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Finite Element Analysis of Gasket in Pressure Vessel

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***Abstract:** Pressure vessel is a closed container designed to hold liquids or gases at a pressure which are higher than the surrounding atmospheric pressure. These pressure vessels are not made as a single component but manufacture with an assembly of many other components and connected through bolted joints or riveted joints or welded joints.*
These joints are susceptible to failure and cause leakage of the liquid or gas which are very dangerous and sometimes causes heavy loss of life, health and property. Hence proper care has to be taken during the design analysis processes by following ASME section VIII division 1 which specifies the design-by-formula approach while division 2 contains a set of alternative rules based on design by Analysis (FEA) to determine the expected deformation and stresses that may develop during operation. The ASME section-VIII division-2 standards are used for the design of pressure vessel.
Leakage in gasketed flanged joints have always been a great problem for the process industry. The sealing performance of a gasketed flanged joints depends on its installation and applied loading conditions. The present project work involves the design procedure and stress analysis (Structural Analysis) for the leak proof pressure vessel at the gasket under three different gasket conditions.
***Keywords:** 1. FEM, 2. ASME, 3. ANSYS, 4. Gasket,5. Displacement,6. Stress*

I. INTRODUCTION

A pressure vessel is a container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Pressure vessels can be dangerous, and fatal accidents have occurred in the history of their development and operation. The pressure vessel referred to those reservoirs or containers, which are subjected to internal or external pressure. The pressure vessels are used to store fluids under pressure. The fluid being stored may undergo a change of state inside vessels as in case of steam boilers or it may combine with other reagents as in chemical plants. These types of vessels are mostly used in oil and petroleum and chemical industry for storage purposes. Pressure vessels have wide applications in chemical industries, thermal and nuclear power plants, process, pharmaceutical industries, and food and beverages industries. The failure of pressure vessel may result in loss of life, health hazards and damage of property high pressure is developed in pressure vessel so pressure vessel has to withstand several forces developed due to internal pressure, so selection of pressure vessel is most critical, ASME standards is most widely used for design ASME section VIII, Division I and Division II are normally used in design. The pressure vessel whenever expansion or contraction occurs normally as result of heating or cooling, thermal stresses are developed. There are many types of stresses developed in the vessel, Stresses are categorized into primary stresses and secondary stresses. Primary stresses are because of pressure inside pressure vessel and secondary stresses are because of thermal loading and Thermal loading is considerable in a pressure vessel due to handling of hot fluids in vessels. Since the pressure in the vessel is high, it has to withstand both thermal as well as structural loadings. The majority of pressure vessels are for industrial use. Some private sector uses include hot water storage tanks and diving cylinders. Industrial uses for pressure vessels include distillation towers, hydraulic reservoirs, and containment of liquefied gases.

II. REVIEW OF LITERATURE

Bertini, Beghini (2001) conducted the study and proposed that the use of a gasket made in soft material is not recommended for large size centrifugal compressor case flange. The two halves are assembled with bolted flanges and leakage is prevented by the metal-to-metal contact under pressure. The flange surfaces interface is regarded as a crack which can be partially open. As the flanges cannot transfer tensile traction, the extension of the open zone, i.e. the crack length is obtained by the condition that the stress Intensity factor K is zero. Hector Estrada (2009) studied the evolution of leakage using detailed contact finite element analysis and analysed the distribution of stress at the gasket using a contact condition based on slide-line elements using FEM, a commercial finite element code. Slide-line elements also take into account pressure penetration as contact that is lost between flange and gasket. And he presented the results for a particular flange, a raised face flange sealed by a mild steel gasket. P Mertiny (2009) further concluded that the Pressure-retaining structures made from fibre-reinforced polymer composites (FRPC) are increasingly being used in industrial applications. Composite pipes and vessels offer advantageous properties compared to conventional metallic components, including higher strength-to-weight ratio and superior corrosion resistance.

