IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 6 Ver. I (Nov- Dec. 2014), PP 01-04
www.iosrjournals.org

Weldability Analysis of T23 Material for Superheater Coil

N.Jeyaprakash[1], R. Prabhakaran[2], G. Murugesan[3]
[1]*(Asst.Professor,Department of Production Engineering,Defence University,Ethiopia,North Africa)*
[2]*(Engineer – Welding ,National Oil Well Varco,NOV India Pvt.Ltd,Chennai,India 600098)*
[3]*(Engineer – Welding ,Toshiba JSW Power Systems Pvt.Ltd,Chennai,India 600103)*

Abstract: *In Fossil power boiler, super heater coil type panel is employed to convert saturated steam to super heated steam. Generally these panels are made by formation of thick wall low alloy steel like STEEL ALLOY-213 TUBE-22 material. The power generating capacity of Fossil power boiler is 500 MW.This STEEL ALLOY-213 TUBE-22 material has low creep strength and it cannot withstand continuous high temperature to rectify the above problem, the usage of an alternate material called STEEL ALLOY-213 TUBE-23 was attempted.The welding operation has been carried out in super heater coil by Tungsten Inert Gas (TIG) welding and Sub-merged Arc Welding (SAW). The welding analysis in STEEL ALLOY-213 TUBE-22 and STEEL ALLOY-213 TUBE-23 materials was carried out by four types of mechanical tests namely Impact Test, Tensile Test, Bend Test and Hardness Test.From the obtained results of the mechanical tests, it can be concluded that STEEL ALLOY-213 TUBE-23 material is having better creep strength while compared with STEEL ALLOY-213 TUBE-22 material.*
Keywords: *Bend Test, Hardness Test, Impact Test, Sub merged arc welding, Tungsten Inert Gas Welding.*

I. Introduction

The steam temperatures of most efficient fossil power plants are the 600ºc which represents an increase of about 60ºc in 30 years. With the recent advancement and technologies, it is expected to be further increased by around 50-100ºc. The need for higher thermal efficiency in fossil fired power plants has led to number of new material developments during past 10 year, which allowed the effective realization of steam temperature as high as 625ºc during continuous operation.Ensuring higher steam parameters, however has also led to increasing requirements for the tube steels of super heater, which with can no longer be fulfilled with the previously used steels T12 or T22.

In addition to the higher creep rupture parameters, the construction of super heater also requires welding properties without the need for a post weld heat treatment (PWHT). These new requirements profiles lead to the development of the T23 steel. It proves not only suitable for being used as a super heater, but also offer favorable alternative 9% Cr martensitic steel.

The advantages of these new steels are therefore not only important for power plants with high steam parameters, but also for new facilities with conventional parameters. This T23 steel contains alloying additions such as niobium, vanadium, boron, tungsten etc; this work concentrates on the effect of various alloying elements present in the T23 steels for the microstructural development and the mechanical properties improvement in the weld metal. Various steels have been made over the T23 material and the results are compared with the existing steels. Based on the results various properties such creep, hardness, toughness, yield strength has been discussed to determine the effective suitability of T23 superheater steel component.

II. Experimental Procedure

Chemical composition:

Chemical composition of steel grade T23 as per ASME Code ASTM A213/2199 are compared In the table 1.1 to other standard steel grades (T22,T92) used for similar high temperature application.

To develop grade T23 the basic T22 grade was modified by addition of tungsten (1.6%) to reduction of molybdenum (0.2%) and carbon contents (0.04-0.10%) and small addition of vanadium, columbium(cb) nitrogen and boron. After proper heat treatment creep strength values and the resulting allowable stresses are greatly improved.

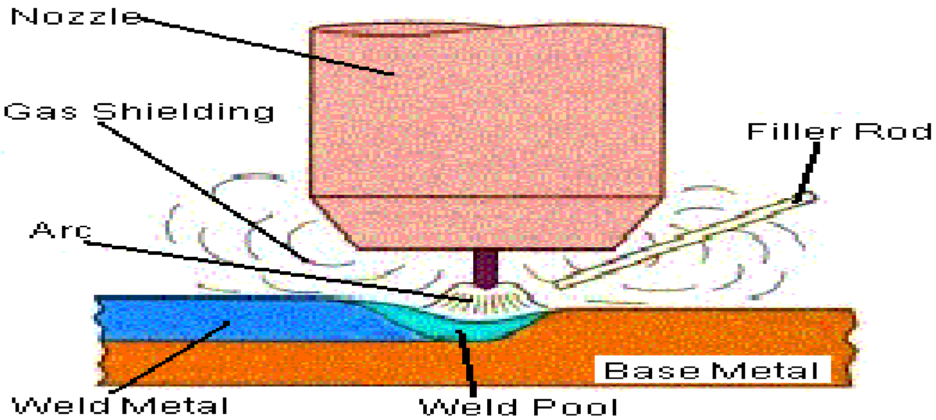
Table 1.1 Comparison of T22 with T23

spec	C%	Si%	Mn%	Cr%	Mo%	W%	V%	Nb%	B%	Al%	N%
T22	<=.15	0.25-1.0	0.3-0.6	1.9-2.6	0.87-1.13	--	--	--	--	--	--
T23	0.04-0.10	<=0.5	0.10-0.60	1.9-2.6	0.05-0.30	1.4-1.75	0.20-0.30	0.02-0.08	0.0005-0.0060	<=0.03	<=0.030

carbon content was intentionally lowered with regards to weldability are strictly limited to ensure consistent behavior during manufacturing and fabrication as well as uniform creep resistance.

