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STRESS CONCENTRATION FACTOR AT THE JUNCTION OF SHELL TO NOZZLE - Review

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Abstract

Pressure vessels are used to stored fluid or gases with the required pressure for necessary process. In pressure vessel nozzle is used to inlet and outlet of fluid; it is the passage of uniformly varying cross-section in which velocity increase. In pressure, vessel weakened by at the junction of shell to nozzle. The higher stress around the nozzle –shell junction due to internal pressure, temperature and external load. At junction of shell to nozzle there is higher stress concentrated in that area that is cause to part fail. Stress concentration is defined as localized stress considerably higher than average due to abrupt change in geometry .Geometry discontinuity cause stress increase. The effect of stress concentration to determine by dimensionless factor called stress concentration factor (Kt). The determine of S.F.C is ratio of maximum stress and nominal stress.

Keywords*- pressure vessel, nozzle, stress concentration, stress concentration factor,*

I. INTRODUCTION

Pressure vessels uses large applications in thermal and nuclear power plants, process and chemical industries, and fluid supply and storage systems in industries. The failure of pressure vessel may occur loss of human life’s, health hazards and damage of property. Due to application l requirements, pressure vessels are often connecting with openings of various shapes, sizes and positions. Vessels have openings like manholes, handholds, and nozzles. Openings having different in size from small drain nozzles to full vessel size openings with flanges. The openings main function is connect the pipes, inlet and outlet fluid or any other application as required .They allow for the mounting of equipment, the insertion of instrumentation, and the connection of piping facilitating the introduction and extraction of content but they also lead to the high stress concentration which leads to the failure of pressure vessel. Geometric discontinuities at the junction of shell to nozzle such discontinuities in a part can cause a large rise in stress above the nominal P/A value. The junction of shell to nozzle area where the maximum stress concentration .These geometric discontinuities alter that the stress distribution in the neighborhood of discontinuity so that elementary stress equations no longer prevails. These discontinuities are called “stress raisers” and the regions in which they occur are called the areas of stress concentrations.

In this paper the research of various researchers in determines of stress concentration at the junction of shell to nozzle is summarized for design of pressure vessel by using different approaches. The section III-A describes literature review related to junction of shell to nozzle. Where the section II describes literature review about stress concentration and concentration factor and section III describes the literature review about stress concentration factor at junction of shell to nozzle.

II. STRESS CONCENTRATION AND STRESS CONCENTRATION FACTOR

In a cylindrical shell weakened by a hole, the stress distribution caused by an internal pressure, temperature and external load applied to the shell will differ considerably from that in an un-weakened shell. The maximum stress will be much larger if there is a circular hole in the shell than in the case where there is no penetration. This causes the rise in the stress distribution around the hole at the junction of shell to nozzle, to study the effect of stress concentration and magnitude of localized stresses, a dimensionless factor called Stress Concentration Factor (SCF), is used to calculate the stress rising around hole. The determination of S.C.F includes basic concept of engineering like maximum stress and nominal stress. This factor is ratio between the maximum average stress generated in the critical zone of discontinuity at junction and the stress produce over the cross section of that area. Stress concentration factor defined by Kt as defined by

$$Kt = \sigma max/\sigma nom$$

In order to predict the “actual” stress resulting from a geometric stress raiser, a theoretical stress concentration factor is applied to the nominal stress. For a part subjected to a normal stress, the true stress in the immediate neighborhood of the geometric discontinuity is calculated by equation

Characteristics of Stress-Concentration Factors:

1. Function of the geometry or shape of the part, but not its size or material;
2. Function of the type of loading applied to the part (axial, bending or torsion);
3. Function of the specific geometric stress raiser in the part (e.g. fillet radius, hole)
4. Always defined with respect to a particular nominal stress;
5. Typically assumes a linear elastic, homogeneous, isotropic material.

Determination of Kt Value

The stress-concentration factor, associated with a specific geometry and loading condition of a part,Can be derived through experimentation, analysis or computational methods.

1. Experimental Methods. Optical methods, such as photo elasticity, are very dependable and widely used for experimentally determining the stress concentration at a point on a part. However, several alternative methods have been used historically: the grid method, brittle-coating, brittle-model and strain gauge.
2. Analytical Methods. The theory of elasticity can be used to analyze certain geometrical shapes to calculate stress-concentration factors.
3. Computational Methods. Finite-element method provides a powerful and inexpensive computational method of assessing stress-concentration factors.

The literature review was carried out to study about the lubricant core formation in Journal Bearing and its effect on the performance characteristics of Journal bearing. Also the effect on the dynamic characteristics of Journal bearing has been studied that are lubricated with Electro-Rheological and Magneto-Rheological fluids.

III LITERATURE REVIEW OF STRESS CONCENTRATION FACTOR AT THE JUNCTION OF SHELL TO NOZZLE

The maximum stress will be much larger if there is opening in the shell than in the case where there is no penetration. This causes the rise in the stress distribution around the opening to calculate this stress rising around hole the stress concentration factor where mostly used in practice. This section describes the work done by researchers on stress concentration factor at openings in pressure vessels.

