Quantifying the Role of Stiffener Rings in Pressure Vessels using FEA

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Abstract— **Stiffener rings are a popular way of controlling stress in certain locations of the pressure vessels. They prove to be cost effective and are relatively easy to assembly. However the role they play in structural stability is unclear especially when they are located near a nozzle. The discontinuity in stress generated by the nozzle opening is going to affect the stability and the presence of a stiffener rings may balance it. The stiffener rings are to be designed and checked as per ASME standard. Plant safety and integrity are of fundamental concern in stiffener ring design and these of course depend on the adequacy of design code. The objective of the project is to understand the role that stiffener ring play and try and quantify it into a parameter so that future designs may incorporate them.**

Index Terms— **ASME Codes & Standards, FEA, Pressure Vessel Design, Stiffener ring.**

I. INTRODUCTION

Tanks, vessel and pipelines that carry, store or receive fluids are called pressure vessel. A pressure vessel is defined as a container with a pressure differential between inside and outside. The inside pressure is usually higher than the outside. The fluid inside the vessel may undergo a change in state as in the case of steam boiler or may combine with other reagent as in the case of chemical reactor. Pressure vessel often has a combination of high pressure together with high temperature and in some cases flammable fluids or highly radioactive material. Because of such hazards it is imperative that the design be such that no leakage can occur. In addition vessel has to be design carefully to cope with the operating temperature and pressure.

In pressure vessels, nozzles are required for inlet and outlet of fluid. Pressure vessels find wide applications in thermal and nuclear power plants, process and chemical industries, in space and ocean depths, and fluid supply systems in industries. Due to practical requirements, pressure vessels are often equipped with nozzles and stiffeners of various shapes, sizes and positions, at various angles. A nozzle is a cylindrical component that penetrates the shell or heads of a pressure vessel.

II. PROBLEM DEFINITION

A pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. In pressure vessels, stiffener rings and nozzles are required for inlet and outlet of fluid.

Stiffener rings are a popular way of controlling stress in certain locations of the pressure vessel. They prove to be cost effective and are relatively easy to assembly. Stiffening-rings have mainly been one of the best solutions for reducing the thickness of cylindrical shells under external and internal pressure and to stop the buckling of the shells subjected to external pressure. The greater the number of suitable rings, the lower the shell thickness required to resist internal and external pressure.

However the role they play in the structural stability is unclear especially when they are located near a nozzle. The discontinuity in stress generated by the nozzle opening is going to affect the stability and the presence of a stiffener ring may balance it.

III. OBJECTIVES

The objective of present study is to make thickness optimization of stiffener ring such that which will lead to understand the role in pressure vessel.

After making the thickness optimization of stiffener ring by means of ASME Code & analytical calculations its induced von-mises stress &deformation is to be analyzed by using structural & thermal analysis in ANSYS 15.0 version. An ANSYS result is needed to be verified with the experimental results for validation purpose.

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IV. MATERIAL PROPERTIES

Material used for pressure vessel is **SA 516 Grade 70** (Carbon steel plate).

Description	Values
Material	SA 516 Grade 70
Modulus of elasticity	200 GPa
Poisson’s ratio	0.29
Allowed stress	137.8951Mpa

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V. DESIGN PARAMETERS

Design parameters for pressure vessel

Sr. No.	Parameter Description	Given Value
1	Internal Pressure	0.2 MPa
2	External Pressure	Atmospheric
3	Process Volume	100 cu m
4	Expected Stagnant Volume	10 cu m
5	Buffer Volume Requirement	10 cu m
6	Vessel radius	2 m
7	Temperature	500 C
8	Nozzle Diameter	0.05 m
9	Number of nozzles = 4	4
10	Head type	Hemispherical
11	Support	Saddle
12	Support Ht	1.2 m

VI. MODELING OF PRESSURE VESSEL

For this study model is created using ANSYS 15 work bench to represent pressure vessel. It includes shell, head, support, stiffener ring, and nozzle.

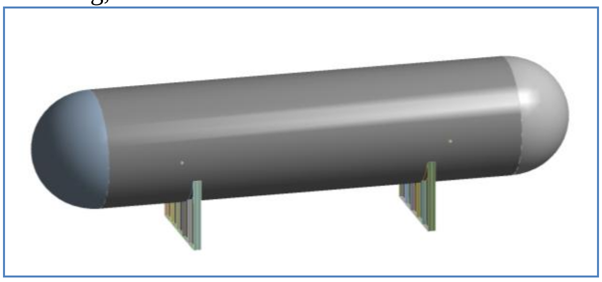

Fig1.Model of pressure vessel

VII. FINITE ELEMENT ANALYSIS

Finite element analysis is a technique, which discretizes the model into finite number of elements and nodes. It is actually a numerical method employed for the solution of structures or a complex region defining a continuum. This is an alternative to analytical methods that are used for getting exact solution of analysis problems.

