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Fatigue Analysis of Pressure Vessel Validation with FEA and Pv Elite Software

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ABSTRACT*:*The significance of the title of the project comes to front with designing structure of the pressure vessel for static loading and its assessment by Ansys, is basically a project concerned with design of different pressure vessel elements such as shell, Dishend, operating manhole, support leg based on standards and codes; and evolution of shell and dish end analyzed by means of ansys. The key feature included in the project is to check the behavior of pressure vessel in case of fluctuating loads. The procedural step includes various aspects such as selecting the material based on ASME codes, and then designing on the standards procedures with referring standard manuals based on ASME. Further we have included the different manufacturing methods practice by the industries and different aspects of it. And step by step approaches to the NDT method practice by the industries followed with standards and also included within the report work. This will be making a clear picture of this method among the reader. Conclusively, this method of design based on technical standard and codes, can be employed on practical design of pressure vessel as per required by the industry or the problem statement given associated to the field of pressure vessel.

KEYWORDS: Fluctuating loading, ASME, Ansys.

I. INTRODUCTION

This project focus on design and analysis of the 2000 Litres Air Receiver.

There are various code for pressure vessel design and construction like ASME Sec.VIII, IS 2825, PD 5500, EN 12445. In general thecylindrical shell is made up of a uniform thickness which is determined by maximum circumferential stress due to internal pressure; since the longitudinal stress is only half of this circumferential stress.

With the help of Finite element analysis we can study actual stress distributions in different components of pressure vessel and the actual behaviour of pressure 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 loads.

Problem Definition

The most important one is that the given geometry of pressure vessel must be analysed to assure it meet the design standards, design of pressure vessel is required to meet an acceptable stresses and to determine fatigue life of vessel.

Objectives

i. Design a pressure vessel (Air Receiver) as per ASME Sec. VIII code.

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ii. Determine the geometrical parameters used to design pressure vessel as per ASME code so as to get optimum design.

iii. For analysis after valid design, study the different methods and select optimum method for analysis.

iv. Using optimum method to analyse the pressure vessel having different outputs like stresses, no. of cycles etc. within the allowable range.

v. Verify these outputs by another suitable method / software for safe design.

Scope

The scope of this project is to set a basis for designing geometry of 2000L Air Receiver subjected to cyclic pressure loadings and conducting analysis on the derived geometry for Fatigue Failure so as to determine Fatigue life and Damage Factor of the Receiver following ASME standard code rules and also using advanced design software PV Elite and Ansys for Analysis.

II. METHODOLOGY

1) Definition of problem: Design and fatigue analysis air receiver as per ASME sec. VIII code in order to have safe design.

2) Study the literature available on design and fatigue analysis of pressure vessel having different considerations.

3) Next step is design of air receiver as per process requirements as per ASME code and define the parameters of it according to it.

4) After designing or defining all parameters of air receiver, next step is to analyse it for fatigue stress by using FEA techniques. For it, ANSYS software method is selected as optimum method among different methods of analysis.

5) After getting optimum solutions in terms o output like maximum stresses, no. of cycles etc. this solution is to be verifying using another method in order to have safe design.

6) For this validation, PV Elite software is used to verify the results of ANSYS
7) If the results of both softwares are not matching then we have to check the inputting of correct parameters in both the softwares and make suitable changes.

8) If the results are close to each other then the solution obtained is optimum and design is safe is ensured.

Modes of Analysis

The stress analysis can be done by Different modes or ways. Out of which the best one suitable for the project is to be selected as per the conditions.

Following are the different modes of analysis.

1) Numerical method

2) FEA softwares

3) Experimental analysis

Finite Element Model is based on 3D CAD model of 2000L air receiver, consisting of Shell, Dish ends, Nozzles, Lugs & saddle supports. The 3D geometry is meshed using Solid 187 having element size of25mm.

