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Effect of stress concentration factor at the junction of shell to nozzle

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Abstract - ***Pressure vessels find wide applications in thermal and nuclear power plants, process and chemical industries, in space and ocean depths, and fluid supply systems in industries. 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.. 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. This causes the rise in the stress distribution around the hole, 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 effect of stress concentration to determine by dimensionless factor called stress concentration factor (Kt). Determine of S.F.C is ratio of maximum stress and nominal stress. so ultimate aim of this research work ,reduce the SCF by designing Reinforcement Pad and also find the minimum thickness of the pad using ABAQUS. Also study the parametric study of R.F.Pad to use in radial Nozzle***

. *Keywords – pressure vessel, nozzle, stress concentration, stress concentration factor.*

I. INTRODUCTION

Pressure vessels are 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. The openings have main function is connect the pipes, inlet and outlet fluid or any other application as required. 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. Some of 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.

II.PROBLEM IDENTIFICATION

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.. In pressure, vessel weakened by at the junction of shell to nozzle. The higher stress around the nozzle –shell junction due to internal pressure 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.C.F is ratio of maximum stress and nominal stress. some of the data taken from for analysis from company .Ultimate aim of this thesis is reduce the effect of stress concentration by designing of reinforcement pad. and also find the minimum thickness of reinforcement pad using FEA tool ABAQUS and also study parametric study of R.F.Pad

III.PRESSURE VESSEL DESIGNAND R.F.PAD DESIGN

1. Design of Steel Pressure Vessel

Pressure vessel design under internal pressure by using conventional method and ASME boiler and pressure vessel code section VIII and division 1, the following parameter are used for calculating and analysis. Article (UG-27) gives the following rule for the minimum thickness of a cylindrical shell subjected to internal pressure and geometric details of cylindrical shell. To safely resist internal pressure, boiler and pressure vessel code section VIII requires that the thickness of a hemispherical head be given by UG-32 .The geometric details of pressure vessel were selected as shown in fig. Material properties and allowable stress has been taken from ASME section II. The material used for the cylinder and head is low carbon steel i.e. SA-516-Gr70 whereas material for nozzle is SA-106-GradeB.

Input parameter of steel pressure vessel	Values
Operating internal pressure (P)	2.45 Mpa
Inside diameter of shell (D_i)	2438 mm
Shell length (L)	3657 mm
Thickness of nozzle N1 (t_n)	22.09 mm
Thickness of nozzle N2 (t_n)	25.4 mm
Thickness of nozzle N3 (t_n)	25.4 mm
Corrosion allowance (CA)	3.175 mm
Efficiency of weld joint (E)	1
Diameter of nozzle N1 (d_i)	203 mm
Diameter of nozzle N2 (d_i)	254 mm
Diameter of nozzle N3 (di)	304 mm

Table 1

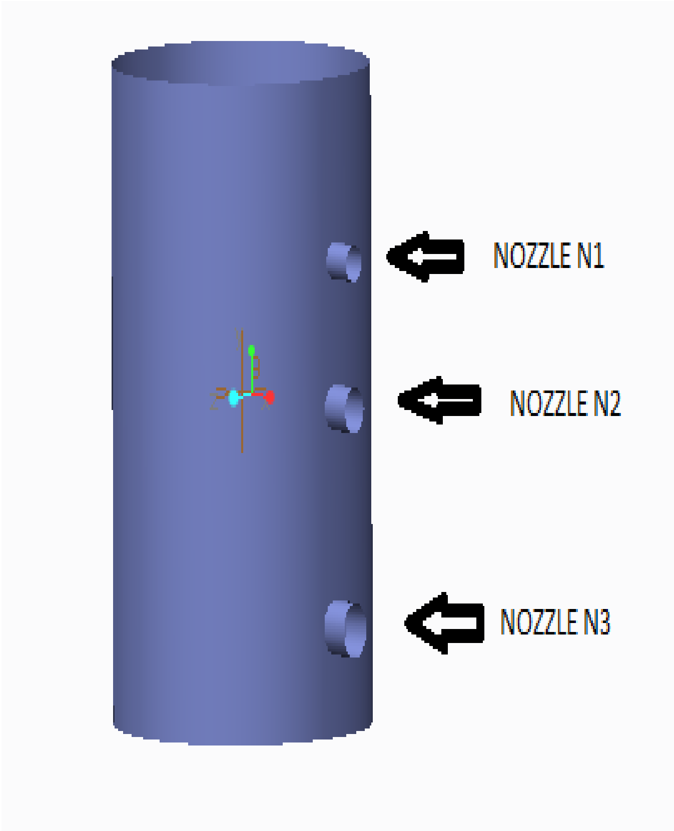

Fig.1.Pressure vessel Design

2. Design Of R.F.Pad by ASME STANDARD (Boiler and Pressure Vessel Code section VIII division 1)

In given condition, checked the reinforcement pad required or not required by using article UG-37. Ares are evaluated for reinforced pad require or not require.

