DESIGN & DEVLOPMENT OF WELD PARAMETER FOR PRESSURE VESSEL of ASTM SA 516 Gr 70

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ABSTRACT

The main objective this technical paper presents is design & development of weld parameter for pressure vessel. Pressure vessel is subjected to many forces & stress due to high pressure rise is produced into the vessel. if the design is not proper it caused defects or failure into the fabrication of pressure vessel which deals with the large accidental incident in firms. So safety is taken as 1st concered about pressure vessel. Pressure vessel is designed accordance with the principles of American Society of Mechanical Engineers (A.S.M.E.) SEC VIII. Pressure vessel is checked accordance with the principles of American Society of Mechanical Engineers (A.S.M.E.) SEC VIII. Efforts are made in this paper for correction in weld parameter of pressure vessel accordance to follow ASME codes & standards for safety operation of pressure vessel.

Keywords: Design, Development, Pressure Vessel, Welding, ANSYS

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1. INTRODUCTION

Pressure vessels are those who subjected to serval types of forces & stress acting on both sides of the vessel i.e. inside & outside which caused the pressure difference produced. At this case pressure inside the vessel is always greater than pressure present at outside. This vessels are container, petroleum tanks, gas carrying pipelines, nozzles, heat exchangers, chemical reactor etc. at all this kind of pressure vessel operating liquid has many property which affects on to the design & fabrication of pressure vessel. The properties of liquid are corrosiveness, flammable, high operating temperature, nuclear material, the material whose phase change occurs into the vessel. Due to such critical operating condition design & fabrication of vessel is such that no defect into the joints of vessel & no leakages to avoid further accident due to the vessel.

In such case welding this is to be used for joining the various parts of pressure vessel play an important role. The various parameters of weld must be accordance with ASME codes & standards. The welding must be checked accordance with ASME codes & standards for safety & smooth operation of pressure vessel. Pressure vessel failure is a major issue for manufactures. This failure can be divided into various categories. The failure of the vessel depends upon –material, design, fabrication. Above parameter is not properly used which caused failure into the vessel. It is necessary for the pressure vessel joints to be filled with proper welding process & proper material used for joining these joints. Also it is necessary the welding parameter which is to set by a design department for specified pressure vessel. This parameter must be accordance with ASME codes & standards.

2. LITERATURE REVIEW

Various researches have been discussed for design & the parameter for welding. They are below

R. W. Hinton et.al. Studied theWelding Preheat Requirements for Unknown Grades of Carbon and Low Alloy Steels also provide the relation for calculating minimum preheat temperature.
Zhang Zet.al. The effect of the PWHT studied by the Norton creep law model. Results of this researchshow that the circumferential residual stress in blade was greater than the vertical residual stress. The residual stresses finally in the impeller are highly decreased by the PWHT.
Prof. Burkul R.Met.al. Studied effect of different welding speed on tensile strength, impact strength, distortions of weld joint at diff. groove angles & bevel heights. Also suggest good welding speed for max. tensile, impact strength& for mini. Hardness of heat affected zone.
Siva Krishna Raparlaet.al.carried out the researched for design & analysis of multilayeredhigh pressure vessels. The Ansys are used for analyzed multilayeredhigh pressure vessels& calculate stresses developed into the vessels.
Luis D. Cozzolino et.al. The mechanisms of post-weld rolling and how it reduces and eliminates residual stress and distortion are poorly understood. Finite element analysis was applied to two different methods of rolling: rolling the weld bead directly with a single roller and rolling beside the weld bead with a dual flat roller. The models showed that both rolling techniques were able to induce compressive stress into the weld region, which increased with rolling load. The distribution of stress was sensitive to the coefficients of friction between the workpiece and the roller and the backing bar. High friction coefficients concentrated the plastic deformation and compressive stress within the centre of the weld bead. Distortion can be eliminated by rolling; however, the experiments indicated that this was only achieved when applied to the weld bead directly.

