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EFFECT OF OPENINGS ON STRESSES IN PRESSURE VESSEL

Ms. Nalla Neeraja[1], Dr. D.V. Bhope[2]

[1]Student, IV Semester M.Tech (CAD/CAM),
Rajiv Gandhi College of Engg. Research & Technology, Chandrapur – 442 403
[2]Professor, Mechanical Engineering Department,
Rajiv Gandhi College of Engg. Research & Technology, Chandrapur – 442 403

Abstract – *This paper deals with the effect of openinsgs on stresses in pressure vessel using Finite Element Method. The study is constrained to only structural analysis. The pressure vessel is subjected to constant internal pressure of 2MPa and supported on two saddle supports. The finite element approach is used to evaluate the stresses in pressure vessel with and without reinforcement around the opening. This analysis revealed that reinforcement reduces the magnitude of stresses in pressure vessel having openings.*

Keywords: Pressure vessel, Opening, Cylinder, Cover plate

1. INTRODUCTION

Tanks, vessel and pipelines that carry, store or receive fluids are called as pressure vessel. A pressure vessel is defined as a container with a pressure differential between inside and outside. The inside pressure is usually higher than outside.

In this paper, the stress analysis of pressure vessel with variation in size and number of circular openings with and without reinforcement is carried out. The finite element approach is used to evaluate the stresses in the pressure vessel around the openings by varying the size and number of openings on cylinder and cover plate. Fig. 1 shows the revolved section of pressure vessel. The various geometrical & other parameters considered for analysis are as follows,

Length of pressure vessel: 500 mm
Diameter of pressure vessel: 250 mm
Thickness of wall: 5 mm
Internal pressure: 2 MPa
Material of pressure vessel: Plain Carbon steel

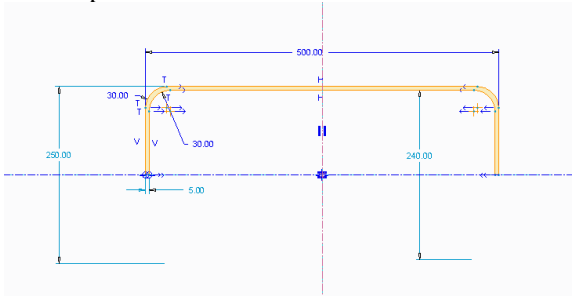

Fig.1: Revolve Section of Pressure Vessel

The diameter of opening is considered as 'd', outer diameter of reinforcement around the opening is considered as 'D' and height of reinforcement is considered as 'h'. For the analysis, various ratios of D/d are considered as 1.1, 1.2, 1.3, 1.4 and 1.5 and h/d ratios are considered as 0.1, 0.2, 0.3, 0.4 and 0.5.

Fig. 2 shows the CAD model of closed pressure vessel and table 1 gives the properties of material of pressure vessel and reinforcement.

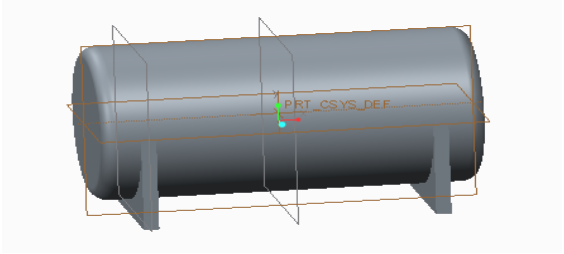

Fig.2: CAD Model of Closed Pressure Vessel

Table 1: Properties of Material of Pressure Vessel

PARAMETER	VALUE
Density (Kg/m^3)	7850
Elastic Modulus(GPa)	200
Poission's ratio	0.3

3. ANALYTICAL & FE ANALYSIS OF CLOSED PRESSURE VESSEL

Circumferential stresses and longitudinal stresses in the pressure vessel are determined analytically and its comparison with FE stresses is given in table 2, which indicates the close agreement between analytical and FE stresses

Table 2: Comparison of Analytical and FE Stresses

Stresses(MPa)	Analytical	FEM
Maximum Principle	50.52	60.58
Minimum Principle	25.26	32.10

4. STRESS ANALYSIS OF PRESSURE VESSEL WITH OPENINGS ON CYLINDER

The pressure vessel is analyzed for circular openings present on the cylinder and cover plate. Also variation in number of circular openings present on cylinder and cover plate is also considered for analysis. The circular opening diameters are considered as 20 mm, 25mm, 30 mm, 40 mm and 60mm.

Fig. 3 shows the variation of Von mises stresses in cylinder with respect to variations in diameter of circular openings and number of openings.

