"Design and Analysis of Pressure Vessel Using Software"

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Abstract - *The main objective of this paper is to design and analysis of pressure vessel. The designing various parameters of Pressure Vessel checked and designed according to the principles specified in American Society of Mechanical Engineers (A.S.M.E) Sec VIII Division 1. The stress development in the pressure wall critical points are analyzed by using ANSYS13 and an optimized model is modeled to overcome the stresses produced in the vessel. Designers encounter practical difficulties like fatigue stress, weld defect etc. This approach is universally adopted in all known pressure equipment codes around the world. The use of 0.7 and 0.85 weld efficiency factor for a weld having no volumetric inspection and partial volumetric inspection respectively. For leveraging off riveted pressure design, it is concluded that a practical and conservative approach for a given weld detail is to calculate geometric stress parameters at the critical location.*

Key Words: ASME, ANSYS, Vessel shell and head, Weld efficiency.

1. INTRODUCTION

The pressure vessels are closed containers used to hold gases or liquids at a pressure substantially different from the ambient pressure. The pressure inside the vessel is different and may change by various conditions. The vessels are too dangerous and fatal accidents have occurred in the history of pressure vessel development and operation. Cylindrical or spherical pressure vessels are commonly used in industry to carry both liquids and gases under pressure. The pressure produced stress in the vessel. The normal stresses resulting from this pressure are Functions of the radius of the element under consideration, the shape of the pressure vessel as well as the applied pressure Mechanical and thermal loads are considered. It does well to critically appraise the development of pressure vessel design; where it has been and where it is now. Arguably pressure vessel design is mature and with maturity complacency can set in with the feeling that it is all "done and dusted" and as such ingoing development is hindered. It is believed this is the case with the development and use of weld efficiencies in welded pressure vessel design. While the Code gives formulas for thickness and stress of basic components, it is up to the designer to select appropriate analytical procedures for determining stress due to other loadings. The designer must also select the most probable combination of simultaneous loads for an economical and safe design.

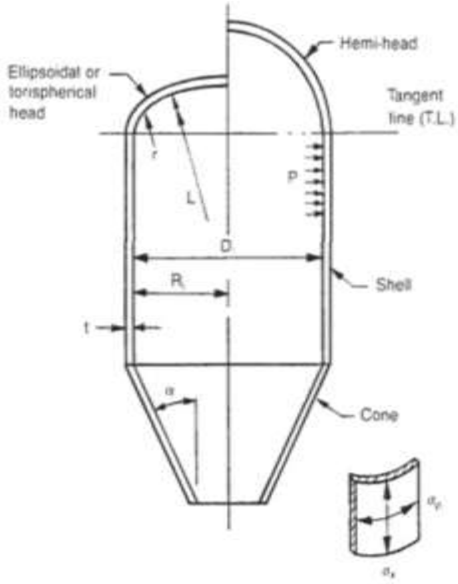

Fig-1 Schamatic of cylindrical pressure vessel

2. DESIGN CRITERIA

2.1 Categories of Failures

- Material: Improper selection of material; defects in material.
- Design: Incorrect design data; inaccurate or incorrect design methods; inadequate shop testing.
- Fabrication: Poor quality control; improper or insufficient fabrication procedures including welding; heat treatment or forming methods.
- Service: Change of service condition by the user; inexperienced operations or maintenance personnel; upset conditions

2.2 Types of Failure Modes

- Elastic deformation- Elastic instability or elastic buckling must be evaluated by considering vessel geometry, stiffness as well as properties of materials.
- Excessive plastic deformation- The primary stress limits as outline in ASME Section VIII, Division 2 are intends to prevent excessive plastic deformation.

- Brittle fracture- It can occur at low or intermediate temperatures. Brittle fractures have occurred in vessels made of low carbon steel in the 40–50F range during hydro test where minor flaws exist. This is addressed greatly in material toughness.

- Stress rupture- Italicized values in Section II, Part D indicate that allowable stress values are governed by time-dependent properties, e.g. stress rupture and creep rate.

- Plastic instability- Incremental collapse; incremental collapse is cyclic strain accumulation or cumulative cyclic deformation. Cumulative damage leads to instability of vessel by plastic deformation. The primary plus secondary limits are intended to preclude any ratchet and validate the use of elastic analysis.

- High strain- Low cycle fatigue is strain-governed and occurs mainly in lower-strength/high-ductile materials. The peak stresses are used to evaluate this condition.

- Stress corrosion-It is well known that chlorides cause stress corrosion cracking in stainless steels; likewise caustic service can cause stress corrosion cracking in carbon steels. Material selection is critical in these services.

- Corrosion fatigue-It occurs when corrosive and fatigue effects occur simultaneously. Corrosion can reduce fatigue life by pitting the surface and propagating cracks. Material selection and fatigue properties are the major considerations.