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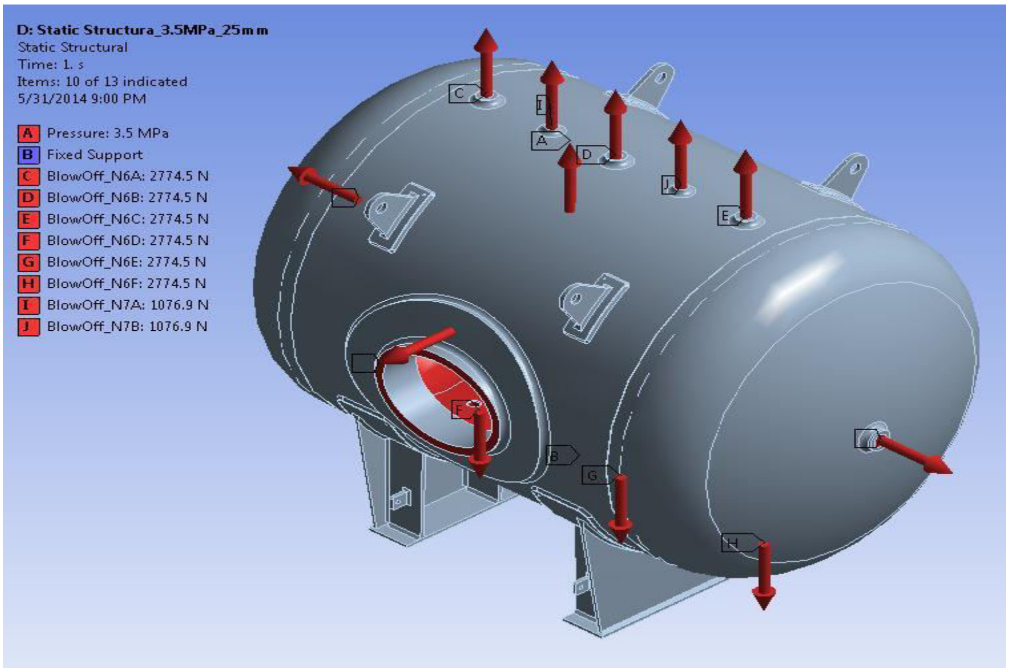
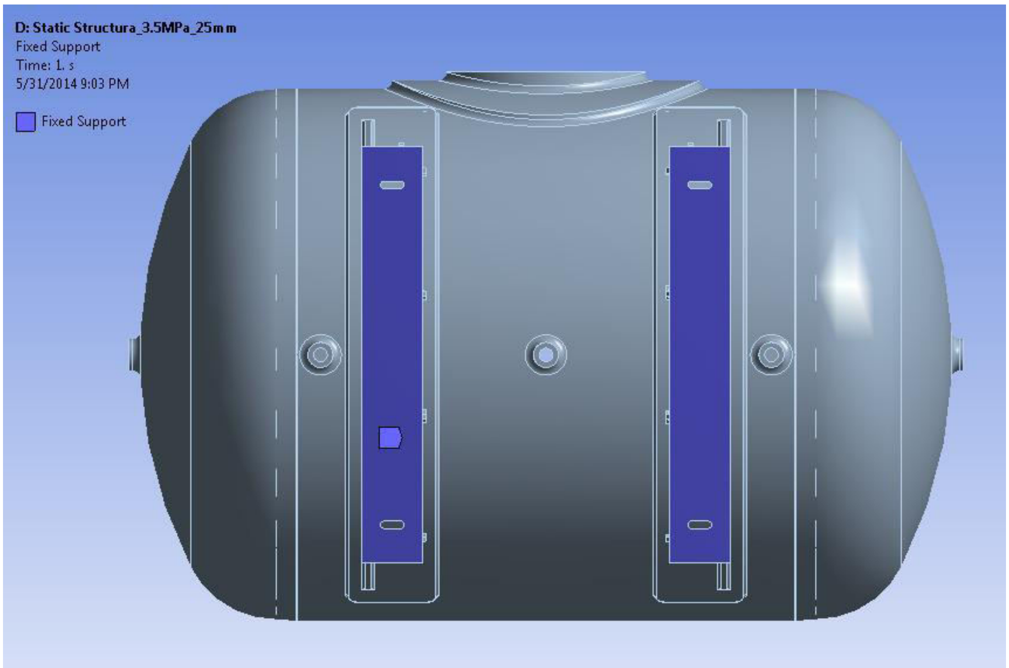
Loadings.
Loading – 3.5 MPa Internal Pressure.

Internal Pressure for 3.5 MPa – Internal Pressure of 3.5 MPa is applied as a surface load on all internal pressure retaining surfaces of the air receiver.Loads on Nozzles – Nozzles are subject to blow off pressure loads on their respective flanges or surfaces. The load acts in direction outwards to the nozzle flange.





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Boundary Conditions

The bottom surface of saddle has fully constrained boundary condition.

