Preparation of W.P.S for Stainless Steel Welding W.R.T Mechanical & Thermal Properties

M.Valliappan[1] P.Akilan[2]
[1, 2] Assistant Professor Department of Mechanical Engineering
[1]M.Kumarasamy College of Engineering, Karur
[2]Dhaanish Ahmed College Of Engineering, Chennai

Abstract—*Today Most commonly used materials in boiler, and also in boilers accessories are S.S which will operate under 700^{o}C with greater performance (creep strength, corrosion resistance) and reliability, especially for temperatures of 700-750^{o}C.The modern technology in welding of materials goes towards anti-corrosion, wear resistance to increase the service of a product. In S.S alloys, Ni content is very good against corrosion resistance; hence we have selected Stainless steel 321, 316 and 347 materials, Which consist of (Ni,Cr,Mo,Nb) widely used for Power piping in 800MW, 1000MW Boiler. In order to maintain the properties of material properties before and after welding, we have Prepared Welding Procedure Specification (WPS) based on the thermal and mechanical properties of materials.*

I. INTRODUCTION

This paper deals with the preparation of Welding procedure specification for SS welding by optimizing the existing WPS method with respect to mechanical and thermal properties. It also aims to reduce the creep, fatigue, Residual stress and thermal stresses in the Boiler materials by the application of stainless steel material and welding it.

Stainless steels are weld able materials and a welded joint can provide optimum corrosion resistance, strength and fabrication economy. However it may undergo certain changes during welding it is necessary to take care of welding to minimize the defects and to maintain the same strength and resistance in the weld zone that is an inherent part of base metal. Seamless Tubes of 316 and 347 and 321 plate materials having improved austenite stability. The stability of the austenite in Cr, Ni and Cr, Ni, Mo steels is achieved by increasing the nickel content over that of standard 18/8 Cr, Ni and 18/8/2 Cr, Ni, Mo steels, and more especially by additions of nitrogen, which is particularly effective in promoting the austenite stability.

The project starts with micro testing and chemical analysis of materials and preparation of WPS based on thermal and mechanical properties, finally calculating the strength of material and to replace the current boiler materials in to improved SS materials. In welding by controlling the parameters of thermal property mechanical deviations are reduced and so weld with fewer defects could be obtained and also the service life of material will be increased.

II. SS MATERIALS

In this paper we are going to weld the 321(Plate) of 5.6mm thick, by TIG and ARC similarly 316(Seamless Tube) of ϕ60.3mm, 6mm thick, 347 (Seamless Tube) of ϕ60.3mm, and 5mm thick by TIG and ARC. Welding is carried out by preparation of WPS under the Properties of the material. The main Purpose of the choosing the TIG and ARC welding is based on the material thickness apart from this TIG gives Higher Accuracy and ARC gives in vice versa. The main purpose of choosing Nb,Mo,Ti in Ni alloy combination is because SS 347 contains Nb which has high Creep Strength, where SS 316 consists of Mo, it has Fatigue strength, and 321 contains Ti which has high Ductility.

III. CHEMICAL & MICRO RESULT

SS321:

Grain	: FSS and ASS grains
ASME Grain Size	: No: 7

SS316:

Grain	: FSS and ASS grains
ASME Grain Size	: No: 7

SS347:

Grain	: Ferrite & Austenite grains
ASME Grain Size	: No: 8

IV. WPS (EXISTING METHOD)

The welding procedure form contains all of the essential information required to make the weld and verify the test result. This information may include the type of base and filler metals, welding process used, preheat, inter pass or post weld heat treatment shielding gases and so on.
(Ref. - Book-PQR, Chap 24. Page No 380)

Base metal
Filler metal
Position
Preheat
Electrical characteristics
Technique
Parameters
Joints

V. WPS (REVISED)

A. .TIG

Polarity
Composition
Color Code
Inert Gas

B. ARC

1) BASE METAL

Position
Edge preparation
Root Gap
Cleaning

2) ELECTRODE

Type
Diameter
Arc length
Coating

3) PROCESS

Polarity
Bead
Technique
Run
Speed
Pre heating
Post heating
Heat treatment

By optimizing the above mentioned parameters with existing W.P.S the strength of a material could be increased.

VI. NEED OF WPS

Welding could be done without preparation of WPS, but which may results in improper weld or with defects like weld decay, knife line attack and stress corrosion cracking. To avoid such cases WPS is followed in all industries .Sometimes

Improper welding will increase the strength due to this the life time of materials may be changed.

To overcome those weld defects WPS is optimized, use extra low carbon electrode, avoiding hylogen family

VII. WELDING PROCESS

Welding is carried out by following parameters based on
Polarity- Straight and Reverse
Position – Down hand, Vertical, Horizontal and 1G, 2G, 5G
Process – TIG and SMAW
Bead – Stinger and weaving
Technique - Forehand and Backhand
Speed – low and high
Edge preparation – based on angle (more than 75)
Root gap - based on thickness
Diameter of electrode – based on thermal conductivity
Arc length – shorter, longer and correct
Run – Longer, shorter, skipping, alternate skipping
Preheating – based on thickness of material

Hence based on the selection of methods from the above mentioned conditions welding could be carried out. In this, for each case of the above mentioned parameters certain methods are chosen according to AWS and WPS, so that welding could be achieved in a greater extent of accuracy.

