

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

Design Optimization of Ammonia Bullet Pressure Vessel

Salman P H¹, Dr.S.Sankar², Sabarish C S³, Tedy Thomas⁴

PG Student, Dept. of Mechanical Engineering, Nehru College Of Engineering and Research Centre, Thrissur,
Kerala,India¹

HOD, Dept. of Mechanical Engineering, Nehru college of engineering and Research Centre, Thrissur, Kerala, India²

Assistant Professor, Dept. of Mechanical Engineering, Nehru college of engineering and Research Centre, Thrissur,
Kerala, India³

Assistant Professor, Dept. of Mechanical Engineering, Nehru college of engineering and Research Centre, Thrissur,
Kerala, India⁴

ABSTRACT: Ammonia is the basic raw material which is widely used throughout the world for the production for fertilizers and petroleum products. In order to achieve its extensive requirement it is being imported from foreign countries. Ammonia is transported by means of waterways due to the risk involved in other means of transport. It is stored and transported in pressure vessels. Due to high toxicity involved in Ammonia it is to be handled very carefully. A pressure vessel is a container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. These pressure vessels need to be safe and should withstand any external or internal impact. Pressure vessels are designed according to ASME Boiler & Pressure Vessel Code, Section VIII, Division I. Here an alternative solution to withstand any accidental external impact on the pressure vessel which results in more safety is proposed. An existing design of pressure vessel is modelled in Solid Works 2016 Edition and analyzed the same in Ansys 15.0. Afterward a new model of pressure vessel which includes an internal design change where a 10 mm thickness of Silicon Rubber is installed is designed. The same is analysed with an external point load of 20KN and results are compared with the existing one. Two different materials such as SA 537 and Stainless steel 302 are analysed in order to find out the best suitable one for the shell of the pressure vessel. The compared results include static structural, modal and harmonic analysis. From the results it can be concluded that pressure vessel with silicon rubber introduced is the best choice for advanced safety in ammonia transportation.

KEYWORDS: Pressure vessel, Stainless steel 302, SA 537, Silicon rubber.

I. INTRODUCTION

Tanks, vessels and pipelines that carry, store or receive fluids are called pressure vessels. 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 vessels often have 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, a vessel has to be designed carefully to cope with the operating temperature and pressure. Pressure vessels are usually spherical or cylindrical with dome ends. Cylindrical vessels are generally preferred because of the present simple manufacturing problem and make better use of the available space. Boilers, heat exchangers, chemical reactors and so on, are generally cylindrical. Many pressure vessels are made of steel. To manufacture a cylindrical or spherical pressure vessel, rolled and possibly forged parts would have to be welded together. Some mechanical properties of steel, achieved by rolling or forging, could be adversely affected by welding, unless special precautions are taken. In addition to adequate mechanical strength, current standards dictate the

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

use of steel with a high impact resistance, especially for vessels used in low temperatures. In applications where carbon steel would suffer corrosion, special corrosion resistant material should also be used. Some pressure vessels are made of composite materials, such as filament wound composite using carbon fiber held in place with a polymer. Due to the very high tensile strength of carbon fiber these vessels can be very light, but are much more difficult to manufacture. The composite material may be wound around a metal liner, forming a composite overwrapped pressure vessel.

II. DESIGN PROCEDURE

This section deals with the analysis of the designed model. The model that is in STEP format is analysed. Static structural analysis of three models such as existing model, modified model and a comparison model of pressure vessel is performed by applying the working load and number of supports used is one and that of displacements is two. The model is imported to Ansys and meshing is performed. The mesh size used is 30 mm. From the results obtained an optimal design is selected. Suitable materials are applied to the pressure vessel and modal analysis is performed. Different softwares such as Comsol, Radioss solver, Abaqus, Hypermesh, Ansys etc. are used for analysis. In this project Ansys R15.0 is used for design analysis.

Design of pressure vessel

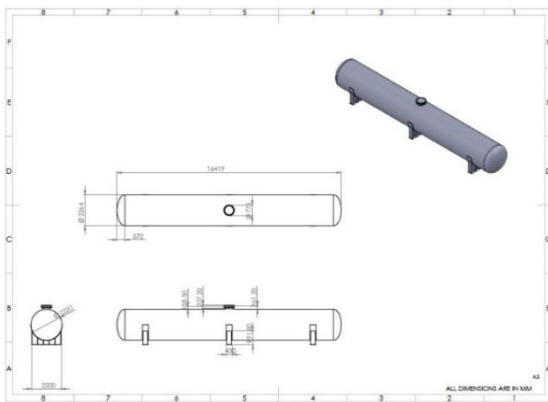


Fig.1 Stabilizer bar link with spring

Table 1 Dimensions of stabilizer bar link with spring

S.no	Description	Dimensions(m m)
1	Total length	16419
2	Diameter of the lid	775
3	Width of saddle support	430
4	Length of saddle support	2200
5	Diameter of the vessel	2220