Nozzle	Thickness of R.F.pad	Diameter of R.F.Pad
Nozzle 1	25.146 mm	349.25 mm
Nozzle 2	25.146 mm	514.35 mm
Nozzle 3	25.146 mm	670.12 mm

Table 2

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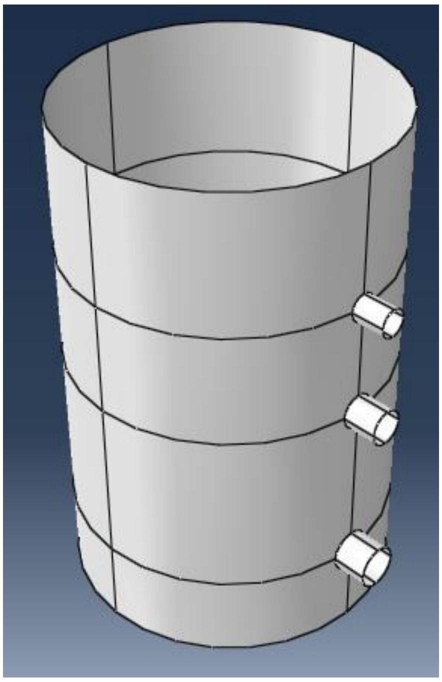
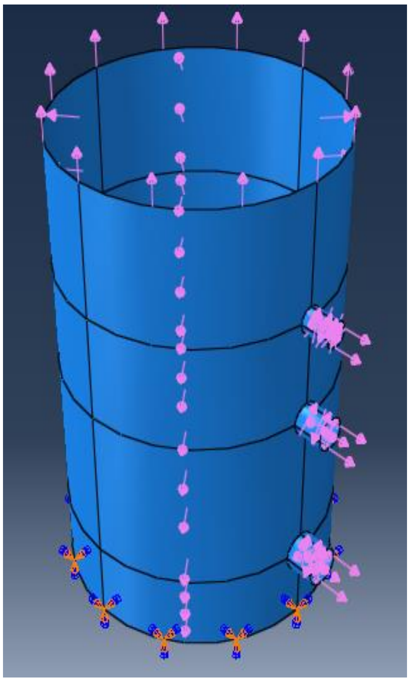
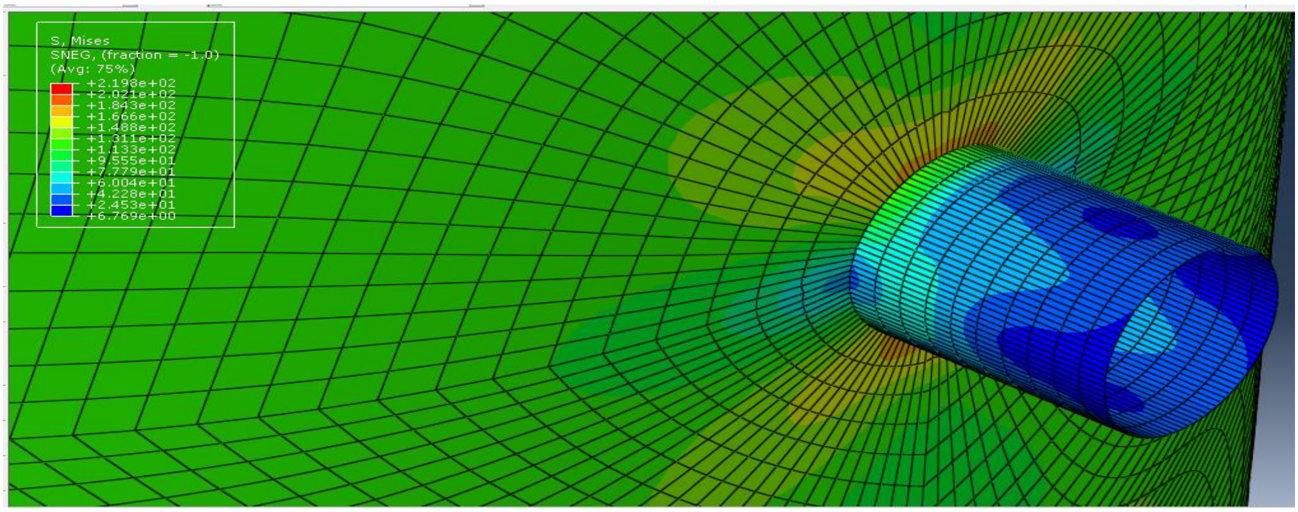
IV.ANALYSIS OF PRESSURE VESSEL NOZZLE JUNCTION WITHOUT R.F.PAD OR WITH R.F.PAD

1.Analysis of pressure vessel without R.F.Pad.