3. PROBLEM STATEMENT

In this project the pressure vessel which is under study made up of carbon steel material & it made to handle for special purpose liquid which is at 3100(max value) operating pressure. Here the parameter which set by design department which caused various defects into the weld joints. this defect includes porosity, crack, lack of fusion, inclusion etc. this parameter is as follows:

1. Weld preparation (weld angel)
   The bevel used for welding is single V. the angle is throughout is 37.5degree.
2. Preheat temperature
   The preheat temperature is taken as 175-200 degree
3. Heat treatment& post weld heating temperature
   No interclass heating arrangement to be set for vessel & PWHT is 300 degrees
4. NDT testing stages
   NDT testing is to taken after complete welding of 80 mm.

4. CODE SELECTION

The various codes &standards are to use in the project. Reason behind using it to give quality assurance, performance, safety. ASME &EN these two are the major codes &standards used universally for pressure vessel. According to manufacture & buyer point of view ASME standards are used here.

ASME section VIII – Rules for construction of pressure vessels Div.1.
ASME section IX – Welding Qualification
ASME section V –Nondestructive testing

4.1 Design Considerations

- A pressure Vessel is designed to ASME Code Section VIII division I.
- A pressure Vessel welding is designed or done to ASME Code Section IX.
- A Safety Factor of "3"on Ultimate Tensile Strength is considered in the design of the shell only. For other parts the Factor of Safety is taken as "4" at room temperature.
- 100%. Joint efficiency for longitudinal seam on liner shell is taken.
- For longitudinal seam of liner shell should be100% radiography.
- Fully ultrasonic test for dished end plates is considered.
- Dished ends to be stress relieved after attachment of boss, nozzle etc.
- The longitudinal welds in a multilayered shell were staggered.

- 100% dye penetrate test for surface of weld is considered

5. METHODOLOGY

In above pressure vessel due to identified defects there was a necessity to adjust or correct the parameter. So, by study & experts guide line the parameter tobe set as follows

1. Weld preparation (weld angel)
   The bevel used for welding is doubled V. the angle is throughout is 30degree.

2. Preheat temperature
   The preheat temperature is taken as 225-250 degree
3. Post weld heating temperature
   PWHT is 350-375 degree
4. NDT testing stages
   NDT testing is to taken into 3 intervals & according to inspection flow chart which is to designed.

i. Material Selection
There are many materials available for pressure vessels. The material used for this vessel as follows,

Table -1 Material Used for P.V.

Head	ASTM 516/A516M
Shell	ASTM 516/A516M
Nozzle relieve Valve	ASTM 516/A516M
Pressure Gauge	ASTM 516/A516M
Drain	ASTM 516/A516M
Outlet	ASTM 516/A516M
Inlet	ASTM 516/A516M

ii. Material Composition
The composition for ASTM 516 Gr 70 material is as follows –

Table -2 Material Composition

Content	**Composition**
C	0.184
Si	0.29
Mn	1.14
P	0.019
S	0.0036
Al	0.029
V	0.007
Nb	0.002

Ti	0.004
Ni	0.012
Cr	0.038
Cu	0.011
Mo	0.003

iii. Shell Design

The maximum allowable working pressure or the mini. Thickness of cylindrical shells shall be the greater thickness or lesser pressure as given by eq. (a) or (b) as mention below

Circumferential stress

$$t = \frac{PR}{SE - 0.6P}$$

Longitudinal Stress

$$t = \frac{PR}{2SE + 0.4P}$$

iv. Design condition for shell

	SI		MKS	
P=Internal Pressure	3100	psi	21.37	Mpa
D=inside dia	29.13	inch	740	mm
S-allowable stress	16600	psi	114.45	Mpa
E=joint efficiency	1		1	
FOS	3		3	

Checking for 0.385SE

S=16600

E=1

0.385SE=6391>3100

$$t = \frac{PR}{SE - 0.6P}$$

$$t = 77.81$$

v. Design for minimum Preheat Temp.

