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Finite Element Analysis Of Toroidal Pressure Vessels With Different Hole Diameters

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ABSTRACT

In the present study, an attempt is made to determine the effect of diameter and position of openings on toroidal pressure vessels. The pressure vessels shall be analysed by using ANSYS software for composite materials.. This paper is an attempt to study of the effect of openings of 50 mm to 100 mm on toroidal pressure vessels. Also find out the variation of stress concentration factor for different diameter of hole for composite materials. To find the effect of position of hole, the holes of different diameters are placed at two different locations of the shell.

INTRODUCTION

Toroidal vessels are commonly used for the storage of pressurized fluids in automotive and aerospaceapplications due to their optimal use of space. Here, the aim is to provide insight into the effect of openingson toroidal pressure vessels.

Openings in pressure vessels in the regions of shells or heads are required to serve the following purposes; i) Man ways (for maintenance and repair),ii)Holes for draining or cleaning the vessel, iii)Hand hole openings (forinspecting the vessel from outside, iv)Nozzles attached to pipes to convey the working fluid inside and outside ofthe vessel. The stress levels at the opening will be peak due the removal of the material and hence will lead toweak region of the total structure. So the stress concentration at these locations should be estimated for the safedesign of pressure vessels. The amount of weakening is dependent on (i) Diameter of hole, (ii) The number ofholes, (iii) Spacing of holes (iv) Location of hole.

FINITE ELEMENT ANALYSIS OF TOROIDAL PRESSURE VESSEL FOR EGLASS/EPOXY MATERIAL

Eglass/Epoxy Mechanical Properties:

Table: Properties of E-Glass/Epoxy

Property	Units	E-Glass/Epoxy
E_{11}	GPa	50.0
E_{22}	GPa	12.0
G_{12}	GPa	5.6
ν_{12}	-	0.3
$S^t_1= S^c_1$	MPa	800.0
$S^t_2= S^C_2$	MPa	40.0
S_{12}	MPa	72.0
ρ	Kg/m^3	2000.0

Static analysis of toroidal pressure vessel with hole on outer side of shell

Boundary conditions:

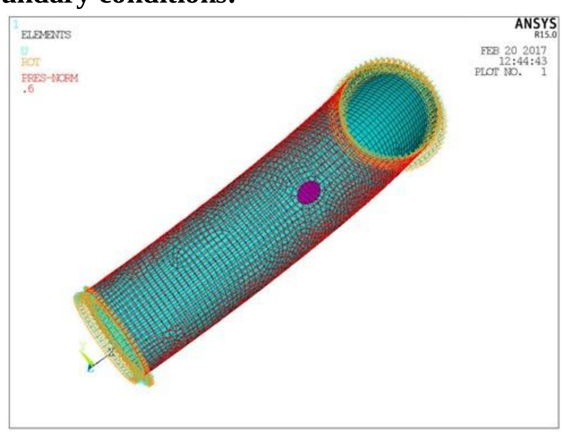

Fig shows applied boundary conditions on Toroidal pressure vessel

Toroidal pressure vessel is subjected to pressure load for different hole diameters on outer shell. Static analysis is done for hole diameters from 50 to 100

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mm. Results of Toroidal pressure vessel with different hole diameters are shown below.

RESULTS:

CASE-1: Toroidal pressure vessel with 50mm hole diameter:

Stresses:

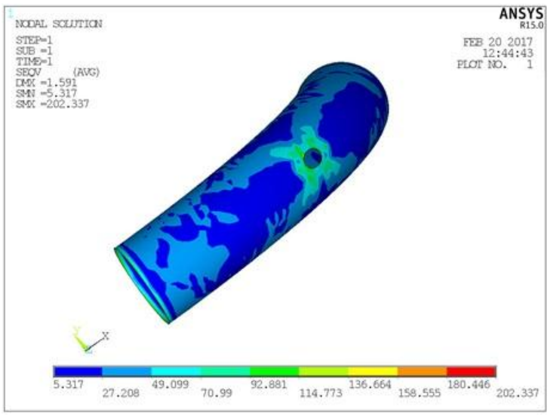

Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 202.3 Mpaand the yield strength is 800 MPa. The von misses stress of Toroidal pressure vessel is less than the yield strength of material. Hence, the Toroidal pressure vessel is safe for pressure load.

