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Thermal Structural of Nozzle Cylindrical Shell Intersection

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ABSTRACT

In this thesis, the effect of nozzle placement on the pressure vessel and nozzle fillet on the basis of stress & temperature distribution is analyzed utilizing FEA software Ansys. The parametric models of the pressure vessel with nozzle at different areas (i.e) nozzle placed at smaller end of cylinder & nozzle placed at centre and each with fillet & without fillet are be done in 3D modelling software Creo 2.0. The Static analysis and Thermal analysis are done on tall the models by applying under internal pressure and temperature to evaluate deformations, stresses, temperature distribution respectively using materials Structural Steel and Aluminum alloy 7075.

I.INTRODUCTION

A nozzle is a tool designed to regulate the direction or characteristics of a fluid flow (especially to extend velocity) because it exits (or enters) an interior chamber or pipe.

PRESSURE VESSEL

A pressure vessel is an instrumentation designed for holding gases or liquids at a pressure differing substantially from ambient pressure.

Nozzles on Heads

After a head is attached to main cylinder or to a nozzle on main cylinder (see below), a nozzle can be attached to head. Pressurised pipings, since the simple structures in chemical industries & nuclear power plants, were special pressure instruments with danger of explosion.The sphere nozzle & cylinder nozzle (tee) intersections are employed in pressure vessel and piping systems of refineries, power generation plants & chemical plants. Some specific samples of these intersections are nozzles in reactor vessels, liquid storage tanks & pressure vessel heads. Since the Nineteen Sixties in depth analysis has been allotted to work out the linear & non-linear behavior of unbroken intersections under pressure loading.

II.LITERATURE SURVEY

A.Y.Kuo [1], 2 unremarkably crossed cylinders below totally different internal pressures in every of the cylinders is solved analytically. The inclusion of nozzle fillet, insert plate and inner nozzle broadens the pertinence of this analytical methodology within the design & analysis of pressurised cylinder to cylinder intersection. The present numerical answer theme has been incorporated within the coding system Nutshell. Comparisons of Nutshell solutions & experimental or finite component results have conjointly been conferred. **K. Vijaya Krishna Varma and V.S.V Sai Sumanth [2],** analyzed the material effect with respect to temperature and stress distribution using finite element analysis.

DESIGN PARAMETERS & MODELING OF CYLINDER AND NOZZLE

The design parameters are considered from the journal paper “Structural and thermal analysis of reinforced nozzle-cylindrical shell intersection under internal pressure and nozzle radial thermal expansion” by K. Vijaya Krishna Varma and V.S.V Sai Sumanth, International Journal of Mechanical Engineering and Technology (IJMET), Volume 8, Issue 8, August 2017.

DESIGN DATA

Pressure: 0.23 MPa; Displacement: X=0, Y=0, Z=0

Reference temperature: 220^0 C. Convection: Film coefficient: 0.0025 W/mm^2.k, Ambient temperature: 323.15 K

Geometry

Vessel id: 1150 mm s, Shell thickness: 75 mm, Length of vessel: 6200 mm, Pad ID: 280 mm; Pad od: 560 mm, Pad thickness: 72 mm, Nozzle ID: 150 mm; Nozzle thickness: 65 mm, Nozzle height (total): 442.3 mm, Nozzle head dia: 400 mm; Nozzle head thickness: 45 mm

3D MODEL OF THE PRESSURE VESSEL CYLINDER

Four pressure vessel cylinder models are modelled in Creo 2.0. One model is with nozzle placed at smaller end & without fillet at nozzle cylinder intersection and second model with fillet at nozzle cylinder intersection. Third model is with nozzle placed at centre of cylinder & without fillet at nozzle cylinder intersection and fourth model with fillet at nozzle cylinder intersection. The dimensions are taken from design parameters. The diameter of cylinder at one end is 575mm (larger end) and diameter at other end is 560mm (smaller end). The nozzle is placed near the larger end in one model and at the smaller end in another model.