To apply boundary condition on pressure vessel and take result

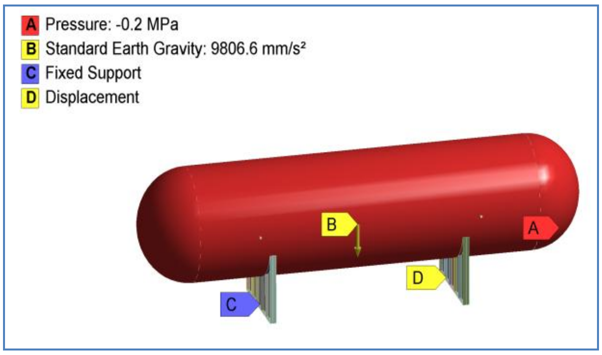

Fig.2 Dead weight loading conditions

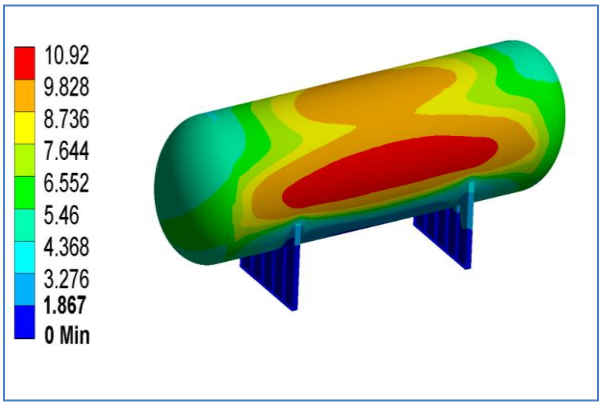

Fig3.Total deformation (DWC) = 10.92mm

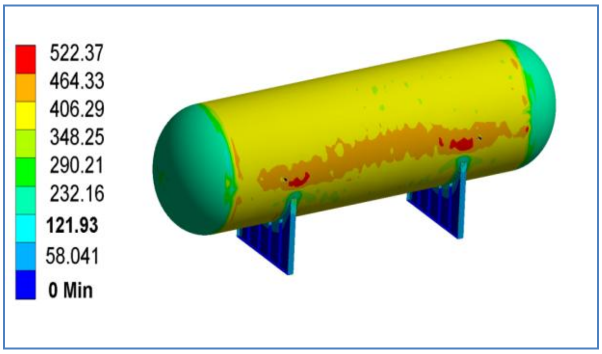

Fig4.Equivalent stress (DWS) = 522.37 MPa

Sr. no.	Max Total Deformation	Max Von-Mises Stress	Max Allowable Von-Mises Stress	Remark
1	10.92 mm	522.37 MPa	411 MPa	Fail

VIII. OPTIMIZATION

From the above results we have seen that Max total deformation and allowable stress is more. So there is need to minimize that value by adding stiffener ring on the pressure vessel.

Following results are taken by increasing thickness of stiffener ring from 20mm to 50 mm and nozzle thickness from 6 mm to 12 mm.

Case1: Nozzle Thickness-6mm & Stiffener ring-20mm

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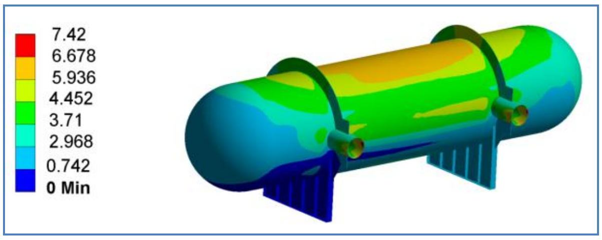

