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Experimental Investigation And Material Charcaterization Of Gas Tungsten Arc Welded Aisi 316l And Aisi 430 Using Different Filler Materials

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Abstract: The article is based on the study of metallurgical and mechanical properties of bimetallic joint welded using Continues Current Gas Tungsten Arc Welding with the presence of ERNiCu-7 and ERNiCr-3 as fillers. The parent metals employed in this study are AISI 316L (low carbon alloy) and AISI 430. The microstructure analysis of the weld region and the Heat Affected Zone (HAZ) can be examined with the help of optical microscope and SEM analysis which helps to find the formation of unmixed zones at the HAZ. Tensile and Impact tests are carried out for examining the fracture properties of the weldments. These investigations will be useful for studying the structural –property relationships of dissimilar weldments using different filler rods.

Keywords—component; Tensile strength, Impact strength, SEM-EDAX, factrography, macro/microstructures

I. INTRODUCTION

Bimetallic joints are widely used in power generation industries for the manufacturing of turbines in Thermal power plants and for manufacturing nozzles, piping in petrochemical industries and also in nuclear power plants some components like heat exchangers and evaporators .The studies on the performance of these kind of bimetallic joints are rarely found in the literature because of its difficulties in the process due to its individual mechanical and morphological properties

K.Devendranath Ramkumar et.al [1] made an study on the influence of the filler metal and welding method on welding Inconel 718 and AISI 316L and reported that by employing any one of the both CCGTA and PCGTA welding techniques sound joints can be obtained by using ERNiCu-7 fillers. Sajjad Gholmi SHIRI et.al,[9] reported from his studies on welding 304 stainless steel and CP-copper using different filler material stated that high hardness was achieved in Fusion zone than base material in all the samples using copper and he also stated that for the welding of stainless steel using gaseous tungsten arc welding carbon is the good filler. N.kaiee et.al [5] from their studies stated that at 130A and welding speed of 9.4cm/min at the gas flow rate of 15.1 l/min desired hardness and tensile strength can be achieved. A.Ravisankar et.al [4] reports that the distribution of the heat took place with the increase in the weld speed and power and also with the help of finite element simulation they stated that the residual stress were negligible at those parameters. K.Devendranath Ramkumar et.al [3] in his studies he stated that the micro

Chemical composition % wt													
Material	C	Si	Mn	Cr	Ni	Mo	Ti	Al	Su	Ph	Va	Cu	Fe
AISI 316 L	0.028	.31	1.26	16.79	10.22	2.11	.01	0.01	0.007	0.038	0.08	0.227	reminder
AISI 430	0.043	0.38	0.37	16.27	.15	0.01	0.02	0.03	0.006	0.020	0.11	0.078	reminder

Table.1 Chemical composition of base metals

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Table.2 Chemical composition of filler metals

Chemical composition % wt													
Material	C	Si	Mn	Cr	Ni	Mo	Ti	Al	S	P	Nb	Fe	Cu
ER NiCu-7	0.15	1.25	4	-	65.5	-	2.25	1.25	0.015	0.02	-	2.5	reminder
ER NiCr-3	0.10	0.5	0.5	22	58	9	0.4	0.4	-	-	3-4	5	0.5

Segregation of Cu and Cr accelerated the hot corrosion in E309Lwhich took place in the dendrite structure in the weld interface of the weld metal. G.R.Mirsekari et.al [6] stated that by increasing the no of the passes of the weld then the corrosion and hardness of the weld also can be increased. Chun-Ming Lin [7] reported that the solidification of the morphologies increases with the increase in the number of the cladding layer but which leads to the decreases in the hardness because of the micro structural changes the hardness will occur .H.A.chu[8] from his works suggested that the hot cracking can be eliminated by the addition of proper buffer layers. The report also states that the hot cracking propagates to the over layer which initially initiates at the weld interface region. K.Devendranath Ramkumar et.al [2] proved from his work by using proper filler wire impact and tensile strength of the weld improved without forming the deleterious phases

It is evident from the literature that AISI 430 and AISI 316L stainless steel joints have wider-range of applications. The outcomes of this work will be highly rewarding to the end users who are working with dissimilar combinations

II. EXPERIMENTAL DETAILS

A. *Base metal and Welding Procedures*

At first the chemical composition of the base metal and fillers are tested. Before proceeding for the welding the base metals are sliced into pieces of dimensions 150x55x4mm with the help of wire cut EDM(Electrical Discharge Machining) .Single V-groove with the root gap of 2mm and included angle of 70° for the standard butt welding configuration has been machined on the base metals. Then the continuous current arc welding process with the suitable fixture for holding the work piece and proper back plate for avoiding the bending of the specimen during the welding due to the heat exerted from the welding process. The suitable parameters for the welding can be found by putting a bead on the plate or by undergoing some trail runs. After finding the suitable parameters from the trail runes then by using both ERNiCu-7 and ERNiCr-3 fillers the parent metals are welded. The mechanical and metallurgical properties of the weld will be discussed in the following chapter.

