International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 6, Nov-Dec-2019, ISSN (Online): 2395-566X

Survey on Stress Analysis and Design Optimization of A Pressure Vessel using Ansys

M.Tech. Scholar Nitesh Katiyar Assistant Professor Ranjeet Kumar
Department of Mechanical Engineering,
Vaishnavi Institute of Technology & Science
Bhopal , M.P, India

***Abstract* - Pressure vessels are a commonly used device in marine engineering. Until recently the primary analysis method had been hand calculations and empirical curves. New computer advances have made finite element analysis (FEA) a practical tool in the study of pressure vessels, especially in determining stresses in local areas such as penetrations, O-ring grooves and other areas difficult to analyze by hand. This project set out to explore applicable methods using finite element analysis in pressure vessel analysis.**

***Keywords* - FEM, Presser vessel, Pressure, fuel, Boundary conditions.**

I. INTRODUCTION

Pressure vessels are leak proof containers used to hold gases or liquids at a pressure different from the ambient pressure. The end caps fitted to the cylindrical body are known as heads. Pressure vessels are used in various fields such as chemical industry, pharmaceutical industry, oil and fuel industry, and plastic industry. Other example of pressure vessels are diving cylinder, recompressed chamber, distillation towers, nuclear reactor vessel, hydraulic reservoir and storage vessels for liquefied gases such as ammonia and chlorine.

Pressure vessels are boilers and storage tanks that contain liquid or gases and are designed to operate at pressure above 15 psi. A boiler is defined as a welded container or a pipe arrangement in which steam or hot water with a temperature exceeding 120°C is generated by the application of heat, resulting from the combusting of fuel (solid, liquid or gaseous)or from hot combustion gases. The mechanical design of most pressure vessels is done in accordance with the requirements contained in the ASME Boiler and Pressure Vessel Code.

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.

The pressure vessels are designed with great care because rupture of pressure vessels means an explosion which may cause loss of life and property. The material of pressure vessels may be brittle such that cast iron or ductile such as mild steel. Cylindrical or spherical pressure vessels are commonly used in industry to carry both liquids and gases under pressure. When the pressure vessel is exposed to this pressure, the material comprising the vessel is subjected to pressure loading, and hence stresses, from all directions. 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.

II. LITERATURE SURVEY

Riddhish et al. (2019) had done 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

© 2019 IJSRET

development in the pressure wall critical points are analyzed by using ANSYS13 and an optimized model is modelled 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.

Niranjana et al. (2018) designed a pressure vessel using ASME section VIII and Division 2, designing a closed container to find the required thickness of the shell, head, nozzle and leg support. Uniform thickness assigned to the entire vessel, modeling of the pressure vessel is carried out using Pro-e 2.0; meshing is carried out using Hypermesh 6.1. Here we used 2D Quad element for the meshing, Analysis is carried out using ANSYS Software 11 for two different cases, working pressure and Maximum operating pressure, fatigue analysis is carried out, and the result is 106 . Finally, theoretical validation is carried out for the entire model, and the results are within the limit.

Suresh et al.(2018) The improvement in the area of various types of composites revolutionized and brought many changes in the areas of engineering products, manufacturing processes, material processing for various applications, industrial equipment manufacturing, aerospace parts and vehicles manufacturing, defense applications, etc. Due to their light weight and high strength to weight ratio, their applications in the manufacturing of pressure vessels also increased but are limited to small-scale only due to the production cost of the composites.
In order to produce the composites at low cost which can meet the standards of the materials used for pressure vessel construction and to sustain at working conditions of pressure vessels such as high pressure and temperature this paper aims at developing an epoxy composite reinforced with recycled ceramics particles and analyses the pressure vessel using the properties of the prepared composite using simulation studies and by using Finite Element Analysis (FEA).The Recycled Ceramic Reinforced Composite sample is made and tested in the laboratory for its properties. These obtained properties are assigned in simulation package and the analysis is carried out. The design of pressure vessel is carried out in Solidworks Part Design and the finite element analysis (FEA) and simulations are carried out in Solidworks Simulation.
Borade et al.(2018) Shell and tube heat exchanger are known as the work horse of the chemical process industry and represent the most widely used vehicle for transfer of heat in industrial applications. In this paper, carried out the analysis of eccentric cone which is weld with the shell on both sides with nozzle. The heat exchanger is proprietary product. Finite element analysis is necessary to check the heat exchanger component like eccentric cone whose half apex angle exceeds more than 30 degree.

