International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Effect of Filler Wire on Properties of Dissimilar Welding of SA213TP-347H with SA213 T23

O. K. Thirugnanasambandam[1], Dr. T. Senthil Kumar[2]
[1]PG Student, University College of Engineering (BIT Campus), Trichy, India
[2]Head of the Department, Mechanical Engineering, University College of Engineering (BIT Campus), Trichy, India

***Abstract*— *This paper deals with the dissimilar metal butt welding of materials SA213TP-347H WITH SA213-T23. These materials are mainly used in the reheater and super heater coils of supercritical power plants. Specimen will be butt welded in Orbital TIG welding machine having GTAW (Gas Tungsten Arc Welding) Process and shielding with Argon Gas. Dissimilar joint will be welded with each filler wire ER347H and ERNiCr3. Job will be Stress relieved with prescribed temperature and tensile properties analysis will be carried out. The other testing methods include Radiography test and Bend test*.

***Keywords*— *Dissimilar welding, tensile test, preheat, post weld heat treatment.*

I. INTRODUCTION

The current focus is on the newly developed grades of steels like SA213 T23 which is suitable material for the superheaters and reheater tubes of upcoming advanced power plant projects. The T23 tubes can substitute for the conventional grades SA213 T22. T22 is basically 2.25 Crl Mo and 9Crl Mo steels and, T 23 is 2.25Cr 1.5W. In T23 molybdenum is substituted by tungsten which gives a better creep strength than T22. The enhanced creep properties of T23 are developed by the addition of tungsten, niobium, vanadium, nitrogen and boron. But the suitability of a material for an application not only depends on its mechanical properties but also on its weldability, fabricability, resistance to corrosion etc. So it is necessary that all the properties be carefully evaluated. In superheater and reheaters both alloy steel and stainless steels are used. Hence dissimilar weld joints are inevitable during fabrication of these components. So the detailed characterization of these dissimilar joints is important for the proper long-term service of the component. At present, T23material is procured by most of the boiler manufacturers, it is important to evaluate its properties. Hence different combinations using T23 and SS 347H is welded by using ErNiCr3 & ER347H filler wires and detailed characterization of the joints is made through various conventional and advanced tests.

II. DISSIMILAR METAL WELDING

The importance of dissimilar metal weld (DMW) are located in the final super heater and re heaters of power plant boilers and to join low alloy steel to 300 series austenitic stainless steel. They operate at steam out let temperature gradually ranging from (900 – 1100^{o}F) with internal pressure ranging from 3.5 to 26.2 MPa. Typical tubing sizes from 38 mm to 63.5 mm with 13 mm wall thickness for super heater and 4-8 mm wall thickness for re heater. Common practice has been to make these walls by the shielded metal are process, using with 300 series stainless steel (or) nickel base filled metal. But in recent times, welds have been made by using automotive gas tungsten arc welding process.

2.1 Factors Influencing DMW Behaviors

Major factors influencing DMW performance in boiler super heater and re heaters are

(a) Service condition to which the DMW is subjected
(b) The filler materials used for DMW

In all operating conditions commercially available nickel base filler metal is suitable for DMW of low alloy steel and stainless steel. But it is also demonstrated that nickel base filler metal base limitations in the content of elevated temperature DMW service (Ref 5, 4.1). As the array of carbides are formed during welding with low alloy steel when nickel base filler metal are used. It reduces the load carrying capacity of the materials. It also reduces the rupture strength.

2.2 Combination of Joints Welded

Dissimilar material combinations of SA213 347H and SA213 T23 were welded in orbital TIG welding machine using optimum parameters. Material specifications are 51 mm diameter and thickness of 9 mm with J groove edge preparation. Two trial were made using ERNiCr3 and ER347 filler wires and joints were subjected to Radiographic test. Joint which was made with ER347 filler wire have excess penetration at 3-5 O clock position and another joint made with ERNiCr3 was found with no defect.