B. *Metallurgical and Mechanical characterization of the weldments :*

The welded specimens are need to undergo Non destructive testing (NDT) process Gamma ray radiography for finding whether there is any defect on the weld. After getting the results from radiography the master specimens are cuts into several pieces according to the ASTM American Standards for Testing Materials for several mechanical and metallurgical testing processes.

In order to find the micro structural and metallurgical properties of the weld following tests are need to be taken Optical Microscopy (OP), Scanning electron Microscopy (SEM) and Energy Dispersive X-Ray Analysis (EDAX). For that the “Composite zone” is need to slice out from all the specimens. The composite zone is the one which contains HAZ (Heat Affected Zone), welded region and parent metal. The dimensions of the composite zone are given as 15x10x4 mm. Then the composite zone will be subjected to the serious of polishing and etching process before undergoing for the above mentioned tests. The polishing starts from polishing the specimen with fine emery sheet of Sic from the grade of 80 to 1000 in both the clockwise and anti-clockwise directions in the disc polishing machine and then with the help of alumina paste and distilled water the specimen is polished one more time to get the mirror finish on the weld specimen .After finishing the polishing process the specimen will undergo for the Electrolytic Etching Process. Oxalic acid of 10% with 12V DC supply with the current density of 1A/C m^2 can be used for this etching purpose to examine the microstructure of the specimen.

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III. Results and Discussion

A. *Macro and microstructure of the weldments.*

The macrostructure of the samples proves that both the weldments welded using ERNiCr-3 and ERNiCu-7 had came out without any porosity or lack of penetration or fusion. The levels of penetration are appreciable in both the cases. The composite region of dimension 15x10x4 mm is used for the investigation of the microstructure of the weldments .The microstructure obtained by welding both the AISI 316L and AISI430 using ERNiCu-7 and ERNiCr-3 are shown above. In the microstructure of the weldment using ErNiCu-7 shows the formation of un-mixed zone which is also known as Partially Mixed Zone (PAZ). The weld interface is clearly visible in both the cases. The migrated grain boundaries are clearly visible in both the samples employed using different filler rods. The crystallization of the migrated grains from the base metals is clearly visible in the Heat Affected Zone (HAZ). The dendrites are formed on the HAZ on both the sides of the weldments in both the cases. The reason for the formation of un-mixed zone may be due to the higher heat inputs developed in the welding process.

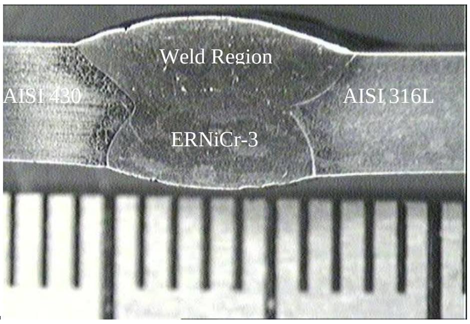


Fig.1 Macrostructure of the GTA weldments of dissimilar weldments employing ERNiCr-3

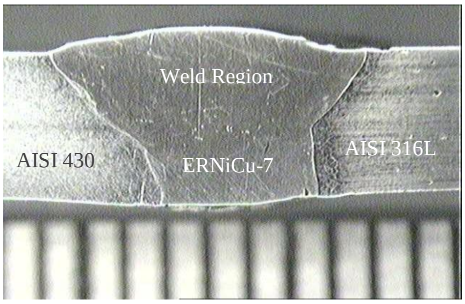


Fig.2 Macrostructure of the GTA weldments of dissimilar weldments employing ERNiCu-7