III. ANSYS PROCEDURE

This section deals with the analysis of the designed model. The model that is in STEP format is analysed. Static structural analysis of both stabilizer bar link and suspension system is performed by applying the working load and number of supports used is two. The model is imported to Ansys and meshing is performed. The mesh size used is 4.4 mm. From the results obtained optimal design is selected. Suitable materials are applied to three different models of stabilizer bar link and modal analysis is performed. Different softwares such as Comsol, Radioss solver, Abaqus, Hypermesh, Ansys etc. are used for analysis. In this project Ansys R15.0 is used for design analysis.

Design Analysis

The figure shown below represents the meshed image, force and temperature application in pressure vessel.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

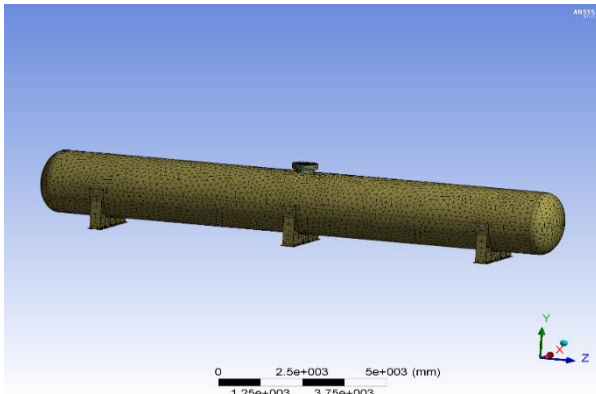


Fig.2 Meshed image of pressure vessel

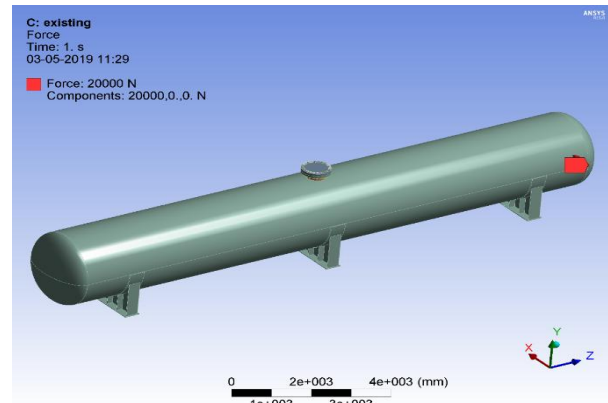


Fig.3 Force application in pressure vessel

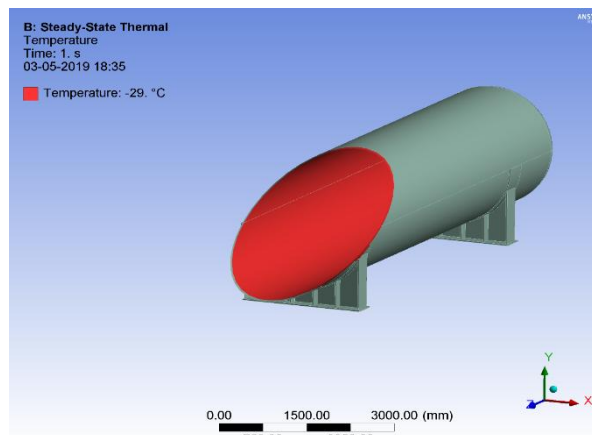


Fig.4 Temperature application in pressure vessel

First phase with Stainless steel 302

The figure shown below represents the total deformation of pressure vessel with silicone rubber

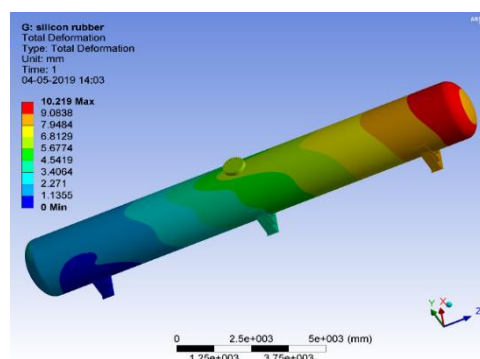


Fig.5 Total deformation of pressure vessel with silicone rubber (first phase)

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

Table 2 Overview of analysis results of first phase

Sl.No	Pressure Vessel	Total deformation(mm)
		Max
1	Existing	12.656
2	Silicon rubber	10.219
3	Thickness	10.711

From the analysis results of first phase with Stainless Steel 302 as shell it can be concluded that the pressure vessel with Silicon rubber have the least value of maximum total deformation. Hence pressure vessel with silicon rubber is selected for further analysis.