2.3 Brief Description About SA 213 T23 Material

SA213 T23 is a ferritic low alloy steel and is developed from T22 by adding tungsten (1.6%), by reducing molybdenum (0.2%) and carbon contents (0.04-0.10%) and small additions of vanadium, columbium (Cb), nitrogen and boron. Due to these additions and proper heat treatment creep strength values and resulting allowable stresses are greatly increased. It has very high creep behavior at 550 ^{o}C with low hardness in the as welded condition, which is essential material quality requirement for the power plant equipments. It is found as replacement material for T21 and T22.

2.4 Brief Description About SA 213 347H Material

SA213 347H is a stabilized austenitic stainless steel material with good general corrosion resistance and somewhat better resistance in strong oxidizing conditions. It has excellent resistance to intergranular corrosion after exposure

O. K. Thirugnanasambandam and Dr. T. Senthil Kumar, "Effect of filler wire on properties of dissimilar welding of SA213TP-347H with SA213 T23," *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 359-364, 2017.

to temperatures in the chromium carbide precipitation range of 800 – 1500°F (427 – 816°C). The alloy has good oxidation resistance and creep strength to 1500°F (816°C). It also possesses good low temperature toughness. Stainless steel tubes can be readily welded by most standard processes. A post weld heat treatment is not necessary.

TABLE 1. Mechanical properties of SA213T23 and SA213 347H.

Properties	**SA213T23**	**SA213 347H**
Tensile strength (MPa) min	510	515
Yield strength (MPa) min	400	205
Elongation (in 50 mm/min) %	20	35
hardness max (Brinell/Vickers)	220 hbw/230 hv	192 hbw/200 hv

TABLE 2. Chemical composition of base metal in accordance with ASTM standards.

	T91	T22	T23	347H
Carbon(C) %	0.08-0.12	0.05-0.15	0.04-0.1	0.04-0.10
Manganese (Mn) %	0.30-0.60	0.30-0.60	0.1-0.6	Max. 2.00
Phosphorous (P) %	Max. 0.020	Max. 0.025	0.03	Max. 0.045
Sulphur (S) %	Max. 0.010	Max. 0.025	0.01	Max. 0.030
Silicon (Si) %	0.20-0.50	Max. 0.50	Max. 0.50	Max. 1.00
Chromium (Cr) %	8.002-9.50	1.902-2.60	1.9-2.06	17.0-19.00
Molybdenum (Mo) (%)	0.85-1.05	0.87-1.13	0.05-03	---
Vanadium (V) %	0.18-0.25	---	0.2-0.3	---
Niobium (Nb) %	0.06-0.10	---	0.02-0.08	0.80-1.10
Nitrogen (N)%	0.030-0.070	---	0.03	---
Aluminium (Al)%	Max. 0.04	---	0.03	---
Nickel (Ni) %	Max. 0.40	---		9.0-13.0
Boron (B) %			0.0005-0.006	
Tungsten (W) %			1.58	
Iron (Fe) %	Balance	Balance		balance

2.5 Effect of Alloying Elements on Steel Properties

Manganese (Mn) – improves hardenability, ductility and wear resistance. Mn eliminates formation of harmful iron sulfides, increasing strength at high temperatures.
Nickel (Ni) – increases strength, impact strength and toughness, impart corrosion resistance in combination with other elements.
Chromium (Cr) **–** improves hardenability, strength and wear resistance, sharply increases corrosion resistance at high concentrations (> 12%).
Tungsten (W) **–** increases hardness particularly at elevated temperatures due to stable carbides, refines grain size.
Vanadium (V) – increases strength, hardness, creep resistance and impact resistance due to formation of hard vanadium carbides, limits grain size.
Molybdenum (Mo) – increases hardenability and strength particularly at high temperatures and under dynamic conditions.
Silicon (Si) – improves strength, elasticity, acid resistance and promotes large grain sizes, which cause increasing magnetic permeability.
Titanium (Ti) – improves strength and corrosion resistance, limits austenite grain size.
Cobalt (Co) – improves strength at high temperatures and magnetic permeability.
Zirconium (Zr) **–** increases strength and limits grain sizes.
Boron (B) – highly effective hardenability agent, improves deformability and machinability.
Copper (Cu) – improves corrosion resistance.
Aluminium (Al) – deoxidizer, limits austenite

2.6 Filler Wire / Electrode

ER347 and ERNiCr 3 (Inconel-82) filler wires are used to make joints between SA213 347H and SA213 T23.