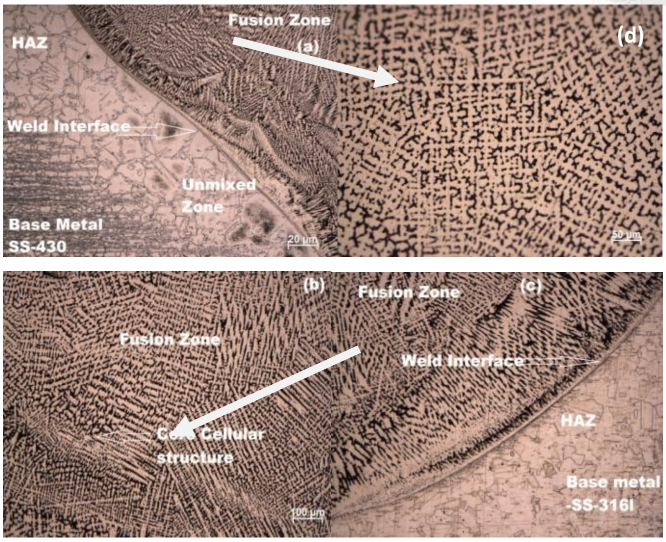


Fig.3 Macrostructure of the GTA weldments of dissimilar weldments employing ERNiCr-37 a) Weld interface at AISI 430.b) Fusion zone .c) weld interface at AISI 316L d) Fusion zone at 200x

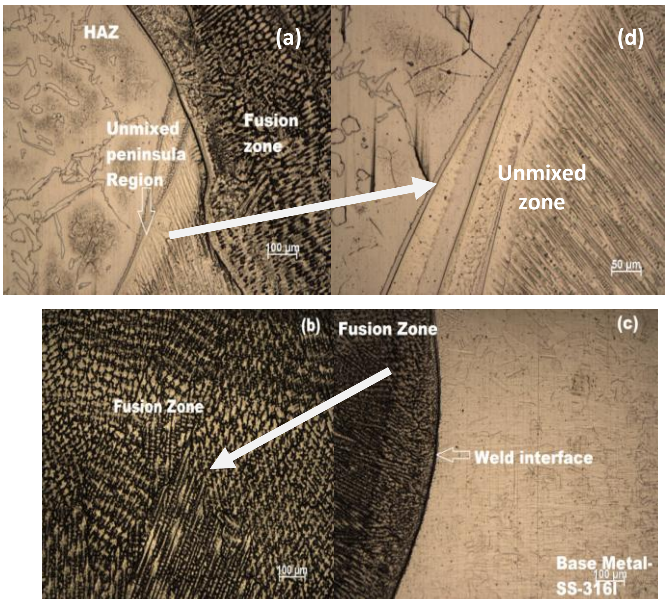


Fig.4 Micro structure of the GTA weldments of dissimilar weldments employing ERNiCu-7 a) Weld interface at AISI 430.b) Fusion zone.c) weld interface at AISI 316Ld) Unmixed region formed at the AISI430

B. *Tensile test*

As per the ASTM:E8/8M standards specimens of the dissimilar metals AISI 316L and AISI 430 welded using the filler wires ErNiCu-7 and ErNiCr-3 are prepared using the EDM wire cut process. The tensile tests on the prepared samples are carried using UTM (Universal Testing

Machine). In both the cases the failure tooks place on the base metal region of AISI 430. The failure occurred may be due to the fibrous network structures and micro voids which is noticed on the surface of the failure region during the fractography process. The Ultimate tensile strength is noticed on the ERNiCu-7 weldments which is 484.5Mpa and the least percentage of Elongation is obtained on ERNiCr-3 weldments

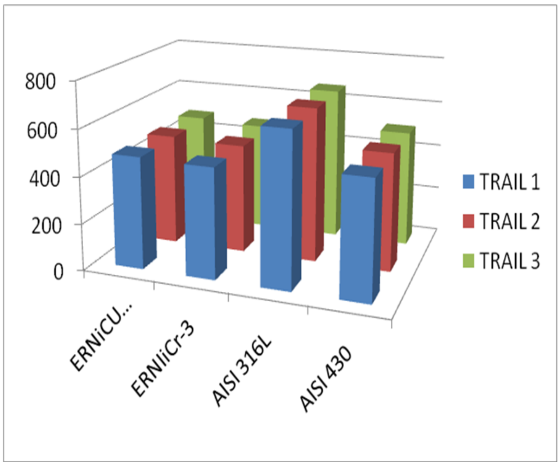


Fig.4 Tensile measurement on GTA weldments of dissimilar weldments employing ERNiCu-7 and ERNiCr-3