Table – Models considered

MODEL1	Nozzle is Placed at smaller end of cylinder & with fillet at cylinder nozzle intersection
MODEL2	Nozzle is Placed at smaller end of cylinder & without fillet at cylinder nozzle intersection
MODEL3	Nozzle is Placed at centre of cylinder & with fillet at cylinder nozzle intersection
MODEL4	Nozzle is Placed at centre of cylinder & without fillet at cylinder nozzle intersection

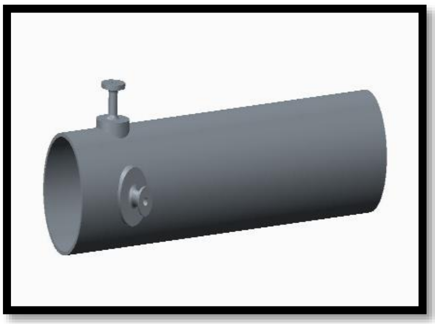

Fig 1:-3D Model with nozzle placed at smaller end of cylinder without fillet

Fig 2:-3D Model with nozzle placed at centre of cylinder without fillet

III.ANALYSIS OF CYLINDER WITH NOZZLE

Static Structural analysis and thermal analysis are performed on all models of cylinder (i.e) one with fillet and without fillet & changing nozzle placement on cylinder. The pressure & temperature taken is considered from the journal paper "Structural and thermal analysis of reinforced nozzle-cylindrical shell intersection under internal pressure and nozzle radial thermal expansion" by K. Vijaya Krishna Varma and V.S.V Sai Sumanth, International Journal of

Mechanical Engineering and Technology (IJMET), Volume 8, Issue 8, August 2017.

The materials considered for analysis are Structural Steel, Aluminum and Copper.

STATIC STRUCTURAL ANALYSIS

Static Structural analysis is done on all the 4 models by changing the boundry condition "displacement" position and materials Structural Steel, Aluminum alloy 7075.

CYLINDER WITH NOZZLE AT SMALLER END & WITH FILLET

DISPLACEMENT APPLIED AT SMALLER END

After completing the models in Creo 2.0, they are saved as .igs files. Open Ansys Workbench and select Static Structural

The displacement is specified on the end of cylinder near the nozzle.

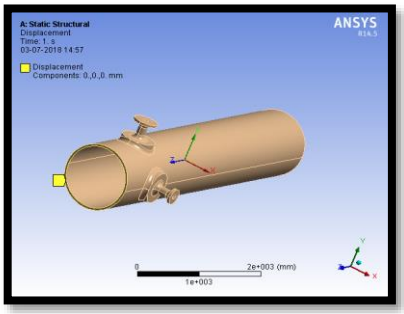

Fig 3:-Displacement is applied on one end of cylinder near nozzle placement

Pressure is applied inside the cylinder.

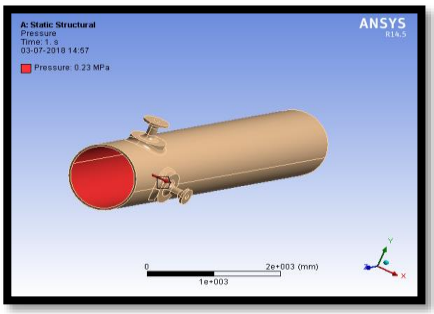

Fig 4:- Pressure is applied inside the cylinder.

Solve the analysis and Total Deformation, Stress & Strain are taken as results.

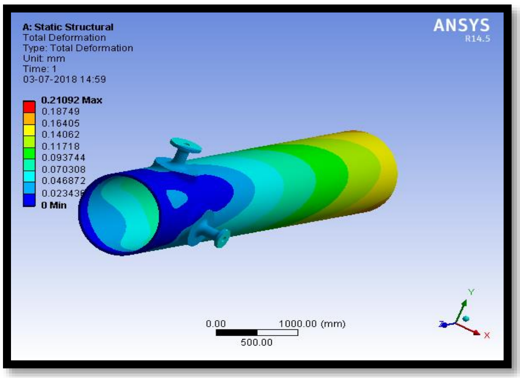

Fig 5:-Total deformation of cylinder with nozzle at smaller end & with fillet using Aluminum 7075

