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A REVIEW ON STRESS CONCENTRATION FACTOR OF COMPOSITE PRESSURE VESSEL

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ABSTRACT:

This paper reviews some of the current developments in the determination of stress concentration factor of composite pressure vessel at openings. The literature has indicated a growing interest in the field of stress concentration analysis of the composite pressure vessels. In this we analyze the stress concentration occurring at the openings of the composite pressure vessels and the mean to reduce the effect of the same.

Keywords: *openings, stress concentration, stress concentration factor, stress analysis, pressure vessel*

I.INTRODUCTION:

Pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Tanks, vessel and pipelines that carry, store or receive fluids are called pressure vessel. The inside pressure is usually higher than the outside. Pressure vessels are usually spherical or cylindrical with dome end. Pressure vessel cylinders find wide applications in thermal and nuclear power plants, process and chemical industries, in space and ocean depths, and fluid supply systems in industries. The fluid inside the vessel may undergo a change in state as in the case of steam boiler or may combine with other reagent as in the case of chemical reactor. Pressure vessel often has a combination of high pressure together with high temperature and in some cases flammable fluids or highly radioactive material. Because of such hazards it is imperative that the design be such that no leakage can occur. In addition vessel has to be design carefully to cope with the operating temperature and pressure.

The structural model to be analyzed is divided into many small pieces of simple shapes called elements. Finite Element Analysis (FEA) program writes the equations governing the behaviour of each element taking into consideration its connectivity to other elements through nodes. These equations relate the unknowns, for example displacements in stress analysis, to known material properties, restraints and loads. The program assembles the equations into a large set of simultaneous algebraic equations - thousands or even millions. These equations are then solved by the program to obtain the stress distribution for the entire model.

II. LITERATURE REVIEW:

The research papers related to the present work on pressure vessel are discussed,

Apurva R. Pendbhaje[1] has presented the work on design and analysis of pressure vessel. This paper presents design, and analysis of pressure vessel. High pressure rise is developed in the pressure vessel and pressure vessel has to withstand severe forces. In the design of pressure vessel safety is the primary consideration, due the potential impact of possible accident. There have a few main factors to design the safe pressure vessel. This paper is focusing on analyzing the safety parameter for allowable working pressure. Allowable working pressures are calculated by using Pressure Vessel Design Manual by ASME codes. The corruption of the vessel are probability occur at maximum pressure which is the element that only can sustain that pressure. Efforts are made in this paper to design the pressure vessel using ASME codes & standards to legalize the design.

Rao Yarrapragada K.S.S. [2] has presented the work on composite pressure vessel. Cylindrical pressure vessels are widely used for commercial, under water vehicles and in aerospace applications. At present the outer shells of the pressure vessels are made up of conventional metals like steels and aluminum alloys. The payload performance/ speed/ operating range depends upon the weight. The lower the weight the better the performance, one way of reducing the weight is by reducing the weight of the shell structure. The use of composite materials improves the performance of the vessel and offers a significant amount of material savings. Moreover, the stacking sequence is very crucial to the strength of the composite material. A graphical analysis is presented to find optimum fiber orientation for given layer thicknesses. In the present work, an analytical model is developed for the Prediction of the minimum buckling load with / without stiffener composite shell of continuous angle ply laminas (±45°,±55°,±65°,±75°,±85°) for investigation. A 3-D finite element analysis is built using ANSYS-12.0 version software into consideration, for static and buckling analysis on the pressure vessel.

Patel Dharmin [3] has presented the work on stress analysis of an infinite plate with cut-outs. In this paper study made on the "stress analysis of an infinite plate with cut-outs". A number of analytical and experimental techniques are available for stress analysis around the different types of cutouts for different condition in an infinite plate, made up of different materials under different loading condition has been reported in this paper. The methods compared are tabulated with their findings. Singularities of circular hole in rectangular plate and elliptical hole in rectangular plate are considered in this study.