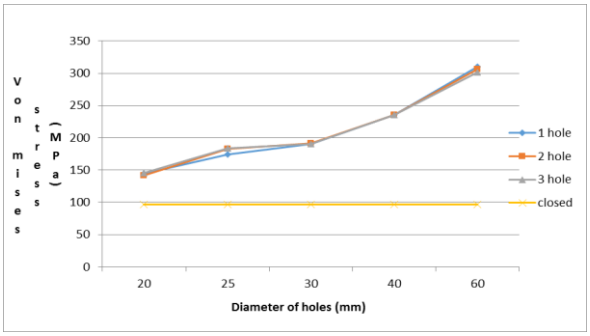

Fig. 3: Diameter of Openings vs. Von mises Stresses

It is observed that, as the diameter of circular openings on the vessel increases the stresses induced also increases. Also, increasing the number circular openings on the vessel increases the stresses. The stresses induced on the closed pressure vessel are lesser in magnitude as compared to pressure vessel haing circular openings.

5. STRESS ANALYSIS OF PRESSURE VESSEL WITH OPENINGS ON COVER PLATE

Fig.4 shows the variation of Von mises stresses in cylinder with respect to variations in diameter of circular openings and number of circular openings on cover plate

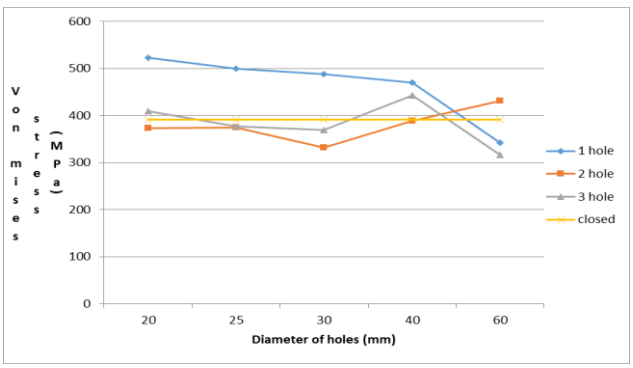

Fig. 4: Diameter of Openings vs. Von mises Stresses

It is observed that, as the diameter of circular openings on the cover plate increases the stresses induced reduces for certain diameters. Also, increase in the number of circular openings on the cover plate reduces the stresses without reinforcement.

6. EFFECT OF REINFORCEMENT AROUND THE OPENINGS ON STRESSES IN PRESSURE VESSEL

In this study, reinforcement is introduced around the circular openings present on the cylinder and cover plate of the pressure vessel and its effect is presented in forthcoming sections.

6.1 STRESSES IN CYLINDER WITH REINFORCEMENT

The fig. 5, 6, 7, 8 and 9 shows the variation of Von mises stresses in cylinder with respect to variations in outer diameter of reinforcement around circular openings and height of reinforcement for circular openings having size of 60mm, 40mm, 30mm, 25mm and 20mm.