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Structures may sustain high pressurization and external loadings. Methods for analysing fibre-dominated damage modes in composites are relatively well established, which allows for the reasonable prediction of associated structural failures (e.g. burst). However, composite pipes and vessels may also be subject to so-called 'weepage' failures caused by micro-damage within the polymer matrix phase. Hence he concluded need for advanced methodologies to suitably describe leakage damage in pressurized composite structures. Jaeminlee and Hyun Chung (2017) conducted the case study on the prismatic pressure vessels for on-ship application and made use of the Engineering authorities guide that codes for a novel concept design such as a prismatic pressure vessel using a design by analysis. DBA methods enable high efficiency because they directly calculate the loads to avoid inherent conservativeness that exists in a design by rule (DBR). However, in DBA methods, the designer should conduct a finite element analysis (FEA) and evaluate the results iteratively to meet the design criteria. The results show that the proposed method can effectively estimate the required minimum shell thickness and designed vapor pressure without conducting an iterative FEA. In addition, minimization of the tank shell thickness is made possible because the proposed method directly calculates the crack propagation rate to avoid an unnecessary margin while satisfying the fatigue crack propagation criteria.

III. OBJECTIVES OF THE STUDY

Gasket are used in pressure vessel as joints to seal the flanges. Coventional gasket flanged joints are widely used in oil and gas and process industries for connecting pressure vessel for Bolted flanged joints the two main concerns are joint strength and sealing capability. In the project, we have considered three different gasket geometry that are quadrilateral, circle and ellipse. These three conditions give the analysis about stress at the gasket region of the pressure vessel.

1) To avoid the leakage at gasket.
2) Ascertaining the appropriateness of gasket for various purposes.
3) To design evaluated pressure vessel, according to load applied.
4) Analysis helps in wasteage of resources.
5) To use the best geometry gasket.

IV. METHODOLOGY

Solid model of pressure vessel will be is created by using Design Modeller of ANSYS program. For given loading and boundary conditions, the deformation and stress developed at the joints are analysed using mechanical workbench of ANSYS software. Guidance concerning the suitability of material used for pressurised parts of the pressure vessel has been provided in ASME section VIII division 2. Suitable materials for seal at the junction for leak proof will be decided based on the analysis.

Pressure vessel is designed using ASME analytical formulae for the dimensions of each component. Static analysis will be carried out to evaluate the leak proof performance. Stress linearization results for different load cases will be analysed and limit verification is performed as per ASME section VIII division 2.

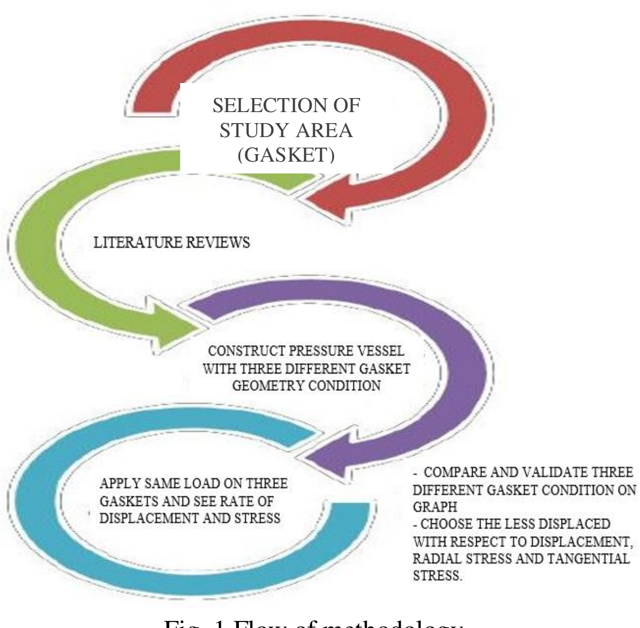

Fig. 1 Flow of methodology.

