Analysis of Effects of Quench Nozzle on Pressure Vessel Design – A Review

Mrs. Jayashri P. Wagh[1], Girish B. Pawar[2], Ajit R. Mane[3], Yuvraj P. Ballal[4]

[1] Assistant Professor, Department of Mechanical Engineering, PCCOE, Pune, Maharashtra, India
[2,3,4] Assistant Professor, Department of Mechanical Engineering, ADCET, Ashta, Maharashtra, India

---***---

Abstract - ***This paper gives the effects of quench nozzle on the pressure vessel design. Generally in Pressure Vessels, Nozzles are required for Inlet and Outlet Purposes. These Nozzle if present on peak of the dish end do not disturb the symmetry of the Vessel. However sometimes process requirements dictate that some quench nozzles be placed on the periphery of the Pressure Vessel. These Nozzles disturb the symmetry of the Vessel and need to analyzed in FEA to understand effects on Stress attributes of the Vessel. Different models of pressure vessel are prepared by varying the number of nozzles on the periphery and angle between the nozzles. Structural Analysis have to conduct for the pressure vessel when both the Nozzles are present and understand the effect of combination and determine the stress distribution. Conduction a Study analysis, on the effects of increasing the number of Nozzles on the periphery at every 45 degrees until full symmetry is achieved. After analyzing the existing pressure vessel nozzle assembly for seven different conditions, the safe stress value are obtained for all conditions which is less than 50 MPa. The minimum deformation is obtained for 4 Nozzles-90degrees type of pressure vessel combination and also the maximum stress for that is within the acceptable limits.***

Key Words: Pressure vessel; Quench nozzle; Pressure vessel-nozzle combinations

1. INTRODUCTION

In Pressure Vessels, Nozzles are required for Inlet and Outlet Purposes. These Nozzles if present on peak of the dish end do not disturb the symmetry of the Vessel. However sometimes process requirements dictate that some quench nozzles be placed on the periphery of the Pressure Vessel. A simple technique is presented for calculating the local primary stress from internal pressure in nozzle openings. Nozzle internal projections, reinforcing pads and fillet welds are considered for nozzles on cylinders. A study comparing the proposed method with ASME Section VIII, Division 1 rules and finite element analysis (FEA) is presented for the range of geometries. The use of finite element (FE) analysis software for investigation of stresses in vessel nozzle-to-shell junctions is now economically practical for many design projects in the refining and chemical industries. The engineer's decision to use brick elements or shell elements for the investigation may have a bearing on the results. The use of brick elements will provide results that must be linearized by the engineer before comparison to the applicable ASME Boiler and Pressure Vessel Code (1995) allowable stress.

1.1 Objective

The main objective is to streamline the interaction between the process engineer and structural engineer. For this streamline the exact coordination between process engineer and structural engineer is required. . However sometimes process requirements dictate that some quench nozzles be placed on the periphery of the Pressure Vessel. These Nozzles disturb the symmetry of the Vessel and need to analyze in FEA to understand effects on Stress attributes of the Vessel.

1.2 Analysis

To conduct Structural Analysis and determine the Stress conditions with a Peripheral Nozzle and determine the stress distribution for various conditions for angle variation between the nozzles. Main objective of this non-linear analysis is to find out the critical stresses under provided boundary conditions. After the application of different forces corresponding to internal pressure, stresses induced in complete pressure vessel will have to be considered and region of maximum stress location is to be found out. It has to be checked maximum stress should be 1.3 MPa. A Design should be proven to be safe with a Factor of Safety of minimum 5. To change the number of nozzles and the angle between nozzles depends upon internal pressure. The best model is that for which deformation is minimum and maximum equivalent stress is within the acceptable limit. The sample model which is used for the analysis with 4 nozzles and angle between the nozzles 90^0 is as shown in figure 1.