Pandey et al.(2018) Pressure vessels use has increases gradually all over the world. Pressure vessel and tank are necessary to the chemical firm, petroleum plant, petrochemical analysis station and nuclear power plant. Vessel is in the division of apparatus that the response, division and keeping storage of raw material happen. The objective of the present review paper is to study the effect of various parameters, due to those pressure vessels can break or fail to get higher performance on the basis of previous research study.

Parkhe et al.(2018),Pressure vessel is a container used to store fluids under pressure and temperature. The fluids can be air, water, chemicals, fuel; gases etc. are most commonly used in food and chemical industries, oil refineries and so on. Pressure vessel is subjected to thermal and structural loads for power plant applications. Since the pressure vessel are subjected to both structural and thermal loads stresses, the design of pressure vessel was done using standard code and design methods. In this paper a design methodology is developed for pressure vessel used in Coker Blow-down application based on ASME Section VIII, Division 1 design code. The design methodology has been developed and the same is verified with numerical method so that it will not fail in case of variable pressure and temperature condition. The modelling has been done using SolidWorks-2015 and analysis is done using ANSYS.

Siva et al. (2017) had done design and analysis of pressure vessel. While 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 Ansys 15 and an optimized model is modeled to overcome the stresses produced in the vessel. For designing we used Pro-E Creo. Both model parts are designed and analyzed individually with ASME three different materials with the results the best suitable material with good design is developed.

Sadanandam et al. (2017) carried out finite element method is a mathematical technique used to design a fuel carrying vessel and performing the stress analysis. In this the geometrical model is created and the model is sub divided into smaller elements. It is subjected to internal pressure and these Boundary conditions are applied at

© 2019 IJSRET

specified points. The aim of this paper is to design a model and analysis of fuel carrying tank using finite element analysis software and also select a proper material composition for pressure vessel. Designing is validated according to maximum principal stress theory and Distortion theory by taking design factor or factor of safety. The comparisons also made between the calculation results and software results.

Nagendra et al. (2017) design spherical pressure vessel by using pro-e and the analysis is done by using ansys. Here two models are generated one is solid walled which is regularly used and another one is multi layered pressure vessel. And the analysis is done on the two models by changing the actual material with the composite material. The results are compared actual solid model with the multi layered pressure vessel and the comparison further extended to find the better material for that the actual material results of the model is compared with the composite material results. By the comparison we may find better design and the design proposed to the company.

Sahu and Nagpal (2017) carried outdetailed design & analysis of a pressure vessel for the application of air storage. It is a low pressure vessel since the internal pressure is 1.48 MPa. In this research paper geometrical and finite element model of pressure vessel (for air storage application) has been done using ANSYS 15.0 software. Optimization process has been also applied using ANSYS 15.0 by screening method.

Kumar M et al. (2017) Pressure vessels are the most used storage equipment in the industrial engineering. They also find wide usage in the process and other mechanical manufacturing industry. The pressure vessels are subjected to varied type of loads and need to be checked for structural safety to prevent any possible failure. Present technology has the advantage of checking the structural safety by virtual simulation without going for costlier destructive experimental techniques.

Bhinde et al.(2017)— Design of head in pressure vessels is a challenging task. Different types of heads or ends can be provided for a pressure vessel. This paper deals with the Finite element analysis of Pressure vessels with different type of end closures (head) keeping the same cylindrical volume and thickness. The desired pressure vessel is designed as per ASME standard section VIII, division I for 120 bar pressure. In this work, a comparative study of different types of pressure vessel heads is discussed. The purpose of the work is to find out the best possible end closure out of Torispherical head, Elliptical head, hemispherical head and conical head. A finite element method based software ANSYS is used to observe the stresses in these heads.