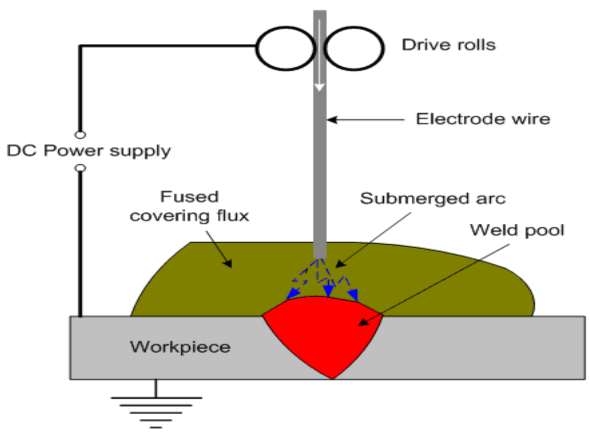
Tungsten Inert Gas Welding

This process is manually operated some times it is fully automatic. Here tungsten is used as a filler rod and argon gases such as helium are used. The arc starting is achieved by additional equipment called high frequency arc starter. The power source should be capable of giving uniform penetration in arc length and melting of the filler wire. The TIG welding as in the fig 1. is used filling root gaps for the pipes/tubes.



Sub-Merged Arc Welding

In the sub merged arc welding the end of the electrode arc is submerged in the flux and hence there is no visible sight of the arc. Welding current flow through the arc and the heat of the arc melts the electrodes, flux and some material to form a weld puddle that fills the joints. Sufficient depth of flux present in the process completely shields the arc column and protects the weld pool from atmospheric contamination. As a result of this unique protection, the weld beads are exceptionally smooth. The filler wire diameter varies from 2.0 mm to 6.3 mm. The SAW is carried out to join the dished ends with the header pipe. The submerged arc welding is shown in the fig 2.



PROPERTIES OF WELDING ELECTRODES

At first, a GTAW filler metal of the same composition was developed for the welding of these walled tubes for the construction of the super heater. In this case a PWHT can be waved, as the low carbon content prevents a hardness increase with values in excess of 350 Hv both in the weld metal and the HAZ. It could be proved that this material is also well suited for the heavy wall components.

Table.1.2

WELDING PROCESS	C %	SI %	MN %	CR %	NI %	MO %	V %	W %	NB %	N %
GTAW	0.08	0.27	0.54	2.14	0.04	0.08	0.21	1.58	0.031	0.001
SMAW	0.06	0.22	0.46	2.28	0.12	0.02	0.28	1.72	0.043	0.017

Mechanical Properties Of Filler Metals

Table 1.1 and 1.2 shows the chemical composition of matching filler metals and gives the mechanical properties for the various welding processes. In the pure GTA weld metal, the toughness with and without PWHT (750ºC) is above 200J depending on the diameter and the welding parameters. Hardness values amount to approximate 270HV without PWHT and to about 250HV after the performance of the PWHT. SWAW process must be followed by a PWHT at 740 ºC as otherwise the toughness will only reach about 20J. For welding higher thickness, it recommended to have root welding GTAW process.

Table 1.3

WELDING PROCESS	TEST TEMPERATURE (ºC)	PWHT (ºC/H)	Y.S (MPA)	T.S (MPA)	ELONGATON (%)
GTAW	+20	-	639	818	21.4
	+20	740/2	520	620	20.2
	+550	740/2	426	449	17.4
SMAW	+20	740/2	509	625	19
	+20	740/15	421	553	25
	+550	740/15	32	350	26.7

Impact Test On T23 Material
Test conducted at : Mechanical Testing Lab
Identification : T23
Type of test : Charpy V notch 2mm depth
Specimen size : 3 x 10 x 55 mm
Test temperature : 0 ºc

Impact Test On T22 Material
Test conducted at : Mechanical Testing Lab
Identification : T22
Type of test : Charpy V notch 2mm depth
Specimen size : 3 x 10 x 55 mm
Test temperature : 0 ºc

Table 1.4 Impact Test on T23 Material

Impact energy in joules
33
19
27
22
30

Table 1.5 Impact Test on T22 Material

Impact energy in joules
11
20
10
10
21

TENSILE TEST ON T23 MATERIAL
Test conducted at : Mechanical testing lab
Identification : T23STI & T23ST2
Room temperature : 25 ºc