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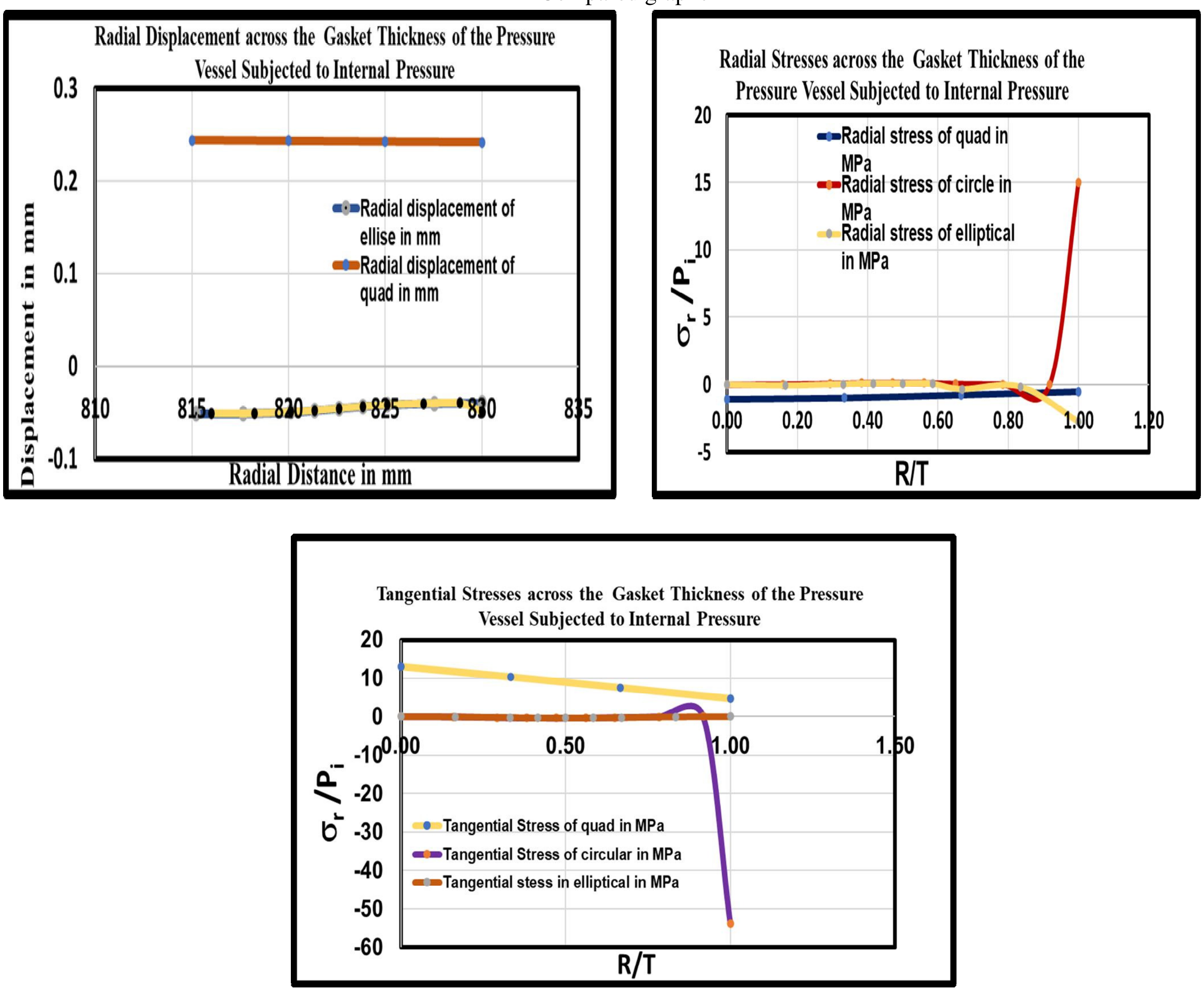
Steps involved in analysis of pressure vessel

1) Creating the geometric model by creating keypoints and lines.
2) The area is created by selecting the line arbitrarily.
3) Then the meshing is done by giving some size control and thus the elements and nodes are created, the gasket is assigned different material property than that of the cylinder material.
4) The boundary conditions and the loading is applied (2.5 Mpa) to the element and the solution is generated.
5) Obtaining the results (radial displacement, radial stress, tangential stress)
6) Plot the graph (three different gasket conditions)
7) Compare the graph

Compared graphs



V. CONCLUSION

A. Comparing the finite element analysis results with the design values found in the ASME code and using lames equation.

B. We have obtained the results by modeling the pressure vessel in ANSYS using Plane 183 element, next material properties for steel and elastomers are assigned, first we have created keypoints, then created lines followed by areas, then we give fine mesh to get exact results.