[1]J.M. Kihiul (1995) presented works on the hoop stress and stress concentration factor distributions in a closed ended thick-walled shell with a chamfered cross bore under internal pressure. The finite element method is used for this stress analysis study. The effect of changing chamfer angle, for a fixed chamfer size, on the hoop stress and stress concentration factor distributions was investigated. The optimum chamfer angle and chamfer length for any cylinder configuration was find out. The study revealed that adding chamfers to cross bores causes a, redistribution and reduction of the stresses attained in internally pressurized thick-walled cylinders. For thick cylinder of a given thickness ratio and cross bore diameter, it was finding that the stresses were find the minimum in pressure vessel in specific chamfer angle and size

[2]K. Magnucki (2002) presented work on the problem of cylindrical pressure vessel in stress concentration with ellipsoidal heads subject to internal pressure. At the line, where the ellipsoidal head is adjacent to the circular cylindrical shell, a shear stress and bending moment occur, disturbing the membrane stress state in the vessel. It is reported that the degree of stress concentration depends on the ratio of thicknesses of both the adjacent parts of the shells and on the relative convexity of the ellipsoidal head, with the range for radius-to-thickness ratio between 75 and 125. The stress concentration was analytically fined and the effect of these values on the stress concentration ratio was numerically fined.

[3]S. Schindler (2003) worked on the large used stress concentration factors for the radial nozzle to spherical shell connection given in the British Standard Specification for Unfired fusion welded pressure vessels [British Standard Specification for Unfired fusion welded pressure vessels, 2000; Welding Research Bulletin, 1963] are examined and contrasted with recent Finite Element analysis simulations. Example graphs showing the possible improvement, with regard to accuracy, and also with regard to other improvement concerned to cyclic fatigue calculations.

[4]sYou-Hong Liu (2004) presented work on Limit pressures and corresponding maximum Stress Concentration Factors (SCF) for two orthogonally intersecting thin-walled cylindrical shells under internal pressure. The local membrane SCF at the intersections of two cylindrical shells subjected to the limit pressure load is fined by elastic thin shell theoretical solutions. Three dimensional finite element analysis using ANSYS in which the material is elastic-perfectly plastic is used. From result found that the local membrane SCF decreases significantly as t/T value increases, and decreases little d/ √DT decreases when D/T value is fixed. The local membrane SCF increases significantly as D/T increases, and varies little as d/ √DT increases when t/T value is constant.

[5]J.M. Kihiu (2006) worked on three-dimensional finite element computer program to establish the stress distributions and stress concentration factors in chamfered cross-bored cylinders under internal pressure. In optimal chamfered cylinders with thickness ratio between 2.25 and 3, the SCF was found to increase by decrease of thickness ratio. In Thick cylinders were found to be more adjusted to chamfering than thin cylinders. The resulting data in this work provides a useful to design tool pressure vessel

[6]Kh. Fuad (2007) worked on analyzed the stress concentration factor (SCF) of adjacent holes in a spherical pressure vessel of thin plate undergoing hydrostatic stresses. Analysis the SCF of various adjacent holes configurations in a spherical pressure vessel used finite element analysis based on the Von Mises stresses. Various arrangements of adjacent holes are investigate in pressure vessel. The results showed that the decreasing of L/d will affect the increasing of SCF in case of five adjacent holes configuration, the increasing of D/T doesn't make any significant effect to the increasing of SCF.

[7]Dwight Snowberger (2008) worked on the effect of an elliptical hole on the stress distribution in a flat plate. The analysis done out using ANSYS for a flat plate with a circular hole and an elliptical hole and finding that the elliptical equations can be used for the case when the ellipse converted in circle.

[8]M. Qadir (2009) presented work on SCF analysis of a pressurized vessel–nozzle junction with wall thinning damage. The significant observations was the systematic increase in the SCF value with an increase in the diameter ratio d/D, for a specified vessel diameter-thickness ratio D/T. It noted that for a specified d/D ratio, the SCF value increases as the D/T ratio is increased.

IV. SUMMARY OF THE LITERATURE REVIEW

Form the literature review it is seen that ASME and other codes are provided solutions for more general cases and requires more factor of safety. Also limit load and stress concentration formulas are not available for non standard shapes, sizes, intersections and geometrical discontinuity. The code does not also consider for openings in thin pressure vessels but some researchers have works on that openings in thin pressure vessel are changing stress concentration value by considerable amount. Most of the researchers have worked on thick pressure vessels, few researchers have worked in thin-pressure vessels and there is scope in studying the junction in thin pressure vessels. Some researchers studied the effect of discontinuity in flat plate with the hole/junction in uni axial and biaxial stresses which gives the basic idea about the stress and loading effect at point of discontinuity. Most of them have used parametric method to study the effect of the different design parameter like thickness, diameter of the cylinder/shell, opening size. The factors analytical methods used by some

researchers basically used the flat plate theory and stress concentration factor or elastic-plastic limit load study. Most of the researchers have used to experimental method in which the results are obtained directly.
From above literature survey presented that study of the effect of change in size, position, location of the openings in pressure vessel to study the stress concentration is essential. The position, sizes, location of the opening on cylinder is not studied in past by researchers and there is no code provision for such design. For such problems codes are suggesting use of DBA (Design by analysis) that includes non linearity. Majority of research have preferred design by analysis than design by code. This approach is help in simulating the exact modes of failure in pressure vessel. From the above literature it is also seen that the finite element method was used by most of the researchers to compared the analytical and experimental results. So it is clear that finite element method is the efficient method to use for simulating the effect in pressure vessel.

V.CONCLUSION

Stress Concentration is very important factors to be studied in the pressure vessels at the junction of shell to nozzle. A review of the literature related to the stress concentration at junction in pressure vessels is presented. Majority of the researchers have worked on thick cylinders and there is a scope in working for thin cylinders. Also the effect of end covers on the position and different size of the openings in pressure vessel needs to be studied.

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