Find carbon equivalent, CE_{IIW}

$CE_{IIW} = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15}$

$CE_{IIW} = 0.385$

The Skoda Method

$T_{PH} = 450\ °C \sqrt{CE_{IIW} - 0.42}$

$T_{PH} = 84.15\ °C$

6. INSPECTION RESULTS

NDT methods are used for inspection of pressure vessel. These methods are –DPT, MPT, UT RT. Inspection is done by ASNT level II qualified person & according to procedure.

Here the images for pressure vessels while inspecting vessel. Images includes before & after of weld parameter setting.

i. Before weld parameter setting

(A) **(B)**

(C) **(D)**

Fig.1. Inspection results of Ultrasonic Testing (A, B) & Liquid Penetrant Testing (C,D)

ii. After weld parameter setting

The flow diagram for inspection of pressure vessel is as follows. According this inspection is carried out.

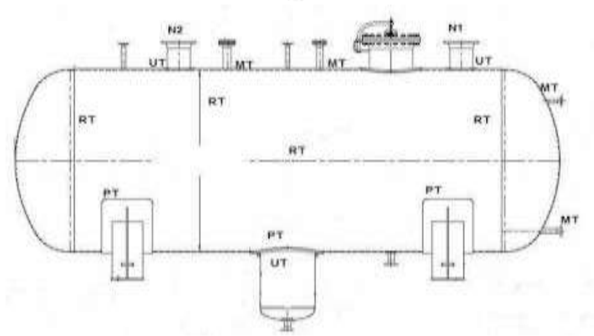

Fig.2. Inspection flow diagram for vessel

(E) **(F)**

Fig.3. Inspection results of UT (A) & MPI (B)

7. ANALYSIS RESULT

Analysis of pressure vessel is divided into 3 analyses in which 1st is related to overall pressure vessel & other 2nd is for weld zone. Above analysis includes 1) Temperature analysis 2) Structural analysis 3) Equilibrium or complete analysis