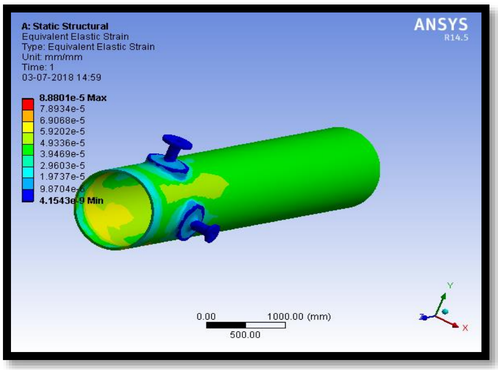

Fig 6:-Strain of cylinder with nozzle at smaller end & with fillet using Aluminum 7075

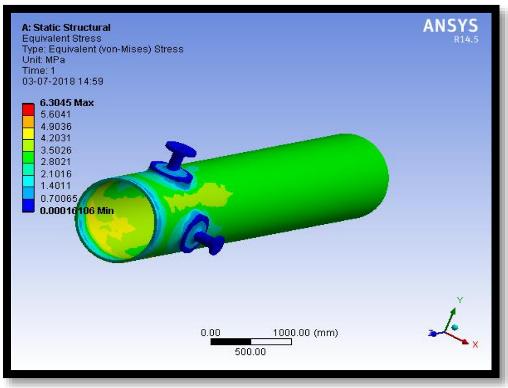

Fig 7:-Stress of cylinder with nozzle at smaller end & with fillet using Aluminum 7075

IV.THERMAL ANALYSIS

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.75436	4.6427 e^{-5}	9.2601
ALUMINUM 7075	2.1257	0.0001 3103	9.2787

Thermal Analysis is performed by applying temperature of 220^{0}C taken from the reference journal paper as specified in Design parameters chapter.

Initial Temperature is applied inside the cylinder, Convection is applied on the external surface of cylinder.

Solve the analysis and the results taken are Temperature and Total Heat Flux

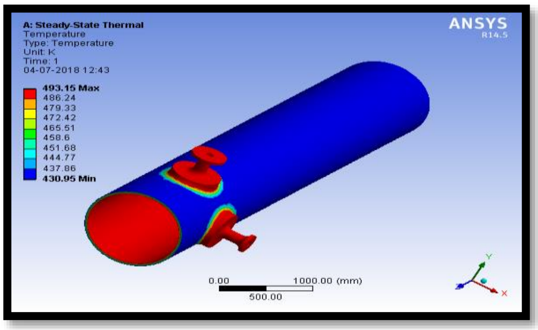

Fig 8:-Temperature of cylinder with nozzle at smaller end & with fillet using Aluminum 7075

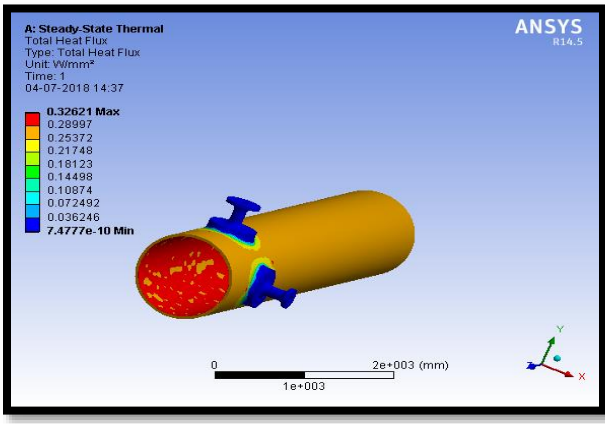

Fig 9:-Total Heat Flux of cylinder with nozzle at smaller end & with fillet using Aluminum 7075

V.RESULTS & DISCUSSIONS

Static Structural Analysis

Model 1 with displacement applied at smaller end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS(MPa)
STEEL	0.072723	3.176 4e^{-5}	6.3526
ALUMINUM 7075	0.21092	8.880 1e^{-5}	6.3045

Model 1 with displacement applied at larger end

By observing above tables the following observations are made:

The deformations and stresses are increasing for the model 1 when the displacement is applied at larger end when compared with that when the displacement is applied at smaller end. The stresses are less when Aluminum 7075 is used. The stresses are increasing when displacement is applied at larger end by about 31% for Steel, by about 32% for Aluminum 7075 when compared with displacement is applied at smaller end.