Mukund kavekar[4] has presented the work on Wt. reduction of pressure vessel using FRP composite material. Pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. The metallic pressure vessels are having more strength but due to their high weight to strength ratio and corrosive properties they are least preferred in aerospace as well as oil and gas industries. These industries are in need of pressure vessels which will have low weight to strength ratio without affecting the strength. On the other hand FRP (Fiber reinforced plastic) composite materials with their higher specific strength characteristics will result in reduction of weight of the structure. E-Glass Filament-wound composite pressure vessels are an important type of high-pressure container that is widely used in the commercial and aerospace industries. On the other hand FRP composite materials with their higher specific

strength characteristics will result in reduction of weight of the structure. On the basis of analysis it is found that FRP pressure vessel has more strength than steel pressure vessel and it is also concluded that the pressure inside the vessel can be reduced up to 75 % by replacing steel with FRP material.

Avinash R. Kharat[5] has presented the work on Analysis of Stress Concentration at Opening in Pressure Vessel Using Anova. Pressure vessels are used for storage, transportation and application of energy and fluids and also for carrying out reactions and many other purposes. Openings in tanks and pressure vessels are necessary to carry on normal operations. Openings are generally made in both vessel shells as well as heads. Unfortunately, these openings also result in penetrations of the pressure restraining boundaries and are seen as discontinuities. Nozzles represent one of the most common causes for stress concentration in pressure vessels and stress concentration factors can be very useful in pressure vessel design. Finite Element Analysis is very efficient method for determination of stress concentration factors; however reliability of Finite Element Analysis should always be assessed.

The analysis of variance method is used to serve the relation between nozzle size and stress produce in the nozzle area. To reduce the errors in the experimental result the randomize sequence method is used. To test the influence of the both parameters that is opening diameter and internal pressure on each other the randomized test sequencing is generated and experimental test is conducted to investigate the stress distribution near opening area.

Pravinkumar Nase[6] has presented the work on Analysis of Pressure vessel. Pressure vessel cylinders find wide applications in thermal and nuclear power plants, process and chemical industries, in space and ocean depths, and fluid supply systems in industries. The failure of pressure vessel may result in loss of life, health hazards and damage of property. It will be shown that an appropriate location and size of the opening in a pressure vessel results in minimizing the stresses induced due to the stress concentration resulting from the end flanges and other attachments. Also design and optimize the spherical and elliptical head profile with hole on the head, also Analysis the above profiles for various stress parameter.

Babulal K. S. [7] has presented the work on SCF on isotropic rectangular plate with central circular hole. Effect of stretching of an isotropic rectangular plate with centrally located circular hole under uniform tensile load. A loaded plate with the presence of hole creates stress concentration near the hole which is much larger than the average stress on the plate. The stress concentration factor has been calculated by using both analytical and finite element methods. Solidworks simulation is used for modeling and static analysis of linear elastic isotropic plate of size 500 x 300 x 25 mm, made up of AISI 4340 steel. The uniform tensile load of magnitude of 50 Mpa is applied on two opposite sides of rectangular steel plate with three different hole to width ratio of 0.2, 0.4 and 0.6 and the error percentage for finding SCF between analytical and finite element method are 4.8 %, 2.9 % and 4.7 % respectively.

Sreelakshmi Das. [8] has presented the work on the FEA of Cylindrical Pressure Vessels with Different Radius of Openings. Pressure vessels have to be designed in such a way that they are able to bear high pressure and extreme level of temperature. In pressure vessels openings are required for inlet and outlet purposes. These openings can cause geometric discontinuity of the vessel wall, so a stress concentration is created around the opening. Hence a detailed analysis is required. In this study behaviour of a cylindrical pressure vessel wall for

increasing diameter of holes are considered to find out the diameter of opening with minimum stress concentration. The pressure vessels shall be analyzed by using PreWin, a graphical pre and post processor for the structural analysis software FEAST (Finite Element Analysis of Structures) and the results are compared with the analytical solutions and the results obtained using ANSYS.

A. Devaraju [9] has presented the work on the A Study On Stress Analysis For Design Of Pressure Vessel. Pressure vessel is a leak proof vessel which has two important functions viz. It should be failure free container and it should separate the gas and liquid. Pressure vessels are very often in spherical, cylindrical and cylindrical shells with hemispherical end shapes. Main part of cylindrical pressure vessel is shell and head. When the pressure vessel is in operation, it is subjected to different pressures which lead to stress. It is due to internal pressure and different loads because of self weight and fluid weight. Normally, the stresses will be acted on vessel wall. If vessels could not retain its strength, wall material exceeds the maximum allowable limit which leads to failure. Therefore, it is important to understood and quantify (resolve) the stresses. The main objective of this paper is to design the standard cylindrical pressure vessel and calculate the stresses induced in the various part of the vessel by manually and compare these results with the ANSYS results.