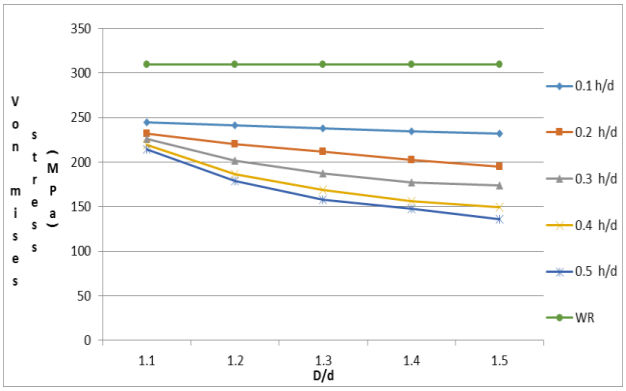

Fig. 5: D/d vs. Von mises Stresses for 60mm dia Circular Openings

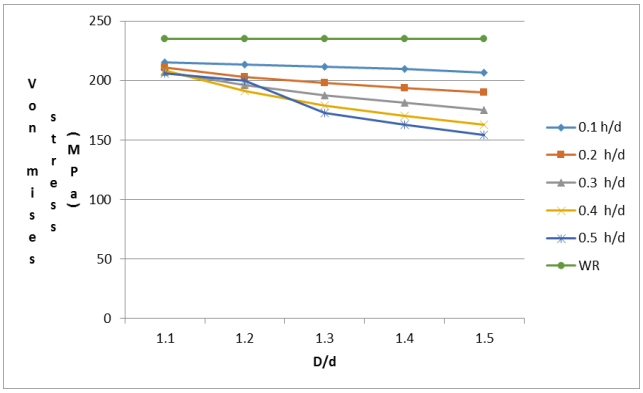

Fig. 6: D/d vs. Von mises Stresses for 40mm dia Circular Openings

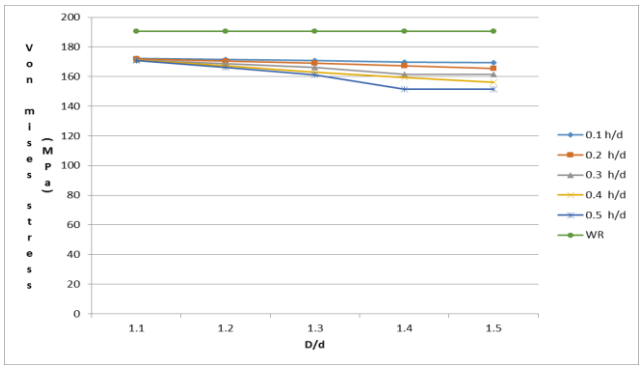

Fig.7: D/d vs. Von mises Stresses for 30mm dia Circular Openings

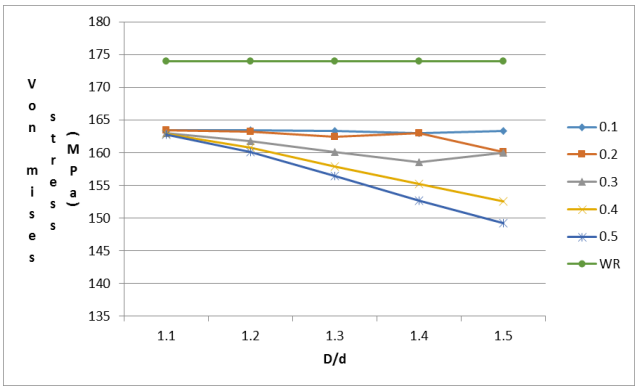

Fig. 8: D/d vs. Von mises Stresses for 25mm dia Circular Openings

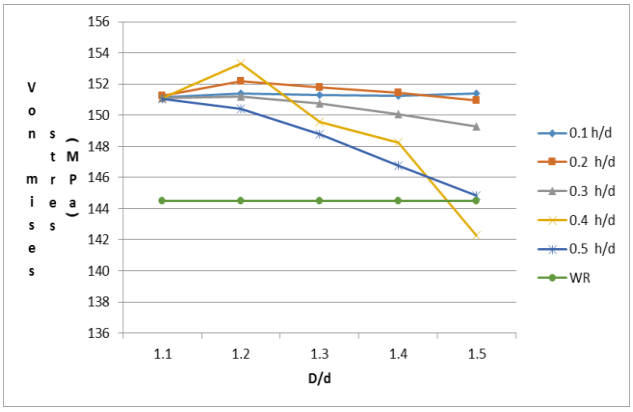

Fig. 9: D/d vs. Von mises Stresses for 20mm dia Circular Openings

6.2 STRESSES IN COVER PLATE WITH REINFORCEMENT

Fig. 10, 11, 12, 13 and 14 shows the variation of Von mises stresses in cover plate with respect to variations in outer diameter of reinforcement around circular openings and height of reinforcement on the cover plate.