ER 347 has good resistance to general corrosion and is suitable for applications where welds are subjected to high temperature (+750 ^{o}F)

ERNiCr3 (Inconel -82) is used for welding alloy steel to stainless steel.

TABLE 3. Chemical composition of ER 347 and ErNiCr3.

	C	Cr	Ni	Nb	Mo	Mn	Si	P	S	Cu
ER347H	0.04	19.5	9.5	0.04	0.30	1.3	0.4	0.025	0.015	0.10
ERNiCr3	0.03	20.4	72.09	2.5	-	2.85	0.22	0.003	0.22	0.5

TABLE 4. Mechanical properties of feed wire material.

Material	Tensile Strength min (MPa)	Yield Strength min (MPa)	Elongation in 50 mm, min (%)
ER347H	607	400	45
ERNiCr3	620	520	20

2.7 Welding Consumables

Most metals can be welded as long as appropriate welding consumables or filler metals and procedures are employed. In order to weld a metal successfully, the welding personnel should have sufficient knowledge of welding consumables (covered electrodes, wires, strips, and fluxes), because the selection and handling of welding consumables greatly affect the quality of welds. A covered electrode consists of the flux material coated on the core wire. A variety of core wires and fluxes are used according to the desired performance of covered electrode.

2.7.1 Core wires

Core wires have two important roles — as an electrode to convey electricity and as a Supplier of deposited metal. Mild steel and high strength steel covered electrodes use core wires made of dead mild steel that contains about 0.06% carbon. Low alloy steel covered electrodes use core wires made of either dead mild steel or low alloy steel. Stainless steel covered electrodes use stainless steel core wires.

2.7.2 Wires for gas-shielded arc welding

Solid wires for gas-shielded arc welding include both those for gas

Shielded metal arc welding (MAG, MIG) and those for tungsten inert gas (TIG) arc welding. These wires can be further classified by the suitable shielding gas. In order to obtain intended wire usability and weld quality, an appropriate shielding gas must be selected according to the chemical composition of wire and the application. For example, CO2 and Ar+CO2 mixture are used for welding mild steel, high strength steel, and low alloy steel; Ar+2%O2 for stainless steel, and pure Ar for nickel alloys. For MAG and TIG welding, flux-cored wires are also available.

O. K. Thirugnanasambandam and Dr. T. Senthil Kumar, "Effect of filler wire on properties of dissimilar welding of SA213TP-347H with SA213 T23," *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 359-364, 2017.

2.7.3 Electrode used in GTAW Process

Tungsten electrodes are non-consumable because they do not melt or transfer to the weld. The function of the tungsten electrode is to serve as one of electrical terminal s of the arc which supplies the heat required for welding. Its melting point is 3410^{o}C approaching this high temperature, tungsten becomes thermionic. It reaches this temperature by resistance heating.

2.8 Shielding Gases

Shielding gas is directed by the torch to the arc and weld pool to protect the molten weld metal zone from atmospheric contamination. Argon and Helium or mixtures of the two are the most common types of inert gas for shielding. Argon-Hydrogen mixtures are used for special applications.