VIII. PREHEATING & POST HEATING

Preheating is done under the Environmental condition by adjusting the current and voltage before welding, generally material with less thickness are not to be considered for pre heating and post heating will be carried out in case of any defects in the weld. Hence after welding heat treatment is required, to maintain the material strength.

A. Preheating Conditions:

For S.S chromium and nickel equivalent is very important and for other alloys carbon equivalent.

B. For Stainless Steel:

Chromium Equivalent = %Cr+%Mo+%1.5%Si+0.5%Nb
Nickel Equivalent = %Ni+30%C+0.5%Mn
Carbon Equivalent =%C + %Mn/4 = % Si/4 for carbon steel

Carbon Equivalent= %C+ %Mn/6 + %Cr/5 + %Ni/15 + %Mo/4 +%V/5 for AS and SS

CE <40	No preheating
CE= 40to70	Preheating 100-300˚c
CE>70	Welding is difficult

Preheating Temperature=1000[C -0.11] + (1.8*thickness) ˚F

Preheating Temperature:

P_1	t<19	nil
P_1	t>19	100-150˚c
P4	all	200-300˚c
P5	all	200-300˚c

IX. ELECTRODE (REF-A.W.S)

E 308	Corrosion resistant
E 316, 317, 330	High temperature strength
E 410, 420	Abrasion resistant

X. WELDING METALLURGY

Ref -ASME Section IX
Voltage: $V = 17.34 + 0.023I - 6.3*10^{-6}I^2$
Speed: $S = 1.6*10^6 I^{-6.38}$
Deposition
$Y = 1.5 + 0.17I + 0.000028I^2$
Q=VI / S (without heat transfer)
Q=VIη / S (with heat transfer)
Power Density Range:

SMAW	$5*10^6$ TO $5*10^8$ Watts /m^2
GMAW	SAME TO SMAW
PAW	$5*10^6$ TO $5*10^{10}$
EBW, LBW	10^{10} TO 10^{12}

Stress Analysis:
Stress due to Sustained load = 0.72 S_y
Stress due to Occasional load=0.80 S_y
S_y = Min Yield Strength of material
S_y = 0.6 to 0.7 of Tensile Strength
Stress due to Expansion load = E $\alpha\Delta T - \nu S_h$
E= young's modulus
α=Coefficient of linear expansion
ΔT=Change in temperature
ν=Poission's ratio
S_h=Hoop stress
Resultant Bending Stress = $(I_i M_i^2 + I_0 M_0^2)^{1/2}$ / Z
I_i=SIF at inplane
I_o=SIF at outplane
M_i=BM at inplane
M_0=BM at out Plane
Resultant Torsional Stress =
Z= Section Modulus
M_t=Torsional Bending Moment
Material: (AWS & ASME Sections)
Tensile Strength
=15.4(19.1+1.8%Mn+5.4%Si+0.025%pearlite+0.5d$^{-1/2}$)
Hardness Vickers test
= 90 + 1050%C + 45%Si + 97%Mn + 30%Cr + 31%Ni

XI. APPLICATIONS

Non-ferrous metals with high strength and toughness
Magnetic properties, nuclear power systems
Corrosion resistance, wear resistance
Aerospace aircraft gas turbines

Steam turbine power plants, medical applications
Chemical and petrochemical industries
Strength at elevated temperature.

Nickel- chromium alloys or alloys that contain more than about 15% cr are used to provide both oxidation and carburization resistance at temperatures exceeding 760°C.

XII. CONCLUSION

The various SS material was welded by TIG and ARC and finally the following test are carried out,
Hardness test
Impact test
Bend test

Tensile test, is carried out after welding to measure the strength of 321, 316, 347 which are compared with the reading from AWS, ASME and finally the suitable boiler material is analyzed. Thus optimization of welding process is also made by checking the strength of each material in different welds. Similarly reading from TIG and SMAW also compared for the three materials. Strength is calculated manually and compared with the ASME, WPS and AWS.

The main factor for choosing TIG and SMAW is, in boiler at higher altitude PAW, EBW, LBW and other type of welding could not be carried out and also it seems to be very expensive hence to overcome such cases TIG and SMAW is selected.

REFERENCES

[1] Parmar.R.S. “Welding Engineering and Technology”, Khanna publishers, Delhi. (1997is carried out by following
[2] Avanar “Material science Engineering”
[3] Dr.Srinivasan “Engineeering Materials”
[4] Peter Mayr , Stefan Mitsche, Horst Cerjak , Samuel M.allen “ The impact of weld metal creep strength on the overall creep strength of 9% Cr steel weldments” , Journal of engineering materials and technology , vol. 133(2011) .
[5] Nattaphon TAMMASOPHAN , weerasak HOMHRAJAI , Gobboon LOTHONGKUM “ Effect of post weld heat treatment on microstructure and hardness of TIG weldment between P22 and P91 steels With inconel 625 filler metal”, Journal of metals, materials and minerals , vol.21(2011) .
[6] SamsiahSulaiman “Structure of properties of the heat affected zone of P91 creep resistant steel”, Research work.
[7] Greg j. Nakoneczny ,carl c schultz “Life assessment of high temperature headers”, American power conference(1995).