Model 2 with displacement applied at smaller end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.047434	3.270 5e^{-5}	6.540 7
ALUMINUM	0.14042	9.163 2e^{-5}	6.505 5

Model 2 with displacement applied at larger end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.33052	3.3065e^{-5}	6.6124
ALUMINUM	0.93261	9.2689e^{-5}	6.5803

The deformations and stresses are increasing for the model 2 when the displacement is applied at larger end when compared with that when the displacement is applied at smaller end. The stresses are less when Aluminum 7075 is used. The stresses are increasing when displacement is applied at larger end by about 1.08% for Steel, by about 7.48% for Aluminum 7075 when compared with displacement is applied at smaller end.

Model 3 with displacement applied at smaller end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.1986	3.345e^{-5}	6.6655
ALUMINUM	0.56276	9.3678e^{-5}	6.6214

Model 3 with displacement applied at larger end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.36733	3.3329e^{-5}	6.6896
ALUMINUM	1.0368	9.3554e^{-5}	6.6508

The deformations and stresses are increasing for the model 3 when the displacement is applied at larger end when compared with that when the displacement is applied at smaller end. The stresses are less when Aluminum 7075 is used. The stresses are increasing when displacement is applied at larger end by about 0.36% for Steel, by about 0.44% for Aluminum 7075 when compared with displacement is applied at smaller end.

Model 4 with displacement applied at smaller end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.088931	3.6715e^{-5}	7.3426
ALUMINUM	0.25465	0.00010297	7.3107

Model 4 with displacement applied at larger end

MATERIAL	DEFORMATION(mm)	STRAIN	STRESS (MPa)
STEEL	0.14626	3.688e^{-5}	7.3755
ALUMINUM	0.41522	0.0001034 3	7.3429

The deformations and stresses are increasing for the model 4 when the displacement is applied at larger end when compared with that when the displacement is applied at smaller end. The stresses are less when Aluminum 7075 is used. The stresses are increasing when displacement is applied at larger end by about 0.44% for Steel, by about 0.43% for Aluminum 7075 when compared with displacement is applied at smaller end.

Thermal Analysis

Model 1

MATERIAL	TEMPERATURE(K)	HEAT FLUX(W/m^2)
STEEL	493.15	0.21534
ALUMINUM	493.15	0.32621

The heat flux value is increasing when Aluminium 7075 is used by 34% when compared with Steel.

Model 2

MATERIAL NAME	TEMPERATURE(K)	HEAT FLUX(W/m^2)
STEEL	493.15	0.19625
ALUMINUM	493.15	0.32232

The heat flux value is increasing when Aluminum 7075 is used by 39% when compared with Steel.

Model 3

MATERIAL NAME	TEMPERATURE(K)	HEAT FLUX(W/m^2)
STEEL	493.15	0.24723
ALUMINUM	493.15	0.37508

The heat flux value is increasing when Aluminum 7075 is used by 34% when compared with Steel.

Model 4

MATERIAL NAME	TEMPERATURE(K)	HEAT FLUX(W/m^2)
STEEL	493.15	0.19376
ALUMINUM	493.15	0.32151

The heat flux value is increasing when Aluminum 7075 is used by 40% when compared with Steel.

VI.CONCLUSION

By observing static structural analysis results, the deformations and stresses are increasing for all models when the displacement is applied at larger end when compared with that when the displacement is applied at smaller end. The stresses are less when Aluminum 7075 is used. The Model 1 has higher stress value when Steel is used and less for Model 2 when Aluminum 7075 is used. By observing thermal analysis results, the Model 3 has higher heat flux value when Aluminum 7075 is used and less for Model 4 when Steel is used. The higher heat flux depicts the higher heat transfer values.

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