International Journal of Latest Trends in Engineering and Technology
Vol.(11)Issue(2), pp.098-101
DOI: http://dx.doi.org/10.21172/1.112.17
e-ISSN:2278-621X

DESIGN CONSIDERATION OF MOUNDED STORAGE VESSEL

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Abstract -Pressure vessels are designed for many applications in Industrial, automobile, aeronautical, aerospace, chemical sectors and many more. They are specially designed to be light in weight and high in strength in order to meet the requirements of the market demands. In this paper we are going to analyse the design and considerations of the Mounded storage vessels. Designing process involves the determination of pressure and temperature of the pressure vessels that is whenever the pressure and temperature of the vessel changes it is considered as a new design. Hence the stress and thermal analysis of each vessel is carried out very carefully and designed in order to be very reliable and constant across the time. Design considerations are made using the PV Elite software and the standards are checked against the American Society of Mechanical Engineering (SEC VIII. DIV-2). For analysis variable pressure and temperature ranges are considered. To improve the lifetime of the pressure vessel fatigue analysis is also done in this consideration.
Keywords: Design, pressure vessel, ASME SEC.VIII, Pressure, stress, LPG Storage vessel.

1. INTRODUCTION

Pressure vessels have their extensive usage from the Industrial application to day to day life usages to store Liquefied gasses. An suitable temperature and pressure is maintained for the long term storage without any adverse effects of leaking and bursting. hence these vessels are installed above the ground water level and the soil is used to cover them as a protective layer. This structure appears to be an soil mound, thereby they got their term as "Mounded Storage". While considering the design factor safety standards also plays an vital role to ensure the safe operation of the vessel. Their physical appearance are described as large cylindrical vessels built of steel with the curved ends buried inside a mound. There can be several tanks set beside in a single mound. The mound is completely sealed with the soil and only a dome or a manhole extend beyond the covered surface. For draining the gasses the vessels are sloped inside the mound at an angle of 1:200 min.

These containers are subjected to pressure both internally and externally. The liquefied gas stored inside reacts with the varying temperature and pressure as in boiler unit or sometimes they react with other chemicals in the plant. Hence high pressure has to be maintained in order to prevent the disasters. American Society of Mechanical Engineering (SEC VIII. DIV- is used to design the code for the construction of pressure vessel with the stress theory. According to this theory the thickness of the vessel increases with the pressure maintained. Hence for maximum pressure the thickness of the vessel should be increased. This increase in thickness limits the fabrication design of the metal used for construction. Mild steel with high ductile and low brittle properties is used for this purpose. Improper design consideration of the fabrication metal, wrong figures in the design data, improper design methods or insufficient testing leads to the failure of the storage tanks ending up in collateral damage. Hence to ensure the safe and fair operations design considerations are made carefully.

2. DESIGN CONDSIDERATION OF PRESSURE VEHICLES

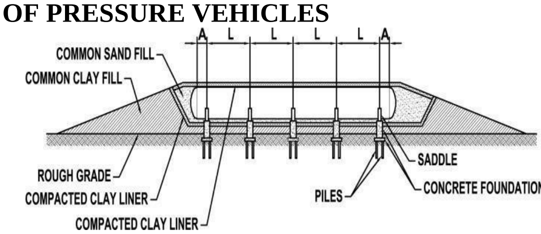

Fig.1.Mounded Storage Vessel

Fig.1. Shows the structure of the mounded storage vessel. The code for testing and design was approved either by PD-5500 or ASME SEC.VIII or equivalent. The considerations are made in specific to the following.

a) Internal vapour and hydraulic pressure
b) External loadings on the vessel
c) Internal vacuum

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2.1. Material

The material used for the construction of the mounded storage vessels should have high tensile strength, ductile and low brittle. For safe operation the fabrication material should be conditioned against the consideration code and design. Since the presence of hydrogen sulphide in the LPG cannot be completely eliminated High stress material is prone for the failure of the vessel.

As hydrogen could pave for the stress induced corrosion cracking the following considerations are made for the material selection. Tensile strength of the material should not exceed allowable limit of 80,000 psi. Alloys like Nickel, Molybdenum and Vanadium should not be considered for fabrication.

Table.1. Design Parameters

Design Pressure (Internal)	15.400 kgf/cm^2
Design Pressure (External)	2.500 kgf/cm^2
Design Temperature(Internal)	55 °C
Working Pressure	15.4 kg/cm^2
Minimum Design Metal Temperature	-27 °C
Operating Temperature	-27 to 55°C
Capacity	1200mt
Length	5982.80 cm
Inside Diameter	7212.0 mm
Density of LPG	539.76 kg/m^3
Miscellaneous Weight Percent	10.0
Wind Design Code	NO Wind Loads
Seismic Design Code	IS-1893-RSM
Importance Factor for IS-1893	2.000
Soil Factor	1.000
Zone Number	4.000
Percent Seismic for Hydro test	33.000
Damping Factor	2.000

Table.1. Shows the design parameters required for the fabrication of the materail and the soil mound.

