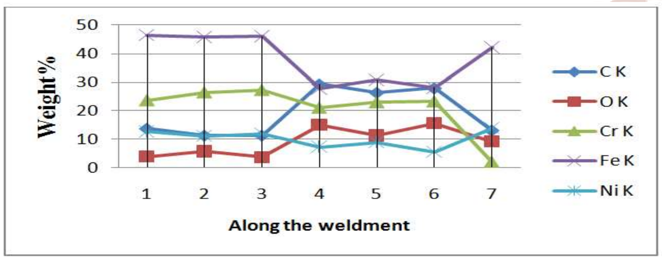


Figure 6: figure a and b shows SAM sample 1 and 2

EDS: Sample 1 310 316L 316L (310 left side fracture piece)

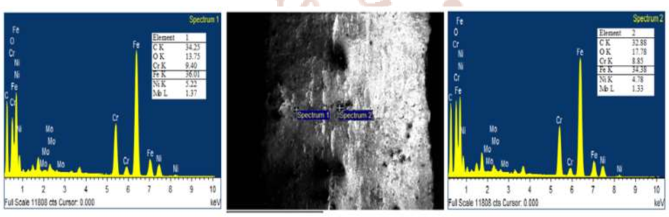
Element	1	2	3	4	5	6	7
C K	13.68	11.27	11.28	29.24	26.29	27.85	13.05
O K	3.77	5.61	3.63	14.98	11.26	15.51	29.08
Cr K	23.54	26.31	27.11	20.91	22.83	23.14	1.88
Fe K	46.40	45.74	46.08	27.59	30.72	28.00	42.18
Ni K	12.60	11.07	11.89	7.27	8.90	5.50	13.81

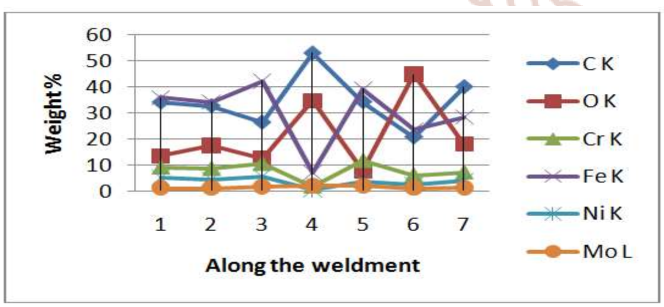




EDS: Sample 2 310 90 S 316L (316L Right side fracture piece)

Element	1	2	3	4	5	6	7
C K	34.25	32.88	26.51	53.12	34.42	20.88	40.19
O K	13.75	17.78	12.73	34.78	8.12	44.93	18.24
Cr K	9.40	8.85	10.82	2.00	11.97	6.32	7.46
Fe K	36.01	34.38	42.36	7.19	39.28	23.71	28.56
Ni K	5.22	4.78	5.76	0.77	4.00	2.87	4.08
Mo L	1.37	1.33	1.81	2.14	2.22	1.29	1.48





CONCLUSION:

Dissimilar material welding was done between AISI 316 L and AISI 310 with TIG welding using two different filler material AISI 316 L and 90 S and mechanical properties are evaluated by conducting various tests and it is concluded that;

1. The filler metal AISI 316L is better as comparative to 90 S because the sample 1 which contains AISI 316 L as a filler metal shows high value of tensile strength in tensile test.
2. Hardness test reveals that improved values compared to 90 S because of relatively high values of micro hardness in HAZ and WM region of sample containing 90 S as a filler metal.
3. Micro-structure of HAZ and WM of sample 1 containing AISI 316 L as a filler metal shows that inter metallic combination filler metal and weld metal is sound.
4. Chemical Composition of Filler Metal 316 L is also better because it contain large amount of Cr, Ni and Mo.

Thus it is concluded that filler metal AISI 316L is better as comparative to filler metal 90 S.

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