Ambient air temp.- 22°C

Convective heat transfer coeff. - 25 w/m^2°C

Conductive heat transfer coeff. - 18 w/m°C

i. Temperature analysis for welding

1. At 190 ℃ At 2.At250 ℃

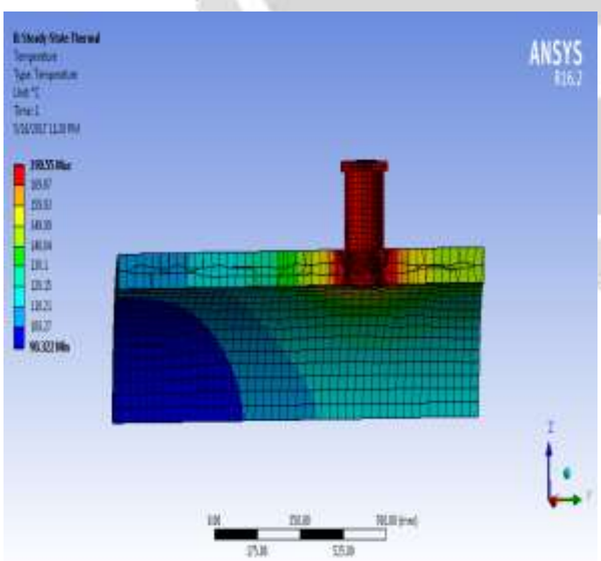

Fig.4. Temp.analysis at 190 ℃

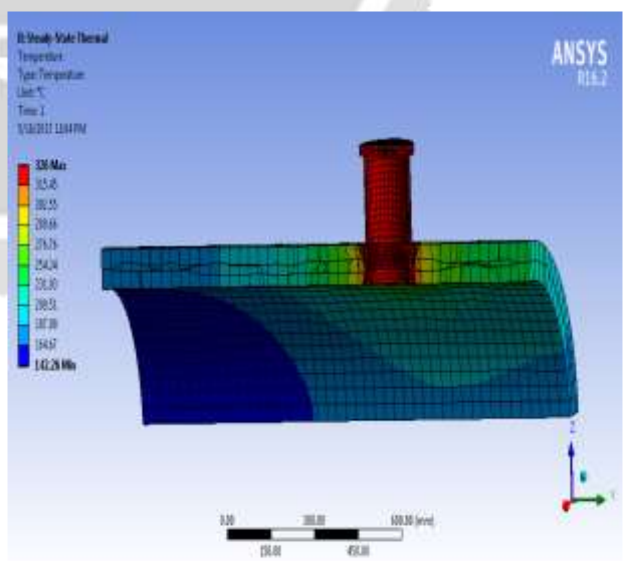

Fig.5. Temp.analysis at 250℃

3. at 300 ℃

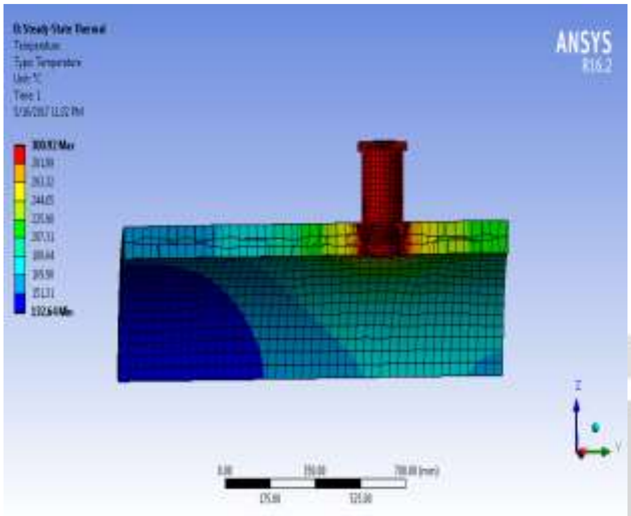

Fig.6.Temp.analysis at 300℃

4. At 350 ℃

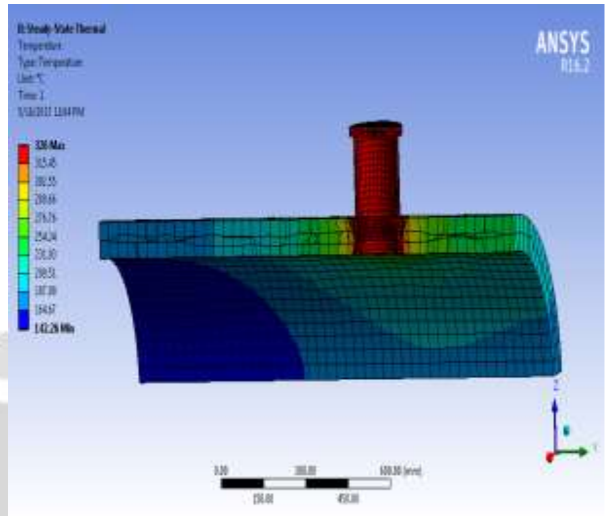

Fig.7. Temp.analysis at 350℃

ii. Structural analysis for welding
This analysis includes

Pressure +temp

Self-weight of P.V.

Calculating the value of Residual stress for preheats& post weld heating temp.