3. DESIGN OF PRESSURE VESSELS TO CODE SPECIFICATION

American, Indian, British, Japanese, German and many other codes are available for design of pressure vessels. However the internationally accepted for design of pressure vessel code is American Society of Mechanical Engineering (ASME). Various codes governing the procedures for the design, fabrication, inspection, testing and operation of pressure vessels have been developed; partly as safety measure. These procedures furnish standards by which, any state can be assured of the safety of pressure vessels installed within its boundaries. The code used for unfired pressure vessels is Section VIII of the ASME boiler and pressure vessel code. It is usually necessary that the pressure vessel equipment be designed to a specific code in order to obtain insurance on the plant in which the vessel is to be used. Regardless of the method of design, pressure vessels within the limits of the ASME code specification are usually checked.

Table -1: Thickness Calculation for Shell End

Parameter	**Selected value**	**Reference**
Shell material	SA 516 Gr.70	ASME Section VIII Div. 1 Table UCS 23
Allowable stress (S)	20000psi	ASME Section IID Table 1A
Joint efficiency (E)	.85	ASME Section VIII Div. 1 Table UW12
Thickness for circumferential shell (t)	PR/(SE-.6P)	ASME Section VIII Div. 1 UG-27
Thickness for longitudinal shell (t)	PR/(2SE+0.4P)	ASME Section VIII Div. 1 UG-27
Minimum thickness (t)	10.425mm	ASME Section VIII Div. 1

4. MODELLING USING BY CATIA

Table-2: Thickness Calculation for Dish End

Parameters	Selected value	Reference
Dish material	SA 516 Gr.70	ASME Section VIII Div. 1 Table UCS 23
Allowable stress (s)	20000psi	ASME Section IID Table 1A
Joint Efficiency (E)	.85	ASME Section VIII Div. 1 Table UW-12
Thickness of ellipsoidal dish end (t)	PE/(2SE.6P)	SME Section VIII Div. 1 UG-32
Minimum thickness (t)	11.2803mm	ASME Section VIII Div. 1