2.8.1Advantages of Argon:

- Smoother, quieter arc action
- Reduced penetration
- Cleaning action when welding materials such as aluminum and magnesium
- Lower cost and greater availability
- Lower flow rates for good shielding
- Better cross draft resistance
- Easier arc starting due to low ionization potential

2.9 Preheat

Application of preheat, to raise the temperature of the parent steel before welding to reduce the risk of cracking induced by diffusible and residual hydrogen in the weldment mainly to slowdown the cooling rate of the weld and base material, resulting in high hard weld metal and heat affected zone with Martensite microstructures. The slower cooling rate results in diffusing out of hydrogen from the weld area by extending the time period over which it is at elevated temperature particularly the time at temperature above 100°C where hydrogen diffusion rates are higher thus reduction in hydrogen reduces the risk of cracking.

Preheat can be applied by various process which depends on material thickness, weldment size. Preheat has been applied by Oxyacetylene gas heating with neutral flame to a temperature of 150-250°C.

2.10 Post-Weld Heat Treatment (PWHT)

Post-weld Heat treatment has been defined as any heat treatment after welding, is often used to improve the properties of a weldment. In concept, PWHT can encompass many different potential treatments; however, in steel fabrication, the two most common procedures used are post heating and stress relieving. The need for PWHT is driven by code and application requirements, as well as the service environment. In general, when PWHT is required, the goal is to increase the resistance to brittle fracture and relaxing residual stresses. Other desired results from PWHT may include hardness reduction, and material strength enhancements. Post heating is used to minimize the potential for hydrogen induced cracking (HIC).After welding has been completed, the steel must not be allowed to cool to room temperature; instead, it should be immediately heated from the interpass temperature to the post heat temperature of 760°C and held at this temperature for one hour minimum in accordance with AWS D10.10M and ASME boiler and pressure vessel code Section 1

Fig. 1. Welded specimen (T23+SS 347H) with 347 H (joint no.0761690) and ERNiCr3 (joint no. 0761691) filler wire.

III. LITERATURE REVIEW

Dinesh W. Rathod et al. [1] has experimentally analysed of dissimilar metal weld joint of Ferritic to austenitic stainless steel. Ferritic steel (SA508 Gr.3.Cl.1) with austenitic stainless steel (SS304LN) welded. They used the Gas Tungsten Arc Welding (GTAW) for welding the dissimilar metals with ERNiCr3 and EniNiFe-3 consumables. They found that fine slag inclusion could promote the undesirable microstructure, which would lead to crack initiation and propagation with low stress field and reduced tensile properties and impact toughness.

Rutesh Mittal et al. [2] hasanalysed the microstructures and mechanical Properties of dissimilar T91+347H steel weldmentsby SMAW & GTAW process. Austenitic and Nickle based filler wires are used for welding. It was found that dissimilar metal joints made by GTAW process with filler wire ERNiCr3 have given better result.

N. Arunkumar et al. [3] has evaluated the mechanical Properties of dissimilar metal tube with (T91+SS347h) and (T91+T22) material combinations by GTAW& GMAW process. The joints fabricated by GTAW process exhibited higher strength value and enhancement in strength is approximately 21 % compared to GMAW joint. Low hardness was recorded in GMAW joint (190 VHN), whereas hardness was maximum in the GTAW joints (293 VHN)

T S Senthil et al. [4] has experimentally analysed the dissimilar welding of materials used for fabrication of super heater coils for Boiler power applications. They carried out welding of T23 with T92, T23 with 347 H & T92 with 347 H, by Manual TIG process by using Inconel-82 filler wire. Hot tensile test was carried out on T23+T92, T92+T92 & T23+T23 combination welding. They concluded that SA213T23 & SA213 347H weldment has satisfactory bent ductility, weld tensile strength, toughness & metallurgical properties

P Mohyla et al. [5] has analysed the reliability and creep resistance in advanced low-alloy steels. They concluded that post weld heat treatment (PWHT) of T23 and T24 welds is necessary to achieve suitable hardness and plastic properties of welds. And also, it was found that weld joints of low-alloy creep resistant steels hardened by dispersed MX particles are subject to a process of secondary hardening during long term exposure at elevated temperatures and application of T23 and T24 steels for membrane water walls is effective only if post-weld heat treatment is carried out.