CASE-6: Toroidal pressure vessel with 100mm hole diameter:

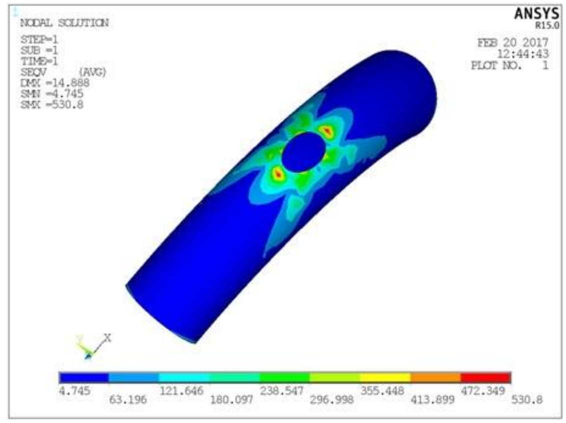

Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 530.8 Mpais less thanthe yield strength of Eglass/Epoxy material is 800 MPa. Hence, the Toroidal pressure vessel with 100mm hole diameter is safe for pressure load.

Static analysis of toroidal pressure vessel with hole on inner side of shell

Boundary conditions:

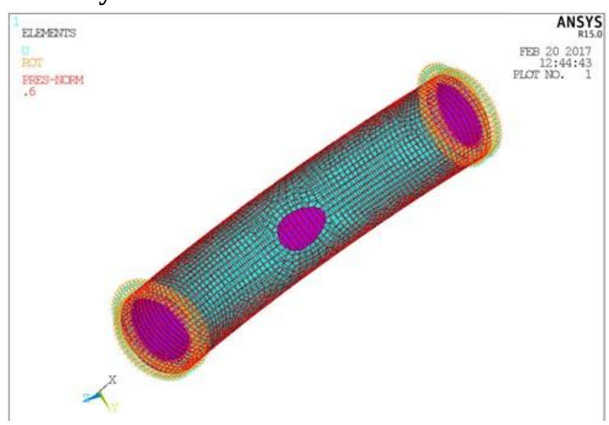

Fig shows applied boundary conditions on Toroidal pressure vessel

RESULTS:

CASE-1: Toroidal pressure vessel with 50mm hole diameter:

Stresses:

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Hole diameter (mm)	Hole on outer shell		Hole on inner shell	
	Displacement (mm)	Von misses stress (MPa)	Displacement (mm)	Von misses stress (MPa)
50	1.59	202.3	3.33	169.9
60	3.04	270.1	4.24	189.5
70	5.26	287.2	5.37	327.6
80	7.93	335.1	6.24	230.2
90	11	563.6	7.31	245.8
100	14.8	530.8	8.16	316.8

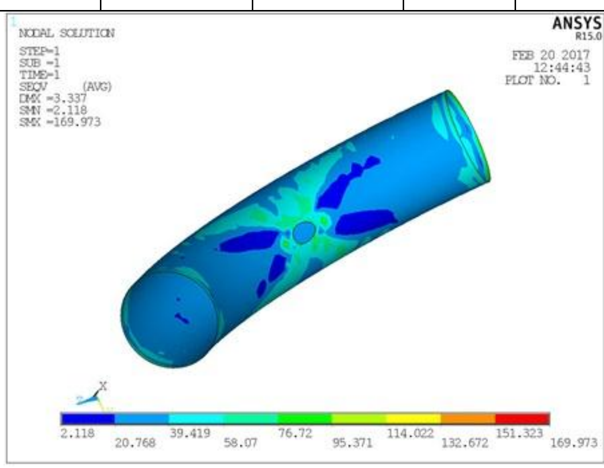


Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 169.9 Mpais less thanthe yield strength of Eglass/Epoxy material is 800 MPa. Hence, the Toroidal pressure vessel with 50mm hole diameter is safe for pressure load.