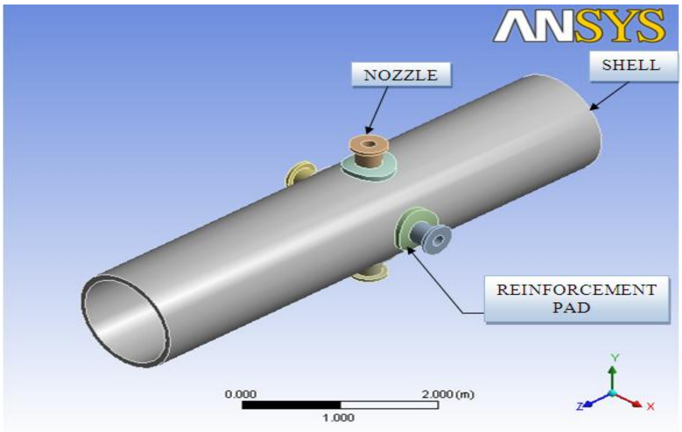

Fig - 1. Nozzle, Reinforcement pad & shell assembly with parts

2. RELATED WORK

2.1 The Design of Vertical Pressure Vessels Subjected to Applied Forces

E. O. Bergman [1] discussed that the pressure-vessel codes do not give design methods except for the relatively simple case of cylindrical shells with standard-type heads and openings under uniform pressure. The designer must apply engineering principles when he deals with more complicated structures and loading systems It deals with vessels that are subjected to various applied forces acting in combination with internal or external pressure. The type of vessels considered is limited to cylindrical shells with the longitudinal axis. The vertical loads on the vessel set up compressive stresses in the shell, and also bending stresses when the resultant force does not coincide with the axis of the vessel. The stresses set up at any section of the shell by the vertical loads can be calculated by equations [1].

2.2 Openings in ASME Code Pressure Vessels

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations [2].

2.3 Stress Evaluation of a Typical Vessel Nozzle Using VRC 3D Stress Criteria: Guidelines for Application

Michael A. Porter et al. [3] described that the use of finite element (FE) analysis software for investigation of stresses in vessel nozzle-to-shell junctions is now economically practical for many design projects in the refining and chemical industries For many design projects in the refining and chemical industries. The engineer's decision to use brick elements or shell elements for the investigation may have a bearing on the results. The use of brick elements will provide results that must be linearized by the engineer before comparison to the applicable ASME Boiler and Pressure Vessel Code allowable stress [3].

2.4 A Proposed Method for Finding Stress and Allowable Pressure in Cylinders with Radial Nozzles

Les M. Bildy [4] presented a simple technique for calculating the local primary stress from internal pressure in nozzle openings. Nozzle internal projections, reinforcing pads and fillet welds are considered for nozzles on cylinders. A study comparing the proposed method with ASME Section VIII, Division 1 rules and finite element analysis (FEA) large openings were introduced in ASME VIII-1 beginning with the A95 Addenda of the ASME Code. Difficulties reported in applying Appendix 1-7(b) rules to successful operating vessels prompted the present investigation into the stresses that are present near nozzle-to-cylinder intersections The proposed method is based on the assumption of elastic equilibrium. A pressure area calculation similar to the technique used when determining tensile stress when applying VIII-1, Appendix 1-7(b) is employed [4].

2.5 Modernization of Pressure Vessel Design Codes

T. P. Pastor et al. discussed that The technology for pressure equipment design continues to advance each and every day. The ASME Boiler and Pressure Vessel Code has been keeping pace with these advances over the last 92 years. As far back as the 1960s, it was recognized that the special requirements for design of pressure vessels operating at pressures over 2000 psi (13.7 MPa) called for special rules, and ASME issued Sec. VIII, Division 2 of Alternative Rules for Pressure Vessels. Since that time, the understanding of failure mechanisms and advances in material science, nondestructive testing, and computer-aided design has progressed to the stage where a new approach was needed not only in the content of design codes but in the way they are presented and organized. This paper introduces the newly issued ASME Sec. VIII, Division 2 of 2007 edition and explores the technical concepts included and the new format designed for ease of use. Included are results of test exercises sponsored by ASME giving actual applications of the new Code for design of vessels. This paper demonstrates ASME's commitment to provide manufacturers and users of pressure equipment with the most up-to-date technology in easy to use standards that service the international market [5].