Second phase with SA 507

The figure shown below represents the total deformation of pressure vessel with silicon rubber

Table 3 Overview of analysis results of second phase

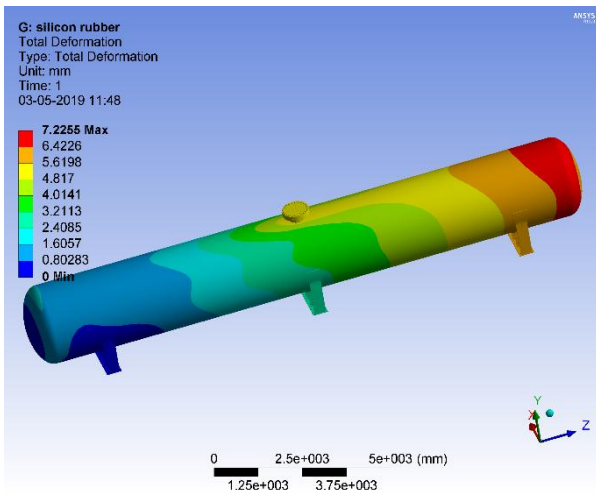


Fig.6 Total deformation of pressure vessel with silicon rubber(second phase)

Sl.No	Pressure Vessel	Total deformation(mm)
		Max
1	Existing	10.044
2	Silicon rubber	7.2255
3	Thickness	7.5181

From the analysis results of second phase with SA 537 as shell it can be concluded that the pressure vessel with Silicon rubber have the least value of maximum total deformation. Hence pressure vessel with silicon rubber is selected for further analysis. Also from the table 2 and 3 we can conclude that shell body of the pressure vessel applied with SA 537 is the best suitable material compared to Stainless steel 302.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

Comparison of results between first and second phase

Table 4 Comparison of results between first and second phase

Types of pressure vessel models	First phase with STAINLESS STEEL 302	Second phase with SA 537
	Total deformation	
Existing	12.656	10.044
Silicon rubber	10.219	7.2255
Thickness	10.711	7.5181

By comparing the results listed in the Table 4 it can be clearly understood that second phase with SA 537 is the most suitable material that can be used for the pressure vessel compared to first phase with Stainless steel 302. Hence SA 537 is selected as the material of the pressure vessel for further analyses. Analysis results obtained by applying SA 537 to the pressure vessel are shown below.

IV. MATERIAL OPTIMISATION

Three different materials are applied to the different components of pressure vessel and the analysis results are compared to select the most suitable model. The three different materials other than SA 537 used for analyses are SA-350LF2, Silicon Rubber and Stainless Steel. The force applied on the pressure vessel is 20 KN in X direction and the mesh size used for analysis is 30 mm. These materials are used in the pressure vessel globally as they meet the required criteria in the production of pressure vessel. Pressure vessel need to be designed in such a precise manner and therefore the materials required is selected in a more accurate way. In the table below there are certain physical properties of the materials used in the production of the pressure vessel.

V. MODAL ANALYSIS

The following tables gives the modal analysis results between Stainless steel 302 and SA 537 which are applied on the shell of the pressure vessel. The tables provide six natural frequencies of both the materials which plays a vital role in determining the suitable material for the pressure vessel

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

Table 5 Comparison of the natural frequencies of the three different models of pressure vessel of first phase with Stainless steel 302

Sl.No	Mode	Existing	Silicon Rubber	Thickne ss
1	1	1.5385	3.211	1.4092
2	2	3.0672	28.549	17.043
3	3	22.681	39.309	32.117
4	4	31.684	42.149	41.312
5	5	39.44	45.102	44.883
6	6	43.975	57.284	49.105

Table 6 Comparison of the natural frequencies of the three different models of pressure vessel of second phase with SA 537

Sl.No	Mode	Existing	Silicon Rubber	Thickness
1	1	1.5385	3.211	1.4092
2	2	3.0672	28.549	17.043
3	3	22.681	39.309	32.117
4	4	31.684	42.149	41.312
5	5	39.44	45.102	44.883
6	6	43.975	57.284	49.105