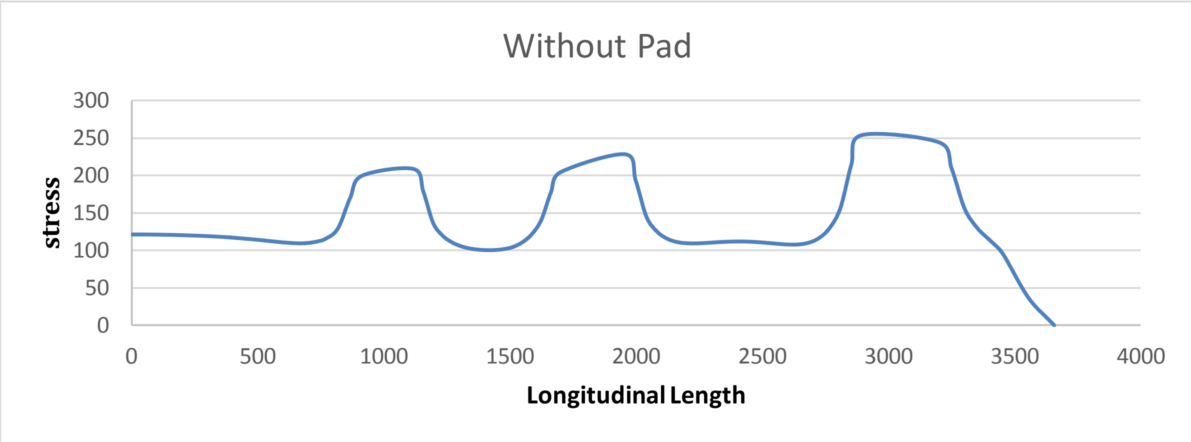


a) Fig.2 Abaqus model without R.F.Pad **b) Fig.3Applied boundary condition** **c) Fig.4Meshing**



d) Fig.5 Stress Distribution And zoomed view without R.F.Pad

Element used
Linear quadrilateral type S4R

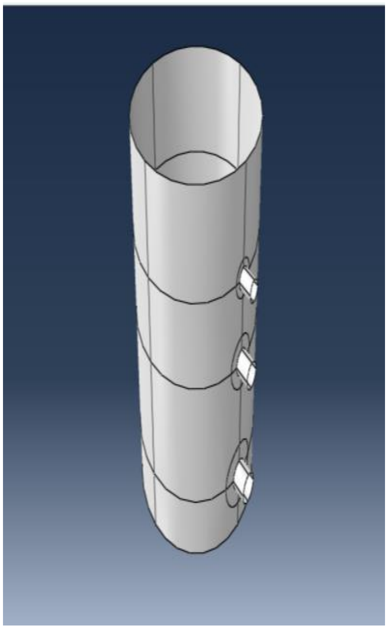
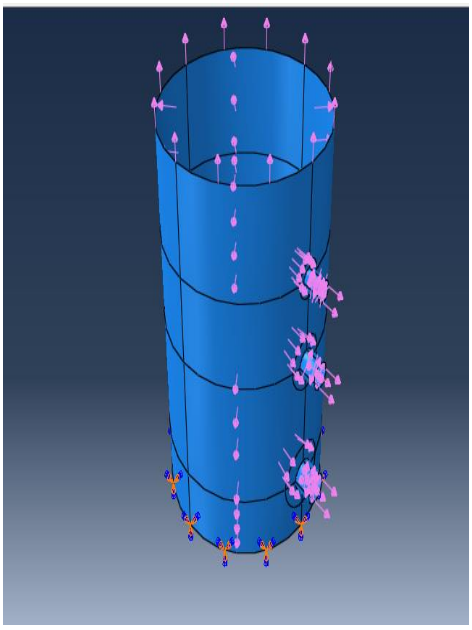
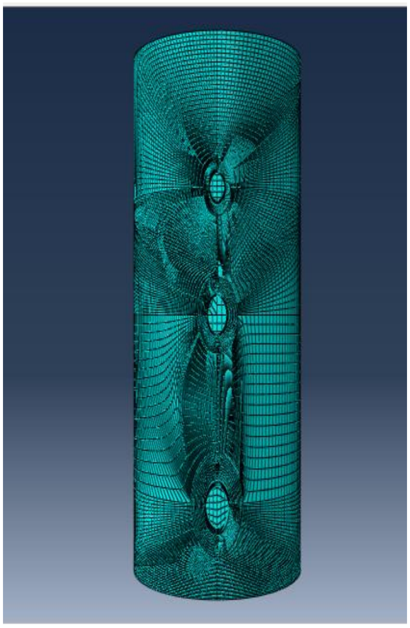