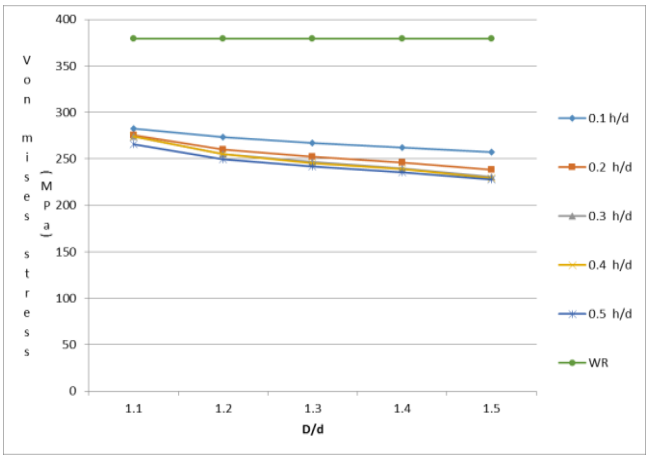

Fig. 10: D/d vs. Von mises stresses for 60mm dia Circular Openings

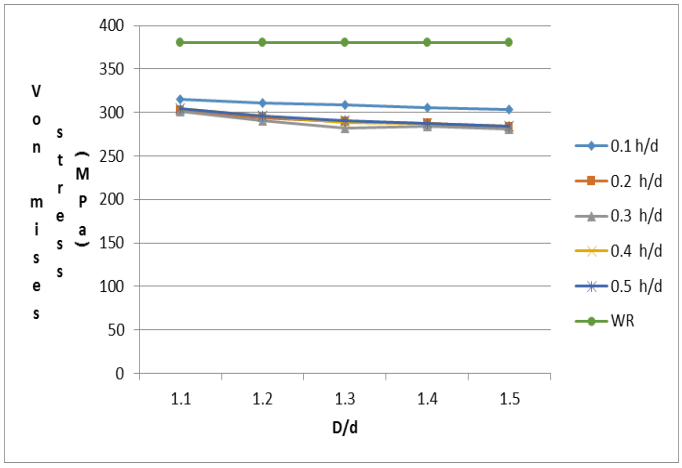

Fig 11: D/d vs. Von mises Stresses for 40mm dia Circular Openings

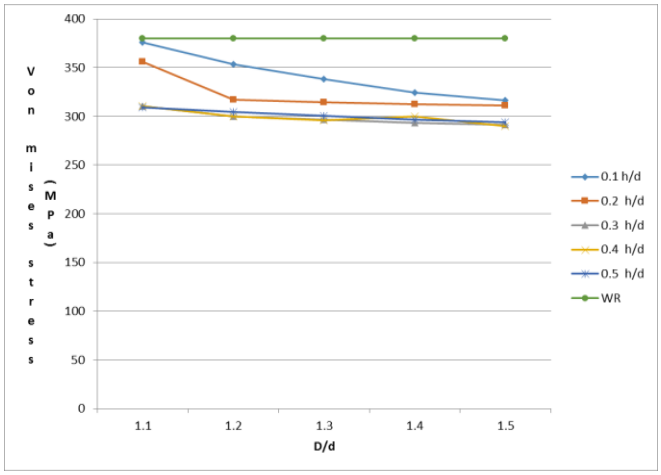

Fig. 12: D/d vs. Von mises Stresses for 30mm dia Circular Openings

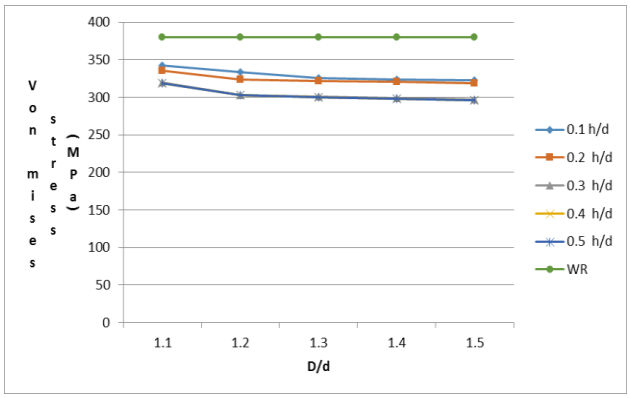

Fig. 13: D/d vs. Von mises stresses for 25mm dia Circular Openings

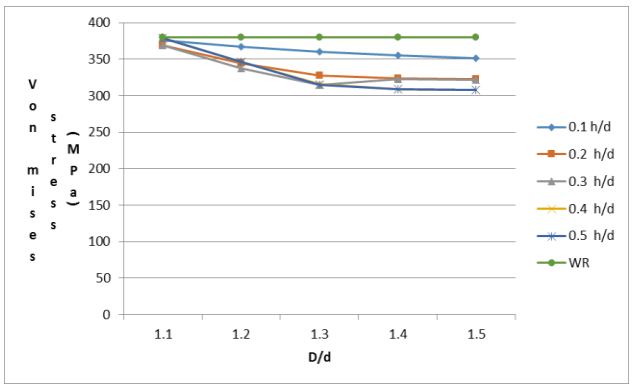

Fig. 14: D/d vs. Von mises Stresses for 20mm dia Circular Openings

7. CONCLUSION

From FE analysis of pressure vessel it is observed that the opening has increased the magnitude of Von mises stresses in the pressure vessel. The number of circular openings on the cylinder also affects the magnitude of stresses. Similar analysis carried out for cover plate indicated that, with increase in number of circular openings the magnitude of Von mises stresses around the openings shows marginal variation. It is further observed that the provision of reinforcement has decreased the stress magnitudes in cylinder and also in cover plate.

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