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Design And Analysis Of Pressure Vessel

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ABSTRACT

This paper present design and analysis of pressure vessel. Design of pressure vessel depends on its pressure and temperature. When pressure and temperature get changed every pressure vessel is new. In pressure vessel design safety is the main consideration. The structural integrity of mechanical components of pressure vessel requires a fatigue analysis including thermal and stress analysis. Pressure vessel parameter are designed in Pv Elite and checked according to ASME (American society of mechanical engineering) sec. viii Div.1.Fatigue analysis also done on modeled in Pv Elite software to improve the life of pressure vessel. Pv Elite helps engineer to comply their design and calculation strictly as per code.

Keywords- **PV ELITE, Analysis, Design, Fatigue, Fatigue analysis, stress calculation.**

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I. INTRODUCTION

The term pressure vessel referred to those reservoirs or containers, which are subjected to internal or external pressure. The pressure vessels are used to store fluids under pressure. The fluid being stored may undergo a change of state inside vessels as in case of steam boilers or it may combine with other reagents as in chemical plants. High pressure is developed in pressure vessel so pressure vessel has to withstand several forces developed due to internal pressure, so selection of pressure vessel is most critical. ASME Sec.VIII div.1 is most widely used code for design & construction of pressure vessel.Div.1 does not consider harmonic analysis. Div.1 consider biaxial state of stress combined in accordance with maximum stress theory.When pressure of operating fluid increases, increase in thickness of vessel. This increase in thickness beyond a certain value possess fabrication difficulties and stronger material for vessel construction. The material of pressure vessel may be brittle such as cast iron or ductile such as mild steel. Failure in Pressure vessel occurs due to improper selection of material, defects in material, incorrect design data,design method, shop testing, improper or insufficient fabrication process including welding. To obtain safety of pressurevessel and to design Pressure vessel the selection of code is important. Corrosionallowance is the main consideration in vessel design. Corrosion occurring over the life of the vessel. During service, pressure vessel may be subjected to cyclic or repeated stresses. Fatigue in pressure vessel occurs due to:

a) Fluctuation of pressure
b) Temperature transients,
c) Restriction of expansion or contraction during normal temperature variations,
d) Forced vibrations,
e) Variation in external load

Fig.1 culindrical pressure vessel

II PROBLEM STATEMENT

A. Mechanical design for air receiver as per ASME Sec.VIII div.1 Air receiver is considered as a pressure vessel. In this

2000 liter Air Receiver Vessel is to be designed as per ASME sec Viii, Div-1

Table 1.list of code

Sr no.	ASME code	Description
1	ASME SEC II	Material specification
2	ASME SEC V	Nondestructive examination
3	ASME SEC VII Div.1	Rules for construction of pressure vessel

Design data

1. Internal Design pressure-3.846 Mpa.
2. Internal Operating pressure: - 3.5 Mpa.
3. Design temp.:-75 ˚C.
4. Operating temp:- 65℃.
5. Design No. of Cycles:- 50000
6. Inside Diameter:- 1260 mm
7. T/L – T/L :- 1316 mm.
8. Corrosion Allowance:- 1mm
9. Type of Heads:- 2:1 Ellipsoidal.

Table.1 Material of Construction

Sr no.	Item	Moc
1	Shell	SA-516 Gr .70
2	Head	SA-516 Gr .70
3	RF Pad/ Pad plates	SA-516 Gr .70
4	Nozzle Neck.	SA-105
5	Base Plate, web Plate, Rib plate	SA-36

1. Shell Thickness Calculation

tr: = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)

= (3.846*631.0000)/ (137.90*1.00-0.6*3.846)

= 17.9001 + 1.0000 = 18.9001 mm

Nominal Thickness:- 20 mm.

2. Dish end Thickness Calculation

Required Thickness due to Internal Pressure

tr: = (P*D*Kcor)/ (2*S*E-0.2*P) Appendix 1-4(c)

= (3.846*1262.0000*0.998)/ (2*137.90*1.00-0.2*3.846)

= 17.6125 + 1.0000 = 18.6125 mm.

Nominal Thickness:- 20 mm.