4.1 Actual pressure vessel individual parts without nozzle modelling are shown in following fig.2 to 3.

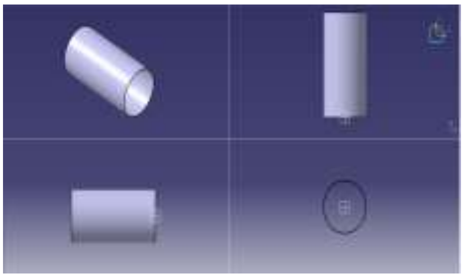

Fig-2 Shell End

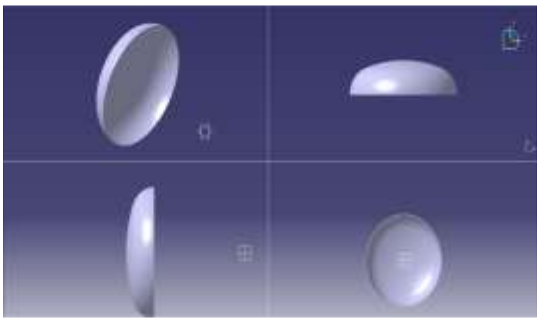

Fig-3 Dish end

4.2 Actual pressure vessel individual parts with nozzle modelling are shown in following fig.4 to 5.

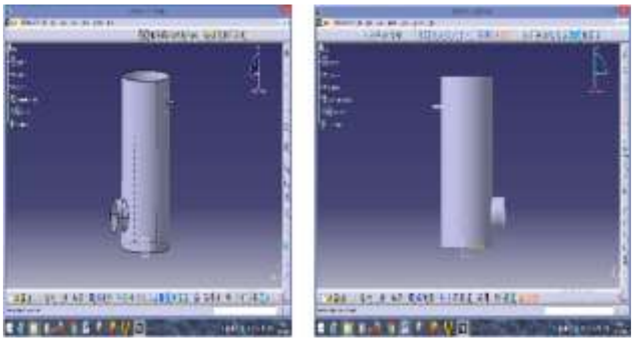

Fig-4 Shell End

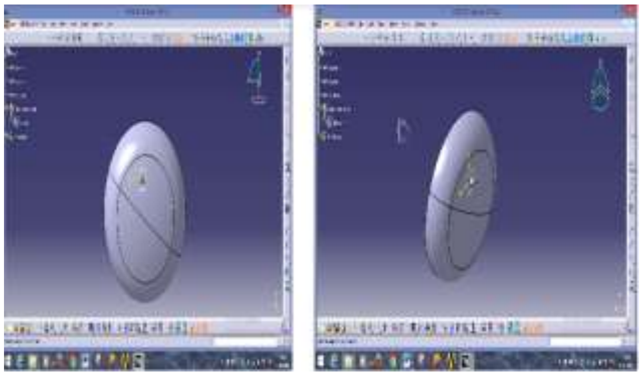

Fig-5 Dish End

5. RESULT AND DISCUSSION

5.1 Stress distribution in the vessel part without nozzle is the following fig.6 to 7.

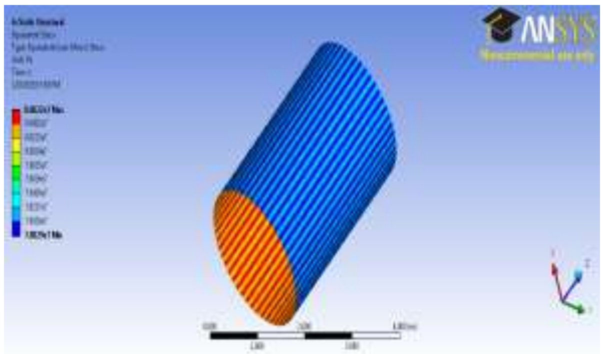

Fig-6 Shell End

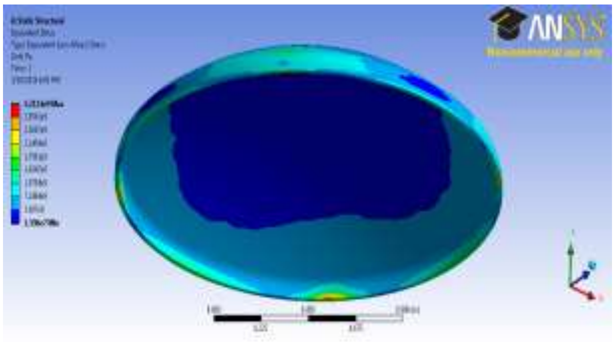

Fig-7 Dish End

5.2 Stress distribution in the vessel part with nozzle is the following fig. 8 to 9.

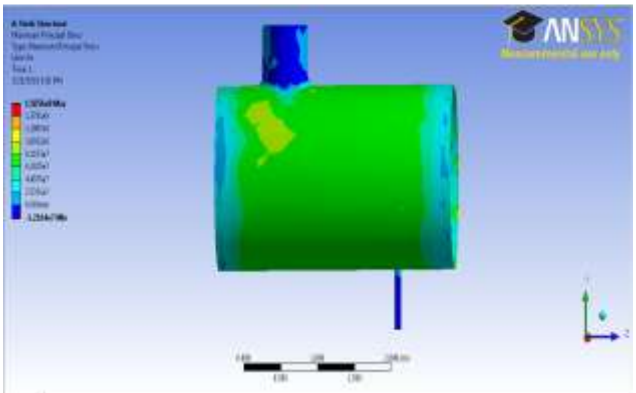

Fig-8 Shell End

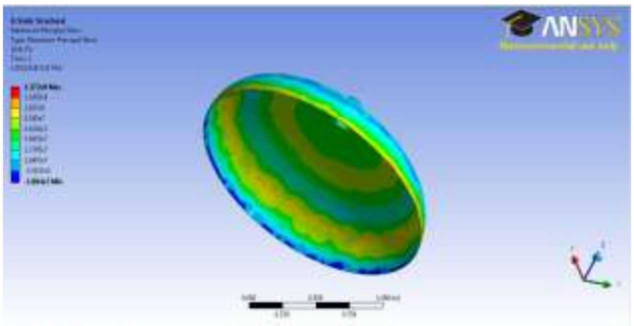

Fig-9 Dish End

6. SUMMARY OF RESULTS

Table- 3: Max. stress intensity, MPa

Sr.no	Vessel part	Without nozzle	With nozzle
1	Shell End	80.62	156.1
2	Dish End	13.36	102.7

7. CONCLUSIONS

Designing the parts of the vessel as per the ASME is successful. The analysis is performed on the both model parts and results are compared. By the results we observed that the stress values of vessel with nozzle are greater than the stress value of without nozzle.

REFERENCE

[1] B .Siva Kumar, P .Prasanna ,J. sushma ,K.P.Srikanth " Stress Analysis And Design Optimization Of A pressure Vessel Using Ansys Package" Materials Today: Proceeding 5(2018) 4551-4562.

[2] R.C. Carbonari, P.A. Munoz-Rojas, E.Q. Andrade, G.H. Paulino, K. Nishimoto, E.C.N. Silva, "Design of pressure vessels using shape optimization: An integrated approach", International Journal of Pressure Vessels and Piping (May 2011), 198-212

[3] Robert Frith, Mark Stone, "A proposed new pressure vessel design class", International Journal of Pressure Vessels and Piping (2016), 1-8

[4] H. Mayer, H.L. Stark, S. Ambrose, "Review of fatigue design procedures for pressure vessels", International Journal of Pressure Vessels and Piping (2000), 775-781

[5] Leslie P. Antalffy, George A. Miller III, Kenneth D. Kirkpatrick, Anil Rajguru, Yong Zhu, "The design of lifting attachments for the erection of large diameter and heavy wall pressure vessels", International Journal of Pressure Vessels and Piping (2016)

[6] ASME CODE BOOK 2018

[7] Pressure Vessel Design Manual by Dennis moss