VI. RESULT AND DISCUSSION

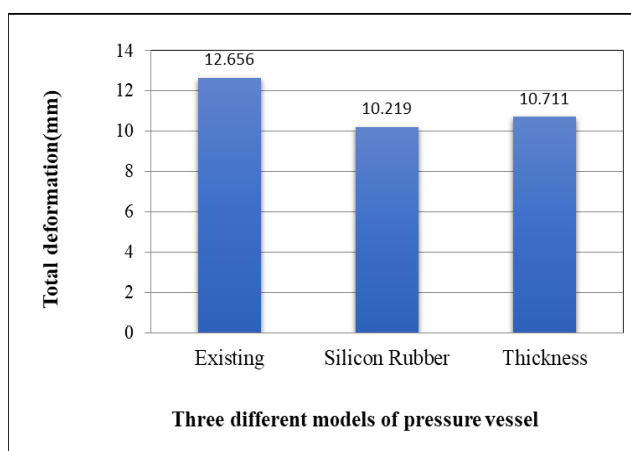


Fig.7 Total deformation of three different models of pressure vessel with stainless steel 302

From the above graphs ,we can see that the total deformation has reduced by 15.37% when thickness was increased in the pressure vessel compared to the existing one.We can also see that the total deformation has reduced by 19.26% when silicon rubber introduced in the internal surface of the pressure vessel compared to the existing one.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

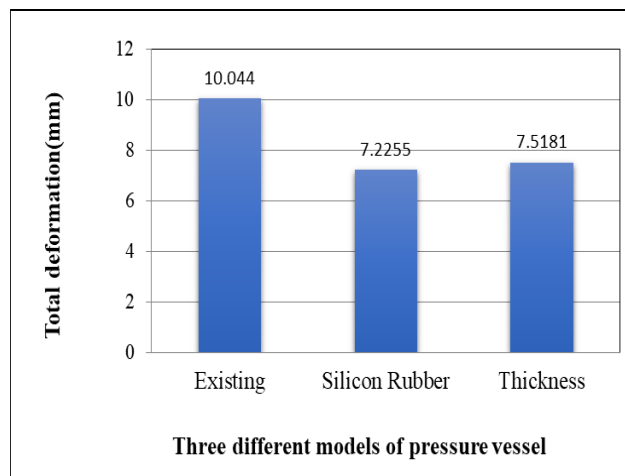


Fig.8 Total deformation of three different models of pressure vessel with SA 537

From the above graphs, we can see that the total deformation has reduced by 25.15% when thickness was increased in the pressure vessel compared to the existing one. We can also see that the total deformation has reduced by 28.06% when silicon rubber introduced in the internal surface of the pressure vessel compared to the existing one.

VII CONCLUSION

In this project three different models of pressure vessel were designed using SolidWorks 2016 edition and the designed model was analysed using ANSYS R15.0. Initially these three different models of pressure vessel such as existing one, the one with change in thickness and the one with silicon rubber introduced were subjected to a force of 20KN with an internal temperature of -29°C and pressure of 2.24 MPa. The shell of the pressure vessel was applied with two different materials such as Stainless steel 302 and SA 537 was analysed accordingly. From the analysis results it was found out that pressure vessel with silicon rubber proved to be the best. Also, the shell of pressure vessel applied with SA 537 is found to be best when compared to Stainless steel 302. Directional deformation, equivalent stress and equivalent elastic strain was also found out for the silicon rubber introduced pressure vessel. The other three different materials used for analysis include SA-350LF2, Silicon Rubber and Stainless Steel also proves to be the best suitable combination for pressure vessel. Modal analysis was carried out on three different models of pressure vessel applied with both materials. Results show that pressure vessel with silicon rubber combined with application of SA 537 on the shell exhibits higher natural frequency. From above results we can conclude that silicon rubber introduced pressure vessel applied with SA 537 proves to be the best choice for improved corrosion resistance and maximum safety.

REFERENCES

- [1] Jan Dzugańb, Miroslav Spaniela, Antonín Prantlč, Pavel Konopík, Identification of Ductile Damage Parameters For Pressure Vessel Steel. Jan Růžička, Jiří Kuzelka Czech Technical University In Prague.
- [2] Barsouma, s.a. lawala, r.j. simmons, c.c. rodrigues, and analysis of a pressure vessel subjected to an internal blast load department of mechanical engineering, Khalifa University of science and technology failure.
- [3] Eswara Kumar, A. R. Krishna Santosh, S. Ravi Teja, E. Abishek, Static And Dynamic Analysis Of Pressure Vessels With Various Stiffeners Dept. Of Mechanical Engineering, K L University, Vaddeswaram, Guntur, A.P.
- [4] B.B. Liaoa, L.Y Finite Element Analysis Of Dynamic Responses Of Composite Pressure Vessels Under Low Velocity Impact By Using A Three-Dimensional Laminated Media Model Jiab, Institute Of Process Equipment, Zhejiang University, Hangzhou 310027, China.
- [5] Zhiyan Xiao¹, Junping Shi¹, Xiaoshan Cao¹, Yong Xu², Yifeng Hu Failure Probability Analysis Of Pressure Vessels That Contain Defects Under The Coupling Of Inertial Force And Internal Pressure.