B. Analysis of pressure vessel by Pv Elite software

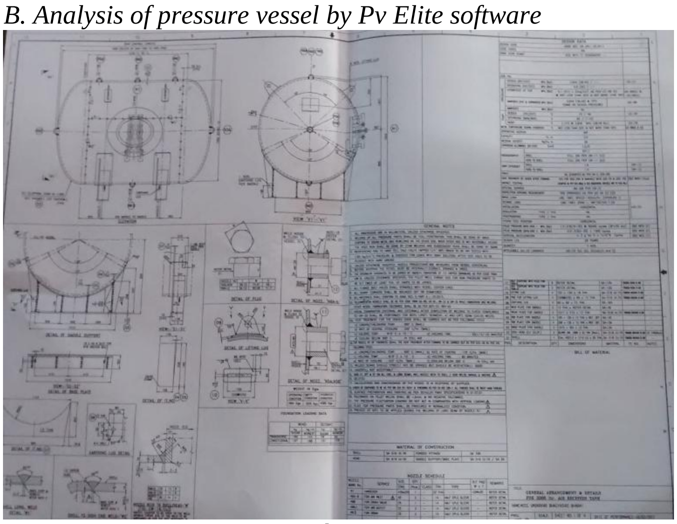

Fig.2. general arrangement

Overview of PV-Elite Software

PV Elite is specialized software used in Oil & Gas, Petrochemical refineries, pharmaceutical industries. It is the most popular & essential software for Pressure Vessel & Heat exchanger design and analysis. PV Elite consist of nineteen modules for design and analysis of pressure vessel and heat exchanger, and assessment for fitness for service. The software provides the mechanical engineer with easy-to-use, technically sound, well documented resulted. The generated report containsdetailed calculations and supporting comments that speed and simplify the task of vessel design, re-rating, or fitness for services.

PV Elite can Design and Analyse:

Pressure Vessels(Horizontal/Vertical),Vessel Supports/ Attachments, Column with internal trays, Heat Exchangers, Jacketed vessels, Limpeted vessels It is noteworthy to mention that PV-Elite Software is upgradable each and every time the Standard ASME Code is revised or amended. This feature helps engineers to comply their designs and calculationsstrictly as per the code. If any error, PV-Elite alerts on the same and does not process furthercalculations until the error is rectified. It also analyses the vessels for seismic & wind loads based on international standards & respective codes. It also has option to perform WRC Analysis for local attachments.PV elite development of air receiverto the scale geometrical model of 2000 Litre Air Receiver was modeled in PV Elite as per ASME standards and Design constraints & other respective parameters were applied to this model. Figure show model of 2000 Litre Air Receiver in PV Elite Software. PV Elite software has inbuilt option for Fatigue analysis in which load case values are to be entered as input to the software for performing fatigue analysis. Once the model is constructed in PV Elite itself. As shown in figure, referring to the 'Fatigue Pressure Cycle and UTS yield data' tab, values for load cases with respective number of cycles to analyse are to be entered. In our case Low Pressure of 1.5 MPa and High Pressure of 3.5 MPa is to be analysed for 50000 Nos. of cycles as seen in figure

Design parameters

Table 2.design parameters

Relevant Code for Analysis	ASME, Sec.VIII, Div.2 Ed.2013
Design Pressure	3.846 MPa
Operating Pressure	3.5 MPa
Corrosion Allowance	1 mm
Design no of cycles for shutdown case (1.5-3.5 MPa)	< 50000 Cycles

Table 3.Material Properties for Analysis

Material	Design temperature (o C)	Elastic Modulus (MPa)
SA 516 Gr 70	75	$199.33 * 10^3$
SA 105	75	$198.33 * 10^3$
SA 36	75	$199.33 * 10^3$