At 190 ℃

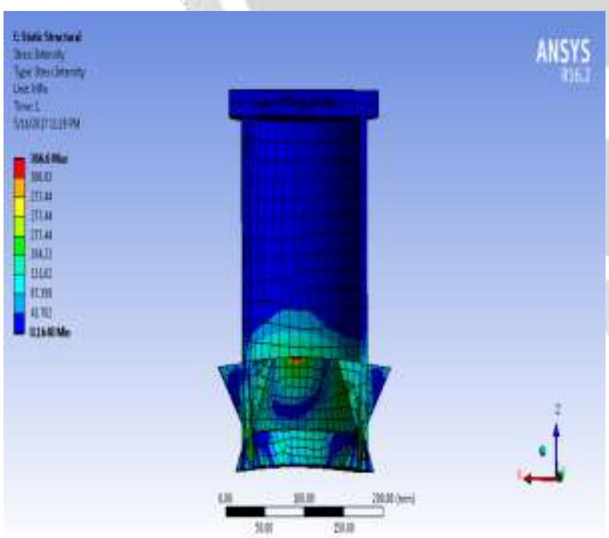

Fig.8. Residual stressesat190℃

At 250 ℃

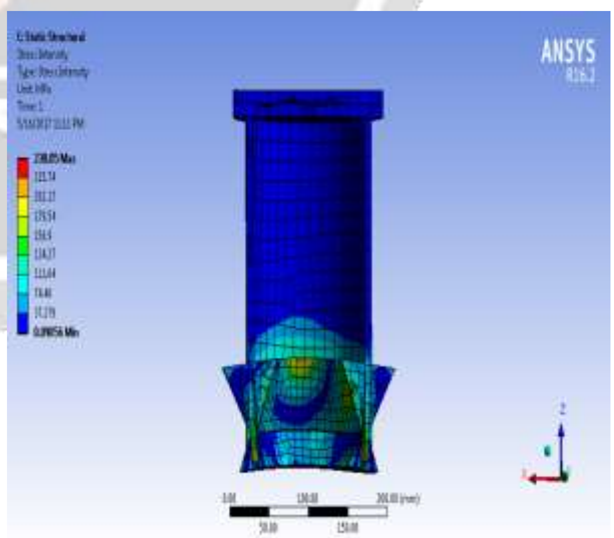

Fig.9.Residual stresses at 250℃

1. At 300 ℃ At 350 ℃

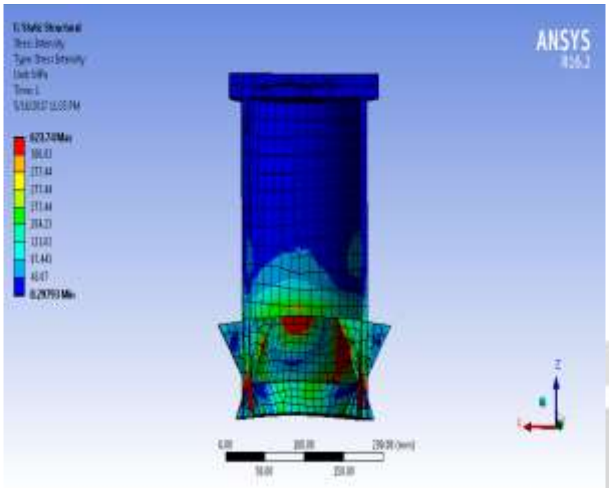

Fig.10.Residual stresses at 300℃

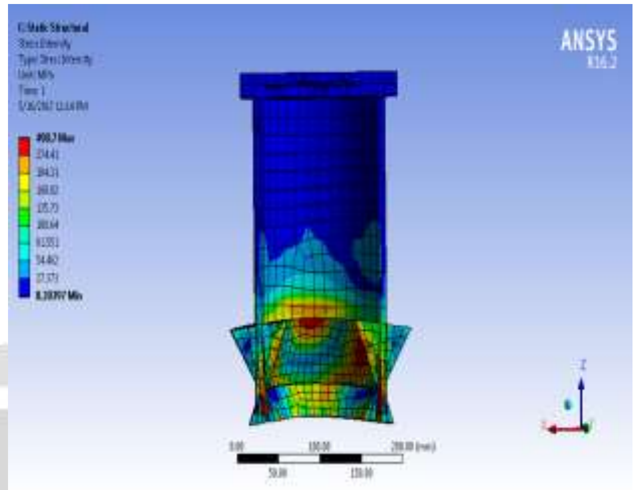

Fig.11.Residual stresses at 350℃

iii. Equilibrium or complete analysis

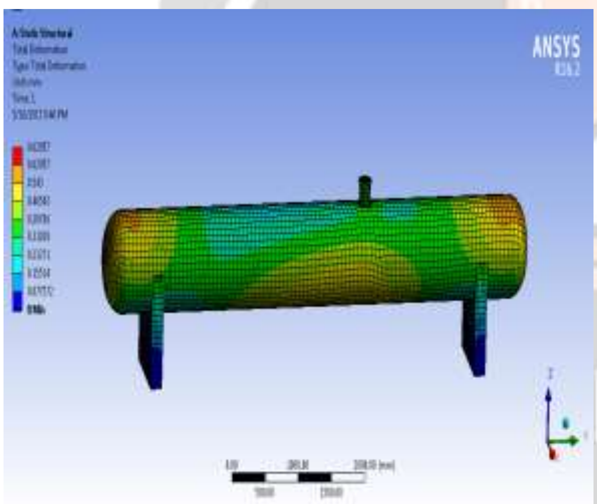

Fig.12.Total Deformation

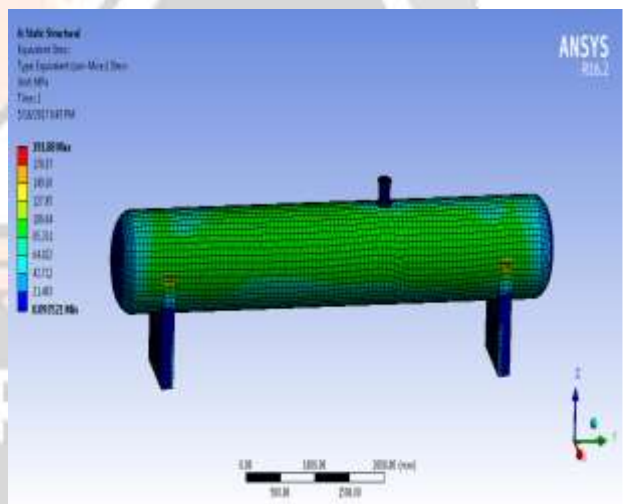

Fig.13.Equivalent (Von-Mises)stress

9. Result And Discussion

The welding parameter of pressure vessel of ASTM 516 Gr 70 is to be changed due to invalid defects are observed during inspection. For that we change that parameter by using analysis. When we reduced the bevel angle for 80 mm thick base metal the defects get reduced. The preheating & post weld heating shows that the value of residual stress are considerably get reduced .

Table -3 Result

Parameter	Old P.V. Design	Result	New P.V. Design	Result
Bevel Preparation	37.5^0 Single V	Defect observed during NDT testing	30^0 C Double V	No Defect observed during NDT testing
Preheat temp	190 ^{0}C	366.6 MPa (max)	250 ^{0}C	238.05 MPa (max)
POWH temp	250 ^{0}C	623.74 MPa (max)	350 ^{0}C	498.7 MPa (max)

9. CONCLUSION

In above pressure vessels of ASTM A516 Gr 70 are to under study.

- The parameter of vessel i.e. bevel angle, preheat, post weld heat & NDT inspection stages are to set & checked by using various inspection test.
- The defect are considerably get reduced or not goes to critical value after using that parameter.
- The analysis is to be done to vessel shows the temperature distribution over the vessel.
- The residual stress developed at preheat temp at 250°C is less than residual stress developed at preheat temp 190°C. This caused reduction in defect formation.
- The residual stress developed at PWHT temp at 350°C is less than residual stress developed at PWHT temp 300°C. This results stress relief into WZ, HAZ, BM.

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BIOGRAPHIES

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