Satanphop Amsupan et al. [6] has studied the influence of the welding heat cycle on the HAZ properties of the T23 joints. It was found experimentally that preheat & PWHT is significant for T23 joints, to have reduced hardness at HAZ. Even though T23 materials are specifically designed to be welded without pre heat and post weld heat treatment (PWHT), Application of preheating & PWHT is necessary irrespective of the tube thickness.

3.1 Discussion

From the literature review the following are discussed below.

i) Welding process has significant influence on hardness of weldment area or heat affected zone (HAZ).
ii) Selection of electrode and filler wires is important for getting quality welding of the product.
iii) Pre heat & post weld heat is to be ensured as required on case to case basis.
iv) Process parameters are to be optimised for better results.
v) Slag inclusion is to be avoided at the weldment area

3.2 Conclusion

The above work reveals that

i) Pre heat and post weld heat treatment (PWHT) is necessary for T23 materials.
ii) Dissimilar metal welding of T91+347H, made by GTAW process with filler wire ERNiCr3 have given better result.

IV. Scope and Planning

4.1 Selection of Objective

To evaluate the effect of filler wire on hot tensile properties, dissimilar metal butt welding of materials SA213TP-347 with SA213-T23 was carried out in Orbital Tig (OTIG) welding machine by Gas Tungsten Arc Welding (GTAW) process with Argon gas shielding.

Specimen joints were made using ER347H and ERNiCr3 filler materials separately and the same were subjected to radiography test. Further specimen pieces will be subjected to tensile, bend test and macro & micro analysis

4.2 Selection of Material

Specimen made from diameter 51 mm, thickness9 mm with J groove edge preparation. Tube ends which joined together were cleaned thoroughly. Specifications of materials are SA213TP-347 and SA213-T23.

4.3 Plan of Experiment

Welded dissimilar specimen joints were stress relieved before taking it to lab for further tests. Specimen joints will be subjected to the following tests:

- Tensile
- Bend
- Macro & micro analysis.

V. Testing & Results

5.1 Radiography Test

Radiography is a non-destructive testing tool widely used in industry. Its unique advantage over other NDT methods is that it preserves the permanent record. Radiography is a process of testing materials that uses penetrating radiations such as X-rays or gamma rays. Radiography is called non-destructive method of testing since objects that are tested are not damaged by the tests and may still be used after testing is completed. n passing through the material, some of the radiation is absorbed or changed. The amount of absorption is dependent upon the thickness of the material, density of the material and the atomic number of the material. Some kind of detector such as film, fluorescent screen is used to record the variations in intensity of the emerging beam as visual image

Radiography test was conducted for assessing the quality of the welded joints. This test was done to assure that the welded joints are free from welding defects like porosity, lack of fusion and lack of penetration. The radiographs were evaluated and the accepted joints were taken for the further testing.

Welder No	Date of weld/shift	Tube size/specn	Qty welded	Qty tested
	RT No	Findings	Remarks	
6065937	10.11.2016/G	51.00/9.10/347H 51.00/9.10/T23	2	2
	0761690 0761691	EXCESS PENETRATION NO DEFECT	DISCARD DEF AREA ACCEPTABLE	

*** End of Statement ***

Fig. 2. Radiography test report.

5.2 Bend Test

The bend test was conducted to determine the soundness of the element like ductility of the welded zone, weld penetration and fusion strength etc. the specimen passed the bend test as there was no open discontinuity on the bend surface. Table 5 shows the results of the face bend test.

TABLE 5. Bend test result.

Sl No.	Filler wire	Face bend	Remarks
1	ErNiCr3	No open Discontinuity	Passed
2	ER347H	No open Discontinuity	Passed

Fig. 3. Bend specimen welded with ErNiCr3 filler wire.

Fig. 4. Bend specimen welded with 347H filler wire.