2.2. Shell

These are the main components which are going to hold the stored liquid. Cylindrical shapes are mostly preferred and widely used as maximum modulus and less stress in the given dimensions. To have a same rotational axis for all the shells the shells are welded together. Other than cylindrical in some cases spherical and conical structures are also preferred.

2.3. Heads

The Shell ends are sealed with the structure called heads. The heads are coming in different shapes like flat, hemispherical, conical, elliptical and tropospherical. But curved heads are preferred more than that of flat head as they are cost effective and provide more blighter and strong support.

2.4. Nozzles

These components play an important role in the operation of storage vessels. They make an input and output path from the storage vessels which are either welded in the heads or shells. Mostly circular nozzles are used to reduce the concentration of the stress during inflow and outflow. The nozzle ends are kept flanged for easy maintenance and access.

2.5. Stiffener Rings

To increase the moment of inertia around the peripherals of the vessel these rings are used. Thus they increase the resistant, strength and reduce the thickness of the shell material. These rings are made up of inexpensive and cheap metals making it economically favourable.

2.6. Loads On Mounded Bullet

The mounded bullet analysis is preferred against the standards of EEMUAPublication190:2005. Parameters like weight, internal pressure, pressure exerted by the mound, axial loads, variation in temperature and pressure are considered in the design consideration of the loads.

Table.2. Materials used for Construction

DESCRIPTION	MATERIAL	TYPE OF STEEL	TENSILESTRES (MPA)	YIELDSTRESS (MPA)
SHELL	BS 1501 Part I 224 Gr.490	CARBON STEEL	490	220/295
DASHED ENDS	BS 1501 Part I 224 Gr.490	CARBON STEEL	490	220/295
RINGS	SA-537 CL.1	CARBON STEEL	485/620	345
NOZZLE	SA 333 Gr. 6	CARBON STEEL	415	205

Table.2 provides the list and properties of material used for the construction of the mounded storage pressure vessels. The stress and the shear values are calculated as per the given standard of code design to ensure the long life of the shell.

3. RESULTS

The Internal pressure values, the external pressure values and the shear values are calculated and the results are given in the Tables 3,4 and 5 respectively.

Table.3. Internal stresses On Elements Due To Test Pressure

FROM TO	STRESS KG/M2	ALLOWABLE (90% OF YIELD)	RATIO
Dish 01	2591.9	2890.9	0.897
Shell	2729.3	2890.9	0.944
Dish 02	2591.9	2890.9	0.897
Dome Dish 01	706.4	2890.9	0.244
Dome Dish 02	705.5	2890.9	0.244

Table.4. External Stresses On Rings Due To Test Pressure

FROM	TO	EXTERNAL ACTUAL TMM	EXTERNAL REQUIRED T.MM	EXTERNAL DESS. PRESS kgf/cm^2	External M.A.W.P. kgf/cm^2
10	20	16.5000	14.3271	3.63200	4.83214
20	Ring	30.0000	22.3054	3.2390	7.17953
30	40	16.5000	14.3271	3.63200	4.8241
40	50	16.0000	4.28479	2.50000	33.0045
50	60	16.0000	4.28479	2.50000	33.0045

The above results prove that with our proposed design consideration the life of the shell is to be extended and teh safety is ensured during the storage of gasses which can avoid disasters like combustion and explosion.

Table.5 Summary Of Results

STRESS (KGF/CM²)	ACTUAL	ALLOWABLE P/F
Primary Shear Stress of Weld :	266.09	1001.17
Secondary Shear Stress of Weld:	483.72	1001.17
Shear Stress above Hole	605.68	1001.17
Pin Hole Bearing Stress	1009.47	1877.20
Total Combined Stress at the base of the lug	-70.66	1651.93

These specifications governs for teh minimum requirement of the materials. These systems are suitable for low temperature of about -55oC and an high tempertaure of about +55oC. High levels of Sulphides and chlorides are also withstanded by our design without corrosion.

4. CONCLUSION

From the obtained results and the datas it is concluded that the proposed design considerations make the vessel safe for both internal and external pressure. The shell and Heads are designed against the leakage and corrosion. Storage vessel sustained the hydraulic pressure test which assures againt the leakage of the liquefied gas. The deisgn considerations assures for the time consumption for implementation and cost effective. All the results compared against the EN-13445 Code standard ensures the safe storage of liquids under pressure.

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