Poisson's Ratio for above materials is 0.3

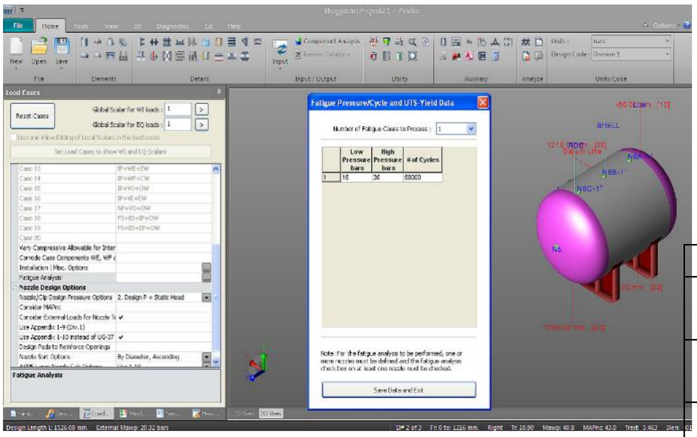

Fig.3 Analysis of air receiver in Pv Elite

After running the analysis, it was observed that nozzle N6-C is subjected to maximum stress with No. of cycles without fatigue failure less than that as compared to other Nozzles i.e. N1, N2, N3, N4, N5, N6-A, N6-B, N6C-1"

ITEM: Main Component: SHELL Nozzle: N6C-1"

Nozzle installed in: A Cylindrical Shell

Input Values: Pressure in bars

Table.4 Pressure range details for no. of cycles

Case	Pressure 1	Pressure 2	Range	Number of cycles
1	15.00	35.00	20.00	50000.00

Table.5 stress ranges

Longitudinal Plane			Transverse Plane	
Stress	Inside corner	Outside corner	Inside corner	Outside corner
sn	3.1000	1.2000	1.0000	2.1000
st	-.2000	1.0000	-.2000	2.6000
sr	-.0301	0.0000	-.0301	0.0000
s	3.3000	1.2000	1.2000	2.6000

Calculation for the First Pressure Range:

Compute Primary Membrane Stress [S]:

$= P / (E * \ln((2 * t + D) /(D)))$

$= 20.000/ (1.00*\ln ((2*19.000+1262.000)/ (1262.000)))$

= 67.4200 N./mm²

Sample calculation for the Intensified Stress Amplitude [Sa]:

= S * 3.3 / 2

= 67.420 * 3.3/2

= 111.2430 N./mm²

Stress Factor used to compute X [Y]:

= (Sa/Cus)(Efc/Et) Imperial Units 3.F.3

= (16.1/1)(28300000/28952368)

= 15.7703 ksi

$[X]:=(C1+C3*Y+C5*Y^2+C7*Y^3+C9*Y^4+C11*Y^5)/(1+C2*Y+C4*Y^2+C6*Y^3+C8*Y^4+C10*Y^5)$

= 5.4191

C Factors used in the above equation:

Table .6 values of factor C

C1 = 2.25451	C2= -464224	C3= -.831275	C4= -.0.863466E-01
C5= 0.202083	C6= -.694053E-02	C7= -.207973E-01	C8= -.0.201024E-03
C9=0.713772E-03	C10= -.0.00000	C11= -.0.00000	

From the table, EFc = 195128 N./mm²

Compute the Number of Cycles from Equation 3.F.1 [N]:

$= 10^X$

$= 10^{5.419}$

= 262492 Cycles

Case 1 Peak Stress: Adjusted below per above Pressure Index

Table. 7 Peak stresses

Longitudinal Plane			Transverse Plane	
Stress Inside corner		Outside corner	Inside corner	Outside corner
Sn 33.710	104.501	40.452	33.710	70.791
St 33.710	-6.742	33.710	-6.742	87.646
Sr 33.710	-1.015	0.000	-1.015	0.000
Sint 33.710	111.243	40.452	40.452	87.646

Table 8. Result of N6C

Sr no.	Streses intens	N cycles	Nmax cycles	Damage factor
1	111.243	50000	0.2625E+06	0.190

Total: Damage Factor: 0.190

Fatigue Analysis Passed: Damage Factor < 1.00

Hence, Design is safe for pressure cycle 1.5 MPa to 3.5 MPa for designed 50000 number of Cycles.

1) Fatigue Analysis is said to be passed since Damage Factor <1.00

2) Hence, Design is safe for pressure cycle 1.5 MPa to 3.5 MPa for designed 50000 number of cycles.

. CONCLUSION

1. Fatigue analysis will be carried out for entire equipment for specified regeneration cycles and we will found fatigue life more than required cycles.

2. Accordingly we conclude that all evaluation points for fatigue are within allowable limits specified by code. The maximum fatigue damage fraction observed which less than unity as required by code.

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