5.3 Tensile Test

The tensile test determines the tensile strength of the weld.the tensile test specimen was prepared as per AWS .0 standard. Since the specimen fails at the base metal side, the weld metal holds better strength than the base metal and hence the specimen passes the tensile test.

Figure 5, Figure 6 shows the tested specimen welded with ER347H and ErNiCr3 filler wires respectively.

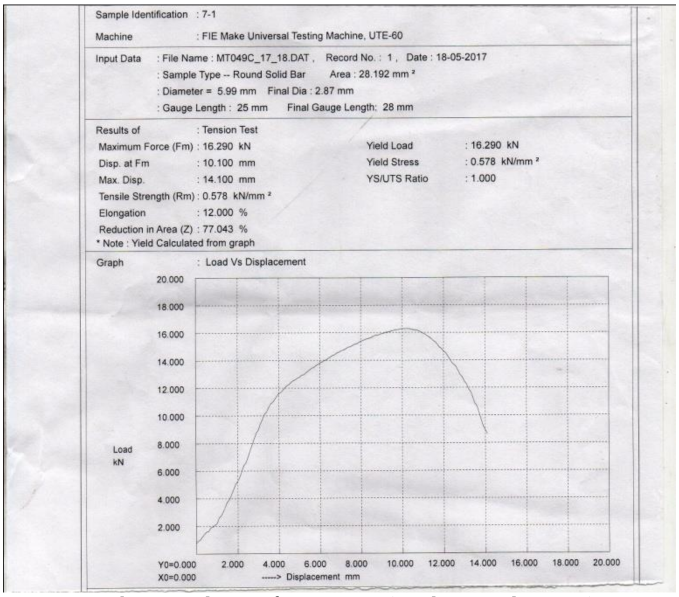
Table-6 shows the result of the tensile test.

Fig. 5. Tensile tested specimen welded with 347H filler wire.

Fig. 6. Tensile tested specimen welded with ErNiCr3 filler wire.

TABLE 6. Tensile test results of the specimen.

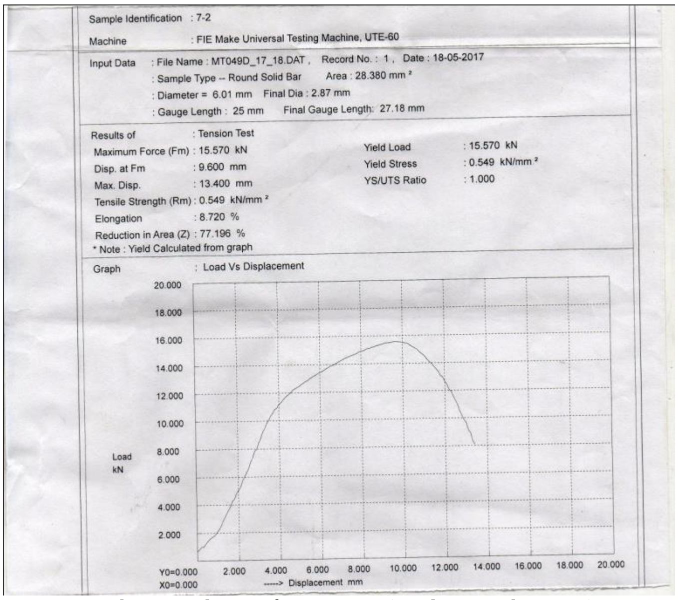
I D No.	Filler wire	Specimen size in mm	U T S in Mpa	Position of fracture
7.1	ER347H	Dia 5.99	578	T23 Base metal side
7.2	ER347H	Dia 6.01	549	T23 base metal side
3.1	ERNiCr3	Dia 6.01	588	T23 base metal side
3.2	ERNiCr3	Dia 6.01	564	T23 base metal side



Graph 1. Tensile test of I D No. 7.1 (Load Vs Displacement).