K. Santa Rao. [10] has presented the work on the analysis of Epoxy composite rectangular plate with circular hole. The composite is a structural material that consists of two or more combined constituents that are combined at a microscopic level and are not soluble in each other to increase the strength of the material. Epoxy resins are widely used for most advanced composites. Composite epoxy materials are a group of composite materials typically made from woven glass fabric surfaces and non-woven glass core combined with epoxy synthetic resin. They are typically used in printed circuit board. In the present work, an attempt is made to design the graphite / epoxy composite plate. A rectangular plate is designed with concentric circular hole and four loads are applied to determine stresses induced. Further, analytical results are validated with FEA results.

Shyam Lohar [11] has presented the work on Design of E-Glass Fibre Rain forced Plastic Pressure Vessel Design as per ASME Sec X. One Glass Fiber Reinforced Plastic pressure vessel, subjected to internal design pressure of 90 psi was designed in accordance with the procedures set out in ASME Section X, mandatory design rules for class II vessels with Method A Design Rules. Destructive testing was done to find out the modulus of elasticity and flexural modulus as per ASTM D 3039. All the design factors were considered and designed the safe pressure vessel.

Dr.Abdul siddique shaik [12] has represented the work on Stress Concentration of Rectangular Plate with a Hole Made with Composite Material Using Finite Element Analysis. A rectangular plate with a central hole have initiate extensive practical applications in different fields of engineering such as aerospace, marine, automobile and mechanical and is well-known to most engineers. High stress due to discontinuity or abrupt change in geometry is known as stress concentration and is mostly set up at the edges of discontinuity. A stress concentration is typically introduced in plates in the form of circular holes. For the design of plate with a hole, proper knowledge of stresses and stress concentration factor (SCF) at the edge of hole under in plane loading are essential. In this project an attempt is made to review the investigations that have been made on the “stress analysis of a rectangular plate with circular hole”. Finite Element simulations using Ansys have been done for stress analysis around the circular hole, made up of different materials. The materials considered are composite

material i.e. carbon / epoxy and also with mild steel. Keywords: Stress concentration factor, Finite element analysis, Carbon / epoxy.

Amol Mali [13] has presented the work on study of pressure vessel, design and analysis. Pressure vessels are containers used to handle fluids which are highly toxic, compressible and which work at high pressures. Pressure vessels have applications in variety of industries such as Oil and Gas, Petroleum, Beverage industries, chemical industries, power generation industries, food industry, etc. Failure of pressure vessels has adverse effects on the surrounding and the industry which can cause loss of life, property and damages. The design of pressure vessel depends on factors such as pressure, temperature, material selected, corrosion, loadings, and many other parameters depending on the applications. The use of Finite Element Methods and Analysis techniques that provide results on failure in pressure vessels are to be studied. The future scope and advancements in pressure vessel design with software's is to be studied.

Anandhu P D [14] has presented the work on Design and Analysis of Horizontal Pressure Vessel and Thickness optimisation. This project deals with design and analysis of horizontal pressure vessel and also thickness optimization of vessel. Pressure vessel is a container for confining fluid at elevated temperature and pressure. In the design of pressure vessel safety is the primary consideration, due the potential impact of possible accidents. Efforts are made in this project to design the pressure vessel using ASME codes & standards to legalize the design. Here we design the pressure vessel with ASME Section VIII, Division 1,2013.Finite element analysis of the pressure vessel has been done in ANSYS. Static structural analysis of the vessel has been done by applying the internal pressure, standard earth gravity, and also by fixing both the legs. Thickness optimisation of the pressure vessel is also done in ANSYS.

CONCLUSION:

Findings:

This analyzing the safety parameter for allowable working pressure.

The lower the weight the better the performance, one way of reducing the weight is by reducing the weight of the shell structure.

On the basis of analysis it is found that FRP pressure vessel has more strength than steel pressure vessel and it is also concluded that the pressure inside the vessel can be reduced up to 75 % by replacing steel with FRP material.

It will be shown that an appropriate location and size of the opening in a pressure vessel results in minimizing the stresses induced due to the stress concentration resulting from the end flanges and other attachments.

A loaded plate with the presence of hole creates stress concentration near the hole which is much larger than the average stress on the plate.

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