VOLUME-1 ISSUE-4
ISSN : 2799-18

INVESTIGATION ON MULTILAYER PRESSURE VESSEL

Dr Akashdeep Singh,

ABSTRACT

The main objective of this paper is to design and analysis of multilayer high pressure vessels features of multilayered high pressure vessels, their advantages over mono block vessel are discussed. Various parameters of Solid Pressure Vessel are designed andchecked according to the principles specified in American Society of Mechanical Engineers (A.S.M.E) Sec VIII Division 1. Various parameters of Multilayer Pressure vessels are designed and checked according to the principles specified in American Society of Mechanical Engineers (A.S.M.E) Sec VIII Division 1. The stresses developed in Solid wall pressure vessel and Multilayer pressure vessel is analyzed by using ANSYS, a versatile Finite Element Package.

I. INTRODUCTION

In Process Industries, like chemical and petroleum industries designers have recognized the limitations involved for confining large volumes of high internal pressures in single wall cylindrical metallic vessels. In process engineering as the pressure of the operating fluid increases, increment in the thickness of the vessel intended to hold that fluid is an automatic choice. The increment in the thickness beyond a certain value not only possesses fabrication difficulties but also demands stronger material for the vessel construction. With increasing demands from industrial processes for higher operating pressures and higher temperature, new technologies have been developed to handle the present day specialized requirements. Multilayer Pressure Vessels have extended the art of pressure vessel construction and presented the process designer with a reliable piece of equipment useful in a wide range of operating conditions for the problems generated by the storage of hydrogen and hydrogenation processes the term pressure vessel referred to those reservoirs or containers, which are subjected to internal or external pressures. The pressure vessels are used to store fluids under pressure. The fluid being stored may undergo a change of state inside the pressure vessels as in case of steam boilers or it may combine with other reagents as in chemical plants. Pressure vessels find wide applications in thermal and nuclear power plants, process and chemical industries, in space and ocean depths, and in water, steam, gas and air supply system in industries. The material of a pressure vessel may be brittle such as cast iron, or ductile such as mild steel.

1.1 Types of High Pressure Vessels: ***(a) Solid Wall Vessel***
(b) Multi Layered Cylindrical Vessel

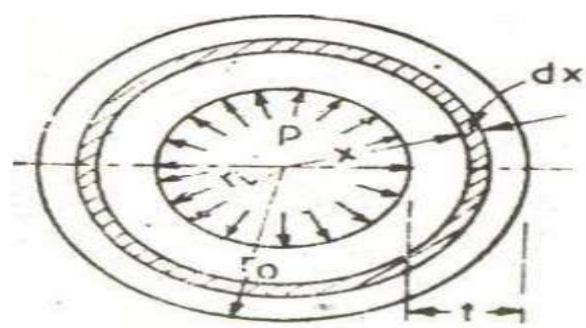

Fig.1.1 Solid Wall Vessel

VOLUME-1 ISSUE-4
ISSN : 2799-18

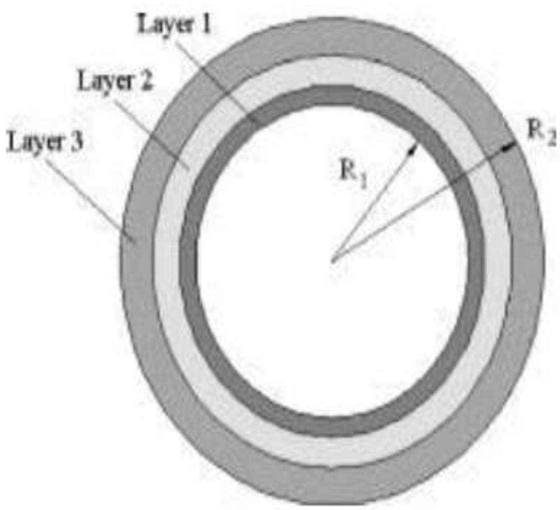

Fig.1.2 Multi-Layered Cylindrical Vessel

II.DESIGN PARAMETER OF PRESSURE VESSEL

"Pressure Vessel Design Guides & Procedures"; G. Ghanbari M.A.Liaghat; 2000;) The following are design parameters of pressure vessel 1. Design Pressure 2. Allowable stress 3. Corrosion Allowance

2. DESIGN PRESSURE

In the pressure vessels, three terms related to pressure are commonly used a) Maximum Working pressure is the maximum pressure to which the pressure vessel is subjected. b) Design pressure is the pressure for which the pressure vessel design c) Hydrostatic test pressure is the pressure at which the vessel is tested. The pressure vessel is finally tested by the hydrostatic test before it is put into operation. d) The design pressure and the hydrostatic test pressure are obtained as follows: *Design pressure = 1.05* (Maximum working pressure) Hydrostatic test pressure = 1.3* (Design pressure)* **2.2 Allowable Stress** As per the IS Code and ASME Code, the allowable stress is based on the ultimate tensile strength with a factor of safety of 3 and 4 respectively. As per the IS Code, the following stress is obtained on the yield strength with a factor of safety of 1. Therefore,