TENSILE TEST ON T22 MATERIAL
Test conducted at : Mechanical Testing Lab
Identification : T22T1, T22T2
Test temperature : 25 ºc

Table 1.6 Tensile Test on T23 Material

Identification	Specimen size in mm	UTS in Mpa	Position of fracture
T23ST1	19.60X4.20	697	Base Metal
T23ST2	19.60X4.20	697	Base Metal

Table 1.7 Tensile Test on T22 Material

Identification	specimen size(mm)	UTS in MPa	Position of fracture
T22T1	19.60X3.60	658	Base metal
T22T2	19.70X3.80	636	Base metal

BEND TEST ON T23 MATERIAL
Test conducted at : Mechanical Testing Lab
Identification : T23FB1 & T23RB1
Mandrel diameter : 4t (t-thickness of specimen)
Specimen size : 3 mm x10 mm x 55 mm
Angel of bend : 180^0
Specimen size : 5 mm x 20 mm x 180 mm
Room temperature : 25 ^{0}C

BEND TEST ON T22 MATERIAL
Test conducted at : Mechanical Testing Lab
Identification : T22FB1, T22FB2
Mandrel diameter : 4t (t-thickness of specimen)
Specimen size : 3 mm x 10 mm x 55 mm
Angel of bend : 180^0
Specimen size : 5 mm x 20 mm x 180 mm
Room temperature : 25 ^{0}C

Table 1.8 Bend Test on T23 Material

Identification	Root bend	Face bend	Remark
T23FB1	-------------	No open discontinuity observed	passed
T23FB2	No open discontinuity observed	--------------	passed

Table 1.9 Bend Test on T22 Material

Identification	Root bend	Face bend	Remark
T22FB1	-------------	No open discontinuity observed	passed
T22FB2	No open discontinuity observed	--------------	passed

HARDNESS TEST ON T23 MATERIAL
Test conducted at : Mechanical Testing Lab
Identification : T1, T2
Room temperature : 25 ^{0}C

HARDNESS TEST ON T22 MATERIAL
Test conducted at : Mechanical Testing Lab
Identification : T1, T2
Room temperature : 25 ^{0}C

Table 1.10 Hardness Test on T23 Material

S.No	Hardness Value For IDFN.T1	Hardness Value For IDFN.T2
1	230	211
2	224	218
3	227	205

Table 1.11 Hardness Test on T22 Material

S.No	HARDNESS VALUE FOR IDFN.T1	HARDNESS VALUE FOR IDFN.T2
1	227	233
2	219	233
3	225	224

III. Conclusion

In this project studies has been carried out about the super heater coil used in fossil power boiler. The super heater made up of Steel Alloy 213 Tube 22 material. During the continuous operation this material cannot withstand high temperature. So efforts have been put in this project to replace Steel Alloy 213 Tube 22 material to newer material. It has been found that Steel Alloy 213 Tube 23 material have some special mechanical properties than Steel Alloy 213 Tube 22 material.

The mechanical tests like impact, tensile, bend and hardness has been carried out in Steel Alloy 213 Tube 22 and Steel Alloy 213 Tube 23 materials. The results confirm that Steel Alloy 213 Tube 23 material can withstand high load even in the high temperature than Steel Alloy 213 Tube 22 material.

Reference

[1]. K. Laha, K.S. Chandravathi, K. BhanuSankaraRao, and S.L.Mannan: Metall. Mater. Trans. A, 2001, vol. 32A, pp. 115–24.
[2]. M Barrie (1997) “Fabrication of steels for advanced power plant”, Mitsui Babcock Energy Ltd.,
[3]. A.K. Bhaduri, S. Venkadesan, and P. Rodriguez: Int. J. Pres. Ves.Pip., 1994, vol. 58, pp. 251–65.
[4]. M.F.Brady (1965) “Design aspects of once through systems for heat recovery steam generators for base load and cyclic operatio”, Innovate Steam Technologies Ltd.,
[5]. J.D. Parker: Mater. High Temp., 1994, vol. 11, pp. 25–33.
[6]. J.D. Parker and G.C. Stratford: J. Mater. Sci., 2000, vol. 35,pp. 4099–4107.
[7]. Y. Gong, J. Cao, L. Ji, C. Yang, C. Yao, Z. Yang, J. WangX. Luo, F. Gu, A. Qi, S. Ye, and Z. Hu: Fatigue Fract. Eng.Mater. Struct.,2011, vol. 34 (2), pp. 83–96.
[8]. M. Yamazaki, T. Watanabe, H. Hongo, and M. Tabuchi: J. Power Energy Systems, 2008, vol. 2 (4), pp. 1140–49.
[9]. J. An, H. Jing, G. Xiao, L. Zhao, and L. Xu: J. Mater. Eng. Perform., Nov. 6, 2010, online.
[10]. Gerhard Buschamann, Herbert Clemens, “The Steam Engine-Status of Development and Market Potential”.
[11]. F. Gauzziand S. Missori: J. Mater. Sci., 1988, vol. 23, pp. 782– 89.