O. K. Thirugnanasambandam and Dr. T. Senthil Kumar, “Effect of filler wire on properties of dissimilar welding of SA213TP-347H with SA213 T23,” *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 359-364, 2017.

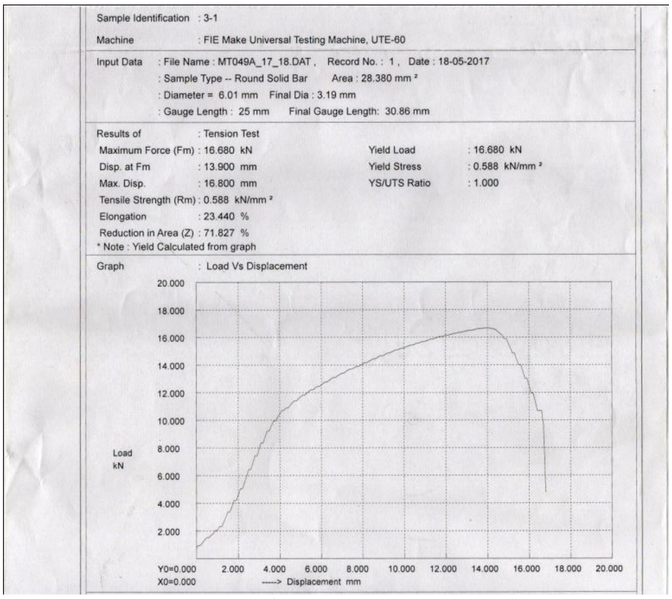
International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024


Sample Identification : 7-2
Machine : FIE Make Universal Testing Machine, UTE-60
Input Data : File Name : MT049D_17_18.DAT , Record No. : 1 , Date : 18-05-2017
: Sample Type -- Round Solid Bar Area : 28.380 mm ²
: Diameter = 6.01 mm Final Dia : 2.87 mm
: Gauge Length : 25 mm Final Gauge Length: 27.18 mm

Results of : Tension Test
Maximum Force (Fm) : 15.570 kN
Disp. at Fm : 9.600 mm
Max. Disp. : 13.400 mm
Tensile Strength (Rm) : 0.549 kN/mm ²
Elongation : 8.720 %
Reduction in Area (Z) : 77.196 %
Yield Load : 15.570 kN
Yield Stress : 0.549 kN/mm ²
YS/UTS Ratio : 1.000
* Note : Yield Calculated from graph

Graph : Load Vs Displacement

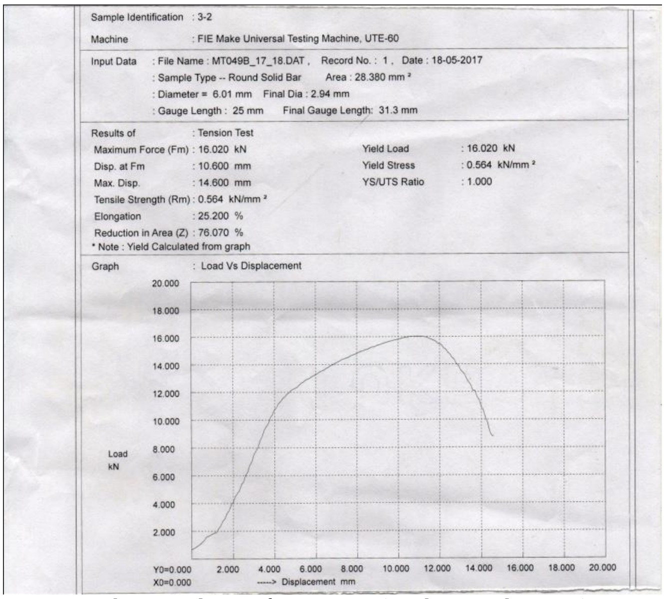
Graph 2. Tensile test of I D No. 7.2 (Load Vs Displacement).