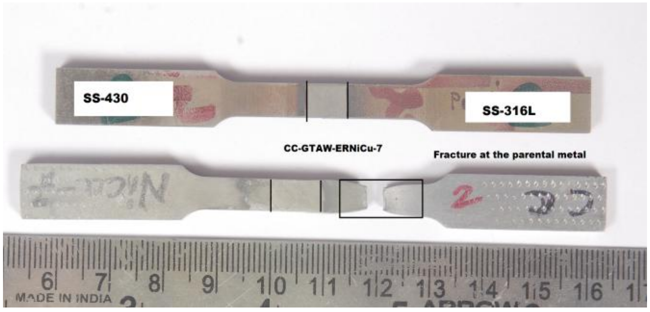


Fig 5.ASTM E8 standard tensile coupon of GTA welded dissimilar metals

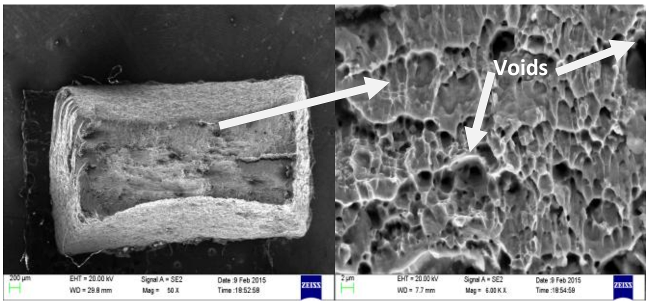
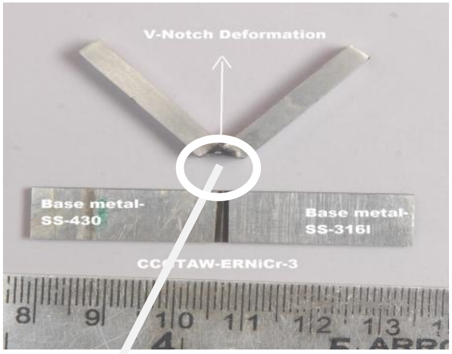


Fig.6 SEM micrographs of Tensile fractured coupons of GTA weldments

C. *Impact test*

The Charpy V-Notch Impact test is used to test the ability of withstanding the sudden application of loads .the samples are sub seized according to the ASTM: E23-12C standards. Both the base metals AISI 316L and AISI 430 have high impact values. Both the samples underwent ruptures only in the welded region without leading towards the complete failure. The fractography results showed that the failure regions having micro voids. The weldments prepared using the filler wire of ERNiCr-3 shows the higher impact energy values.



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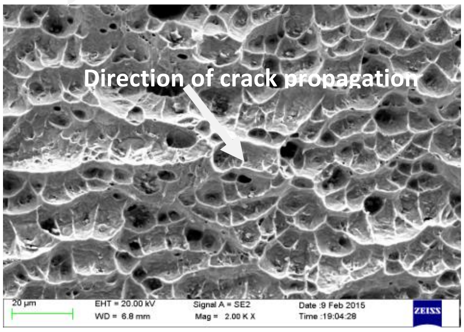

Fig.8 SEM micrographs of fractured Impact test coupons of GTA weldments

IV. Conclusion.

The Macro/Microstructures, Tensile test and Impact test on the welding of dissimilar metals AISI 316L and AISI 430 using ERNiCu-7 and ERNiCr-3 are studied in this article. Some of the important conclusions are listed below.

1) The differences in the metallurgical and mechanical properties of the welding of

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dissimilar metals using both the filler rods are exhibited.

2) The macrostructure shows that the weldments prepared using both the filler wires formed sound weld without any porosity and lack of penetration.
3) The microstructure of the weldment prepared using ERNiCu-7 exhibits unmixed zones and the migration of the grains post weld.
4) The tensile test clearly shows that the weld created using the filler rod ERNiCu-7 exhibits higher Ultimate tensile strength .Whereas the weld created using the filler rod ERNiCr-3 shows very less percentage of elongation. But in both the cases the failure has occurred on AISI 430 region.
5) The Charpy V-notch impact test proves that ability of withstanding the sudden application of loads. In both the cases there is no complete failure of the weld.
6) The fractography on the failure regions of both the tensile and Impact test shows the presence of micro voids along with the fibrous networks.
7) Constant Current Gaseous Tungsten Arc welding for the welding of the dissimilar metals exhibited great weld ability and also both the filler wires are capable of forming the sound weldments of dissimilar metals.

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