2.6 Structural Analysis Of RRRP Reflector Vessel

Jorge E. Magoia et al. presentes the main features of the design and structural analysis of the Reflector Vessel (RVE) for the RRRP. The RRRP is a 20 MW multi-purpose nuclear research reactor designed and constructed by INVAP from Argentina, for the Australian Nuclear Science and Technology Organization (ANSTO). The reactor core is surrounded by the RVE which is filled with heavy water and serves several functions. The successful performance of the RVE is paramount to the success of the RRR project. Its design has meant a large engineering effort that involved a close interaction between structural analysis, neutronic calculations, thermal, hydraulics, material science, and manufacturing and assembly demands. The present report describes the main steps followed in the process of development of the RVE, including design, calculation, RVE mock-up manufacturing, vessel and chimney final construction and testing. Main features of the structural analysis performed are presented, including load cases, their classification and requirements. Pressure and temperature corresponding to normal operation, design load and special situations such as second shutdown system operation, seismic event, irradiation-induced Zircalloy growth, were taken into account. Stresses, displacements and buckling factors are calculated according to requirements and applicable standards, under normal and accidental conditions [6].

2.7 Design by Analysis of Pressure Components by Non–Linear Optimization

Manfred Staat et al. presented the direct route to Design by Analysis (DBA) of the new European pressure vessel standard in the language of limit and shakedown analysis (LISA). This approach leads to an optimization problem. Its solution with Finite Element Analysis is demonstrated for some examples from the DBA–Manual. One observation from the examples is, that the optimisation approach gives reliable and close lower bound solutions leading to simple and optimised design decision. This approach is particularly effective compared to cyclic non-linear analysis, because shakedown analysis needs typically the computing time of 2-3 elastic analyses. One observation from the examples is, that the optimisation approach gives reliable and close lower bound solutions leading a simple and optimised design decision. In combination with an upper bound approach the convergence to the true limits can be indicated. Some application rules have been critically discussed.

3. CONCLUSION

The main objective is to Design and Analysis of proposed Model of pressure vessel nozzle assembly using FEA. By performing these analyses, streamline the process and interaction between the process engineer and structural engineer. As the system is go smooth so that efficiency of the system is to be increased. For that several pressure vessel conditions are taken for analysis. After analyzing the existing pressure vessel nozzle assembly for seven different conditions, the safe stress value are obtained for all conditions which is less than 50 MPa matched with testing report. The minimum deformation is obtained for 4 Nozzles-90degrees type of pressure vessel combination and also the maximum stress for that is within the acceptable limits.

REFERENCES

[1] E. 0. Bergman, "The Design of Vertical Pressure Vessels Subjected to Applied Forces", *1 ALHAMBRA, CALIF.*

[2] Randall W. Whitesides, "Openings in ASME Code Pressure Vessels", P.E.

[3] Michael A. Porter, Dennis H. Martens, "Stress Evaluation of a Typical Vessel Nozzle Using PVRC 3D Stress Criteria: Guidelines for Application"

[4] Les M. Bildy, "A Proposed Method for Finding Stress and Allowable Pressure in Cylinders with Radial Nozzles"

[5] T. P. Pastor, D. A. Osage, "Modernization of Pressure Vessel Design Codes", *ASME Journal of Pressure Vessel Technology*, Section VIII, Division 2, 2007.

[6] Jorge E. Magoia, Alberto D. Abbate, "Structural Analysis ff RRRP Reflector Vessel", 18th *International Conference on Structural Mechanics in Reactor Technology*, Beijing, China, August 7-12, 2005.

[7] Manfred Staat, Marcus Schwartz, "Design By Analysis Of Pressure Components By Non–Linear Optimization", *Proceedings ICPVT-10, Vienna , Austria,* 2003.