Sample Identification : 3-1
Machine : FIE Make Universal Testing Machine, UTE-60
Input Data : File Name : MT049A_17_18.DAT , Record No. : 1 , Date : 18-05-2017
: Sample Type -- Round Solid Bar Area : 28.380 mm ²
: Diameter = 6.01 mm Final Dia : 3.19 mm
: Gauge Length : 25 mm Final Gauge Length: 30.86 mm

Results of : Tension Test
Maximum Force (Fm) : 16.680 kN
Disp. at Fm : 13.900 mm
Max. Disp. : 16.800 mm
Tensile Strength (Rm) : 0.588 kN/mm ²
Elongation : 23.440 %
Reduction in Area (Z) : 71.827 %
Yield Load : 16.680 kN
Yield Stress : 0.588 kN/mm ²
YS/UTS Ratio : 1.000
* Note : Yield Calculated from graph

Graph : Load Vs Displacement

Graph 3. Tensile test of I D No. 3.1 (Load Vs Displacement).


Sample Identification : 3-2
Machine : FIE Make Universal Testing Machine, UTE-60
Input Data : File Name : MT049B_17_18.DAT , Record No. : 1 , Date : 18-05-2017
: Sample Type -- Round Solid Bar Area : 28.380 mm ²
: Diameter = 6.01 mm Final Dia : 2.94 mm
: Gauge Length : 25 mm Final Gauge Length: 31.3 mm

Results of : Tension Test
Maximum Force (Fm) : 16.020 kN
Disp. at Fm : 10.600 mm
Max. Disp. : 14.600 mm
Tensile Strength (Rm) : 0.564 kN/mm ²
Elongation : 25.200 %
Reduction in Area (Z) : 76.070 %
Yield Load : 16.020 kN
Yield Stress : 0.564 kN/mm ²
YS/UTS Ratio : 1.000
* Note : Yield Calculated from graph

Graph : Load Vs Displacement

Graph 4. Tensile test of I D No. 3.2 (Load Vs Displacement).

VI. CONCLUSION

Thus the paper gives the characteristics of dissimilar metal butt welding of materials SA213TP-347H with SA213-T23 using filler wire ER347H and ERNiCr3

a) The dissimilar joints made in orbital TIG were subjected to radiography testing and showed positive results.
b) The majority of the joints in the bend tests did not had any discontinuities open to its surface. This shows that the dissimilar joints made are having good ductility.
c) The tensile test shows that the failure of specimen occurred at the base metal, and it indicates the higher strength of weld metal than the base metal.

REFERENCES

[1] ASME SECTION II C
[2] ASTM A 213/213M-04b
[3] ASME SECTION IX
[4] AWS Volume IV
[5] Dissimilar metal failure analysis and development programe- by Electric Power Research Institute (EPRI) cs 4252 vol. 8.
[6] A Chandrasekara Rao and P Kumar, “Advanced materials for super critical boilers,” Paper presented in IIM Seminar, Frontier 2005 on 25.4.2006
[7] “Failure analysis of high temperature super heater tubes of pulverized coal fired power station,” paper submitted by Md.Mujibar Rahman & Ahmad Kamal Kadir on 14-15 Jan 2016.
[8] R. Viswanathan and W. T. Bakker, “Materials for Ultra super critical power plants, Boiler materials: Part 1 and Turbine materials: Part 2,” *Journal of Materials Engineering and Performance*, ASM, vol. 10, pp. 435-455, 2001.
[9] Jerzy Brozda, “Weldability,Characteristics and benefits of new generation creep-resistant steels and the properties of welded joints,” *Welding Journal*, vol. 18, issue 8, pp. 599-608, 2004.
[10] Lukkari, “Orbital TIG a great way to join pipes,” *Svetsaran*, vol. 60, no. 1, pp. 3-6, 2005.

O. K. Thirugnanasambandam and Dr. T. Senthil Kumar, “Effect of filler wire on properties of dissimilar welding of SA213TP-347H with SA213 T23,” *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 359-364, 2017.