III. FINITE ELEMENT ANALYSIS OF THE PRESSURE VESSEL

An ANSYS command file was written based on the design data of a real-world pressure vessel equipment provided. This script file is executed in ANSYS APDL v17.0 to generate the geometrical entities such as key points, lines, areas and volumes. The ANSYS model as shown in figure-1.3 below represents an axis symmetric cylindrical pressure vessel used in chemical industries that is approximately 6 meter-long and 2 meter-wide, with elliptical heads and four rectangular nozzles supported by the flange. Due to symmetry of the vessel along the z-plane, we consider only half model for our analysis. This saves a lot of computational time during the FEA as well as during the optimization process. A full model displayed in figure-1 can be used for FEA, in case, when large amount of memory (RAM) along with sufficient hardware and software resources are available, or when the computational time is not an issue.

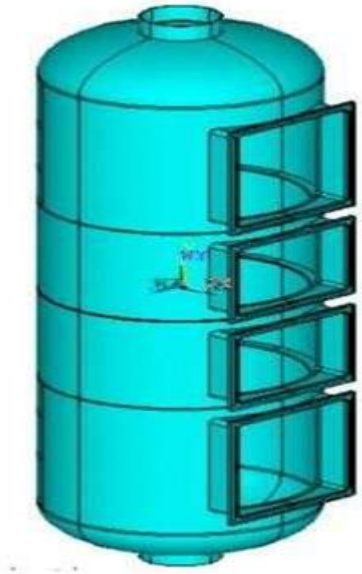

Fig.1. Pressure Vessel full-model.

IV. CONCLUSION

In the industrial sector, the pressure vessels are used as storage tanks, diving cylinder, recompression chamber, distillation towers, autoclaves and many other vessels in mining or oil refineries and petrochemical plants, nuclear reactor vessel, habitat of a space ship, habitat of a submarine, pneumatic reservoir, hydraulic reservoir under pressure, rail vehicle airbrake reservoir, road vehicle airbrake reservoir and storage vessels for liquefied gases. The design analysis of pressure vessels is an important and practical topic which has been

© 2019 IJSRET

investigated for decades. Even though optimization techniques have been extensively applied to design structures in general, very few pieces of work can be found which are directly related to optimization of pressure vessels by interfacing different software packages like ANSYS. These few references include the design optimization of homogeneous as well as composite pressure vessels with different optimization methods.

REFERENCES

[1]. Di Carluccio , G. Fabbrocino , E. Salzano , G. Manfredi (2012), Analysis Of Pressurized Horizontal Vessels Under Seismic Excitation, World Conference On Earthquake Engineering,Pp 1-8

[2]. Ankush A. Wagawad ,. B. Jadhav (2009), Weld Fatigue Stress Evaluation Of Pressure Vessel Nozzle Joint With FEA & Experimental Approach, International Engineering Research Journal ,Pp 789-793

[3]. Arunkumar.M, H.S.Manjunath, Amithkumar.S.N (2017), Design of pressure vessel using ASME codes and a comparative Analysis using FEA, International Research Journal of Engineering and Technology, 4(11), 617-625.

[4]. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 2011a Addenda, American Society of Mechanical Engineers.

[5]. Siva kumar, P. Prasanna, J. Sushma, K.P. Srikanth (2017), Stress Analysis and Design Optimization of A Pressure Vessel Using Ansys Package, Materials Today: Proceedings 5 (2018) 4551–4562.

[6]. BhagatsinhVerma,AnkurMalviya (2016), Design Optimization and Fabrication of a Low Pressure Vessel, International Journal for Scientific Research & Development| Vol. 4, Issue 06, 28-33.

[7]. Chaudhari Riddhish, Damale Rahul, Bhujbal Anurag, Borage Prashant, RutukeshBhosale (2019), Design and Analysis of Pressure Vessel Using Software, International Research Journal of Engineering and Technology, 6(4), 2505-2508.

[8]. Deval Nitin Bhinde, Rajanarsimha S.(2017), Fea Analysis Of Pressure Vessel Withdifferent Type Of End Connections, Journal Of Emerging Technologies And Innovative Research, Volume 4, Issue 02 Pp 1-5

[9]. Dilip M. Patel, Dr. Bimlesh Kumar(2014), Pressure Vessel Limit Load Estimation By FEM And Experimental Method, International Journal Of Innovative Research In Advanced Engineering, Volume 1 Issue 9 Pp 109-114.

[10]. G .Nagendra, G Bhemanna, Dr P Sampath Rao (2017), Design & Analysis of Industrial Spherical Pressure Vessel Using FEA, International Journal Of Innovative Research in Technology, 3(8), 100-115.

© 2019 IJSRET