Stress Vs Longitudinal Length Graph To Find SCF Without Pad

WITHOUT R.F.PAD STRESS CONCENTRATION FACTOR= K_t = σmax/σnom

Max Stress=	253.848 MPa	**Kt**=1.95
Nom stress=	129.84 MPa	

2.**Analysis of pressure vessel with R.F.Pad.**

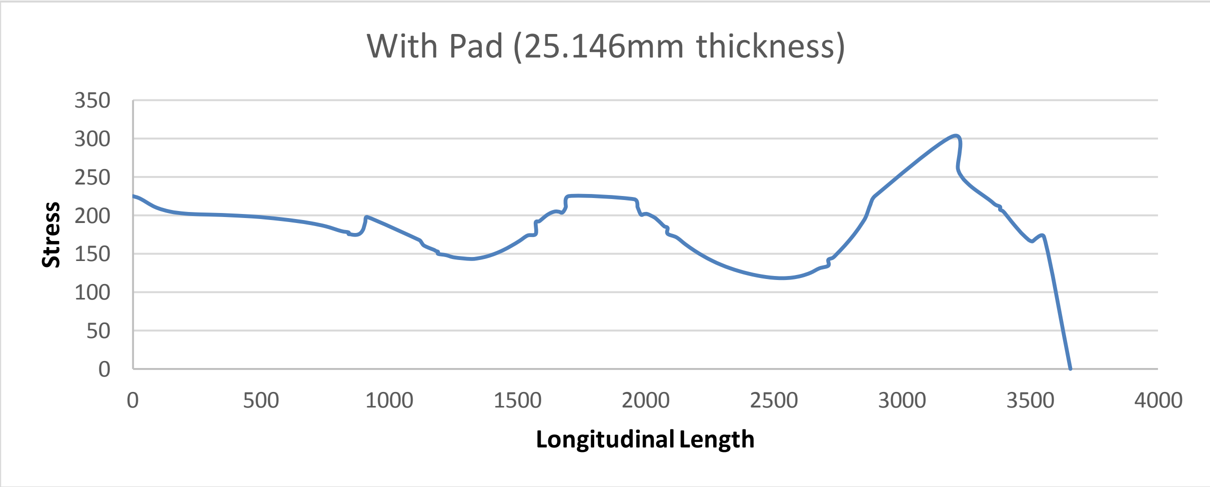




E).Abaqus model with R.F.Pad F).Applied boundary condition G).Meshing of pressure vessel with pad

The boundary condition applied at the top and bottom of pressure vessel and also at the nozzle. the traction force find in the shell and also in the nozzle

Traction on shell and also at nozzle: $P_i = R_i^2 p / (R_0 + R_i)$

Stress Vs Longitudinal Length Graph To Find SCF With R.F.Pad



Stress Vs Longitudinal Length Graph To Find SCF With R.F.Pad

Max Stress= 303.221MPa	**Kt= 1.69**
Nom stress= 178.50MPa	

V.THE EFFECT ON SCF VARYING THE THICKNESS OF R.F.PAD

Thickness of R.F.pad	SCF	Thickness of R.F.pad	SCF
Without Pad	1.95	30 mm	1.52
24 mm	1.71	31 mm	1.51
25.146mm(ASME)	1.69	32 mm	1.50
26 mm	1.60	33 mm	1.52
28 mm	1.55	34 mm	1.54

VI.CONCLUSION

To analysis of pressure vessel at the juncion of shell to nozzle without reinforcement ad stress concentration factor is1.95 and to use of the reinfoecement pad stress concentration factor is 1.69 So the result of the analysis the stress concentration is reduced to use of R.F.Pad.and also the effect on SCF to varying the thickness of R.F.Pad.The thickness of R.F.Pad increase the SCF is decrease.

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