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 (0- 3.5 MPa)	< 1000 Cycles

Material of Construction

Components	Material Grade
Shell, Dish end, Lifting Lug, Lifting Lug Pad & Wear Plate for Saddle	SA 516 Gr 70
Half Coupling with Plug	SA 105
Base Plate, Rib Plate, Web Plate, Washer, Bottom Plate for Saddle,	SA 36

Material Properties

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

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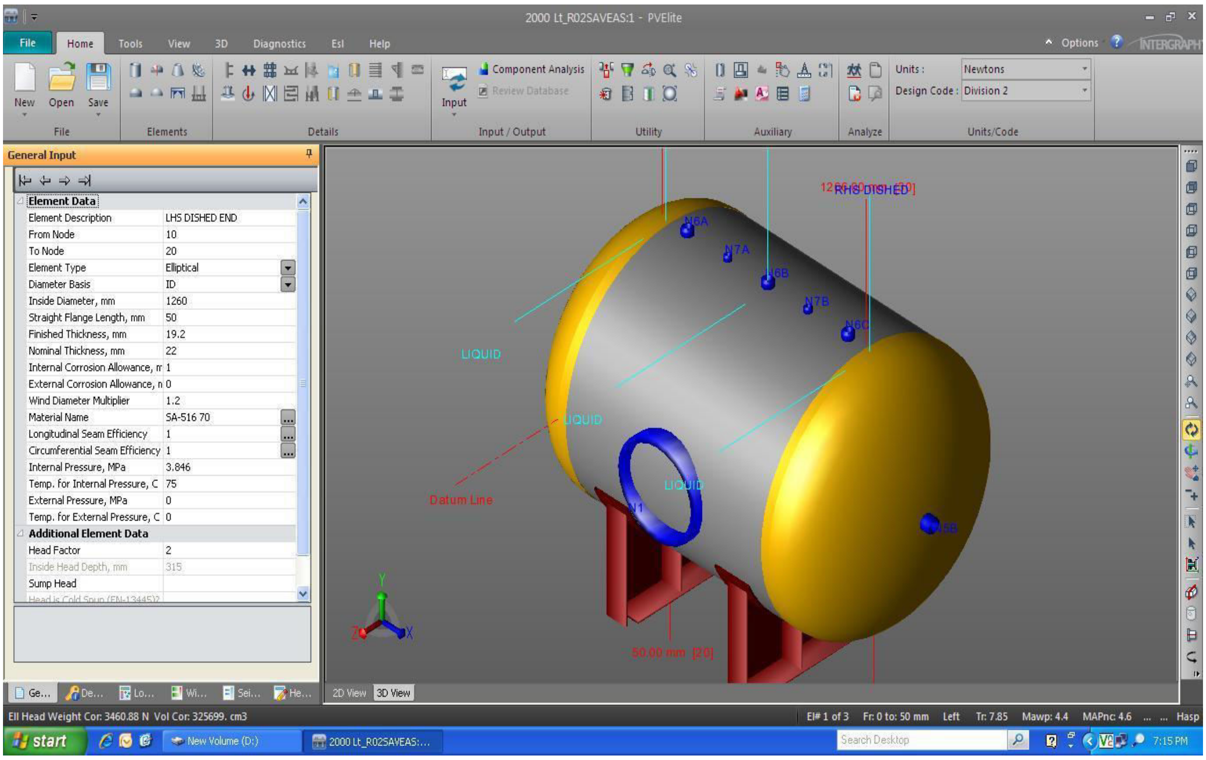
III. VALIDATION

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

Methodology

To 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 5.1 show model of 2000 Litre Air Receiver in PV Elite Software.



IV. CONCLUSION

1. The fatigue strength of vessel is usually governed by the fatigue strength of particular features such as welds, nozzles or other structural discontinuities (e.g. Cone to cylinder junction, knuckles, etc.). It is often necessary to analyse number of these features to determine which will control the failure life but is usually around the nozzles that the higher stresses occur.

2. Fatigue analysis is carried out for entire equipment for specified regeneration cycles and found fatigue life more than required cycles.

3. Accordingly we conclude that all evaluation points for fatigue are within allowable limits specified by code.

4. The maximum fatigue damage factor observed is less than unity as required by code.

5. The damage factor determined from both software are nearly same.

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FUTURER SCOPE

Analysis has been done for Load Case of Shutdown pressure cycles. This study could be extended to analyse Fatigue failure of vessel for Load Case of Fluctuating Operating condition pressure cycles also.

This study could also be extended to analyse Fatigue failure of vessel under combined loadings. i.e. Pressure fluctuation loadings acting simultaneously with vertical acceleration loadings (harmonic vibrations).

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