Allowable stress,

$$\sigma all = \frac{Sut}{3}$$

or

$$\sigma all = \frac{Syt}{1.5}$$

3 CORROSION ALLOWANCE

The walls of the pressure vessel are subjected to thinning due to corrosion which reduces the life of the pressure vessel. The corrosion in pressure vessel is due to the following reasons: a.c a chemical attack by reagents on the inner wall surface of the vessel. b. due to atmospheric air and moisture. c. High temperature oxidation. d. Erosion due to flow of reagent over the wall surface at high velocities. Every attempt should be made avoid the corrosion. However, this may not be always possible. An allowance is, therefore, required to be made by suitable increase in wall thickness to compensate for the thinning due to corrosion. Corrosion allowance is an additional thickness of the pressure vessel wall over and above that required to withstand the internal pressure. Guidelines for providing corrosion allowance: 1.For cast iron, plain carbon steel and low alloy steel component, the corrosion allowance of 1.5 mm is provided. However, in case of these chemical industries where severe conditions are expected, the corrosion allowance may be 3mm 2. For high alloy steel and non-ferrous components, no corrosion allowance is necessary. 3. When the thickness of cylinder wall is more than 30mm, no corrosion allowance is necessary.

4 DESIGN OBJECTIVES

VOLUME-1 ISSUE-4
ISSN : 2799-18

1. To show that multilayer pressure vessels are suitable for high operating pressures than solid wall pressure vessels.

2. To show a significant saving in weight of material may be made by use of a multilayer vessel in place of a solid wall vessel.

3. To show there may be a uniform stress distribution over the entire shell, which is the indication for most effective use of the material in the shell.

4. To check the suitability of using different materials for Liner shell and remaining layers for reducing the cost of the construction of the vessel.

5. To verify the theoretical stress distribution caused by internal pressure at outside surface of the shell and to ascertain that the stresses do not reach yield point value during testing.

6. Finally check the design parameters with FEM analysis by using ANSYS package to ascertain that FEM analysis is suitable for multilayer pressure vessels analysis.

CONCLUSIONS

The following conclusions are drawn from the above work

1. There is a percentage saving in material of 26.02% by using multilayered vessels in the place of solid walled vessel**.** This decreases not only the overall weight of the component but also the cost of the material required to manufacture the pressure vessel. This is one of the main aspects of designer to keep the weight and cost as low as possible.
2. The Stress variation from inner side to outer side of the multilayered pressure vessel is around **12.5%,** where as to that of solid wall vessel is **17.35%.** This means that the stress distribution is uniform when compared to that of solid wall vessel. Minimization of stress concentration is another most important aspect of the designer. It also shows that the material is utilized most effectively in the fabrication of shell.
3. Theoretical calculated values by using different formulas are very close to that of the values obtained from ANSYS analysis. This indicates that ANSYS analysis is suitable for multilayer pressure vessels.
4. Owing to the advantages of the multi layered pressure vessels over the conventional mono block pressure vessels, it is concluded that multi layered pressure vessels are superior for high pressures and high temperature operating conditions.

REFERENCES

1. BHPV manual on Multilayer Pressure Vessels.
2. Brownell and Young, “Process Equipment Design” Chapter 7, Chapter 13, Chapter 14 and Chapter 15.
3. Seely, F.B., and Smith, A.O., “Advanced Mechanics of Materials” Wiley, Newyork, Chapter 10.
4. John F.Henvey “ Pressure Vessel Design - Nuclear and Chemical Applications” An East-west Edition, Newyork, Chapter 5 and Chapter 7.
5. Henry H.Bednar “ Pressure Vessel Code Book”, Chapter 11.
6. Jasper, T.M and Scudder, C.M AIChE Transactions, PP885 -909.
7. Fino, A.F., “ Economic Considerations for High Pressure vessel Design” pp-101-104.
8. Fratcher, G.E : New alloys for Multilayer Vessels” Vol 33,No.11.
9. Jasper, T.M and Scudder, C.M “ Multilayer Construction of Thick-wall Pressure Vessels” Volume 37.
10. Jawad, Maan H., “Wrapping Stress and Its Effect on strength of Concentrically Formed Plywaals,” Paper No72-PVP7.
11. Harold.H.Wait e, “Pressure Vessel and Piping Design Analysis” Volume Four
12. Mc Cabe, J.S and Rothrock, E.W., “ Multilayer Vessels for High Pressure,” ASME Mechanical Engineering PP 34-39.

VOLUME-1 ISSUE-4
ISSN : 2799-18

13. Mc Cabe, J.S and Rothrock, E.W., " Recent Developments in Multilayer Vessels," British chemical engineering Vol.16, No6,1971

14. MCDowell, D.W., and Milligan, J.D., "Multilayer Reactors Resist Hydrogen Attack", Hydrocracking Magazine, vol.44, No12, 1965.