C. From these graphs we can conclude that elliptical gasket is comparatively better**,** as it is less deformed comparatively from quad and circular gasket.

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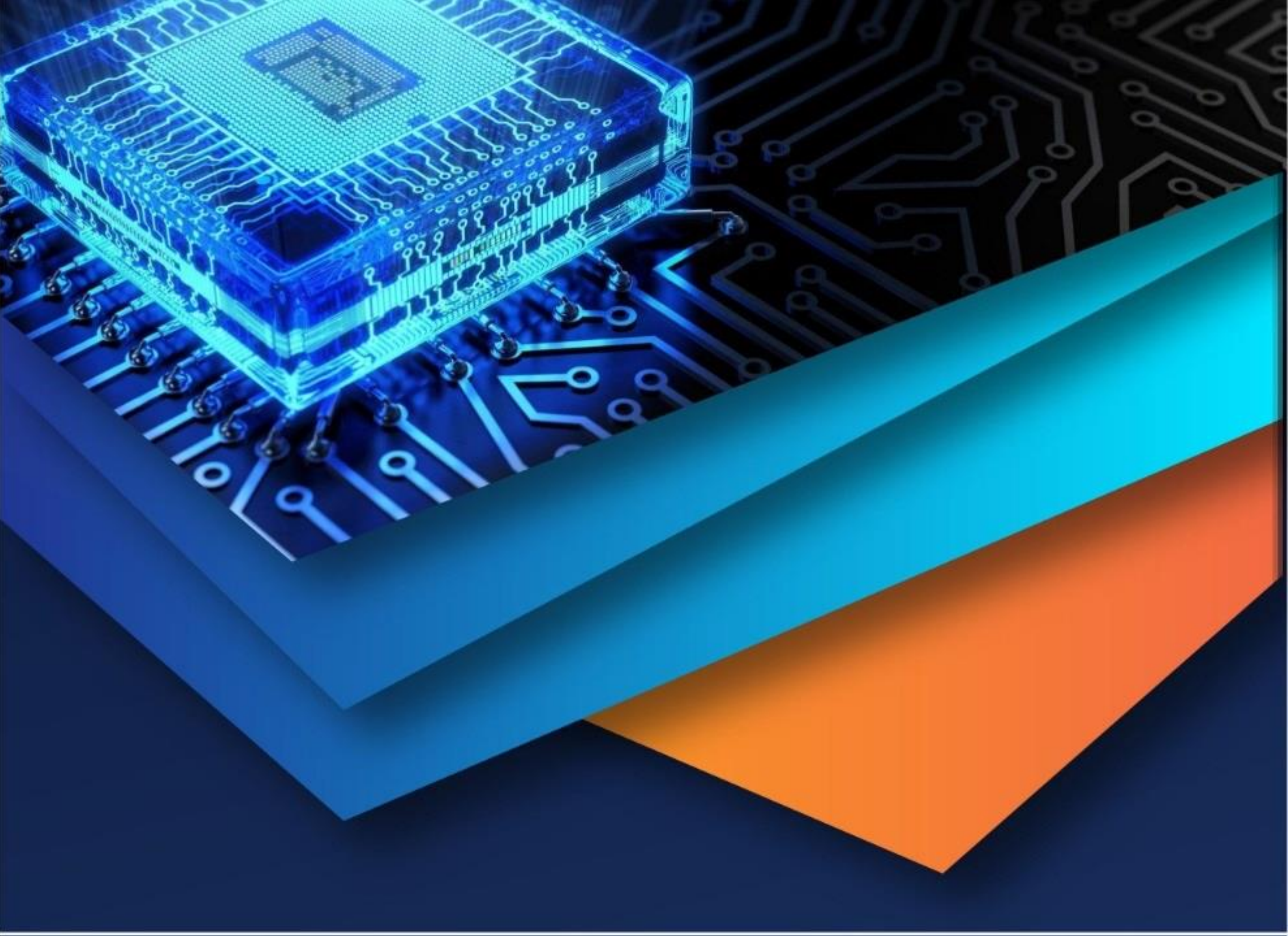

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