Fig.5 Total deformation = 7.42 mm

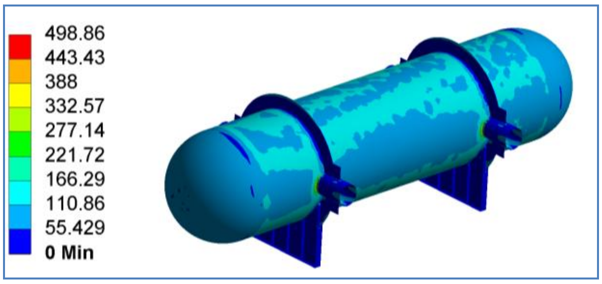

Fig. 6 Equivalent stress = 498.86 MPa

Case2: Nozzle Thickness-8mm & Stiffener ring-30mm

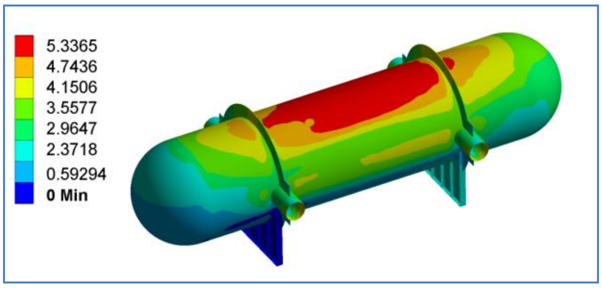

Fig.7 Total deformation = 5.33 mm

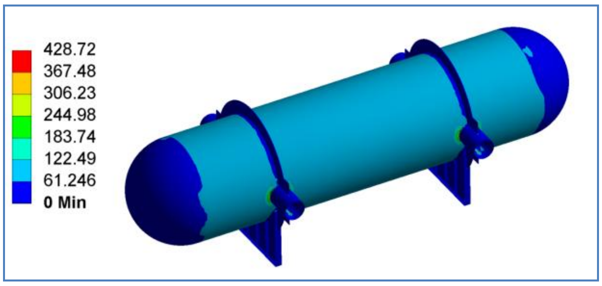

Fig. 8 Equivalent stress = 428.72 MPa

Case3: Nozzle Thickness-10mm & Stiffener ring-40mm

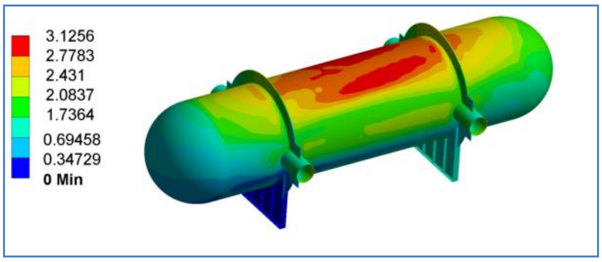

Fig.9 Total deformation = 3.12 mm

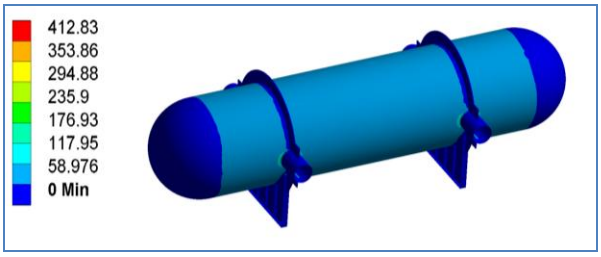

Fig. 10 Equivalent stress = 412.83 MPa

Case4: Nozzle Thickness-12mm & Stiffener ring-50mm

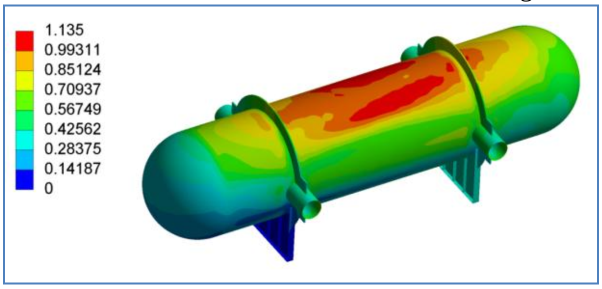

Fig.11 Total deformation = 1.135 mm

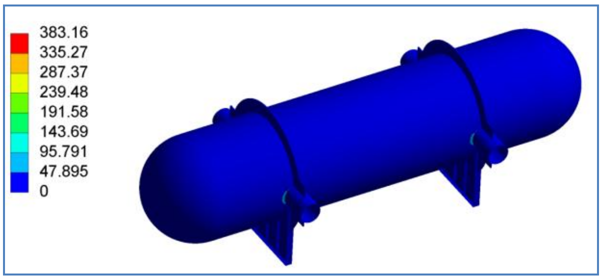

Fig. 12 Equivalent stress = 383.16 MPa

IX. RESULTS DISCUSSION

Case No.	Stress (MPa)	Deformation (mm)	Allowable Stress (MPa)	Optimize nozzle thickness (mm)	Optimize Stiffener ring thickness (mm)	Remark
1	498.86	7.42	411	6	20	FAIL
2	428.72	5.33	411	8	30	FAIL
3	412.83	3.12	411	10	40	FAIL
4	383.16	1.13	411	12	50	SAFE

X. CONCLUSION

This paper outlines FEA analysis proving that deformation stress in pressure vessel is more so there is requirement of stiffener ring or to increase thickness of the shell. Increasing thickness will result in increase in cost and also increase in weight, so to optimize this design implementation of stiffener ring is preferred.

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