CASE-6: Toroidal pressure vessel with 100mm hole diameter:

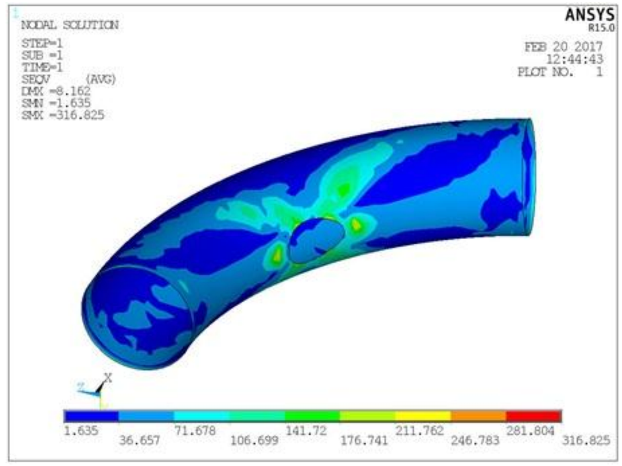


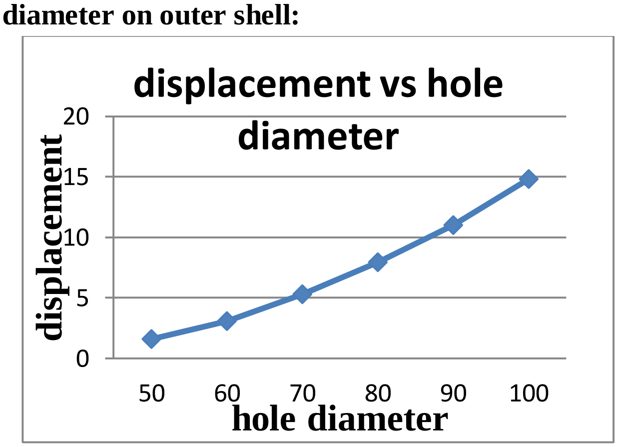
Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 316.8 MPa**.** The yield strength of Eglass/Epoxy material is 800 MPa. the von misses stress of Toroidal pressure vessel is less than the yield strength of material. Hence, the Toroidal pressure vessel with 100mm hole diameter is safe for pressure load

Comparison of Toroidal pressure vessel for different hole diameters and different type of hole

GRAPHS:

Toroidal pressure vessel with different hole diameter on outer shell:



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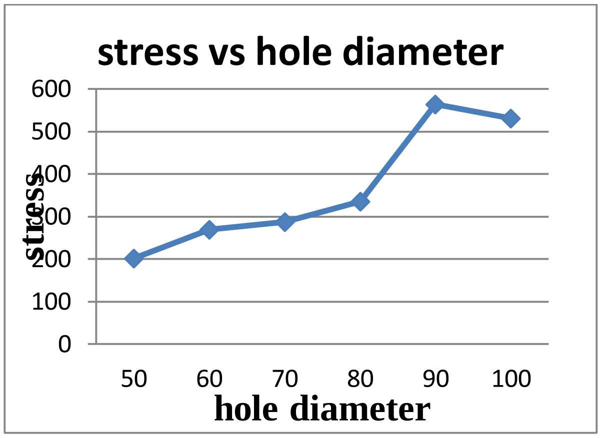
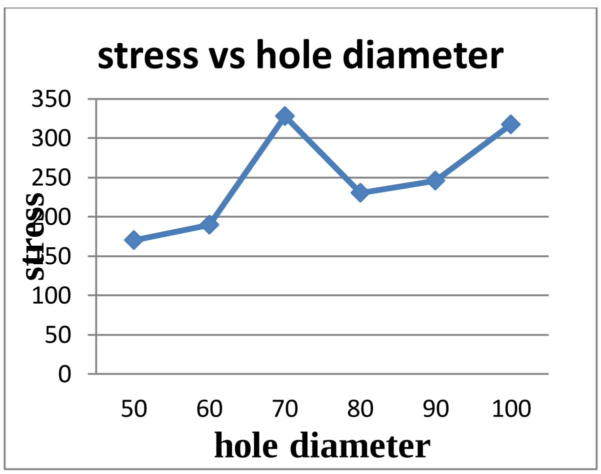
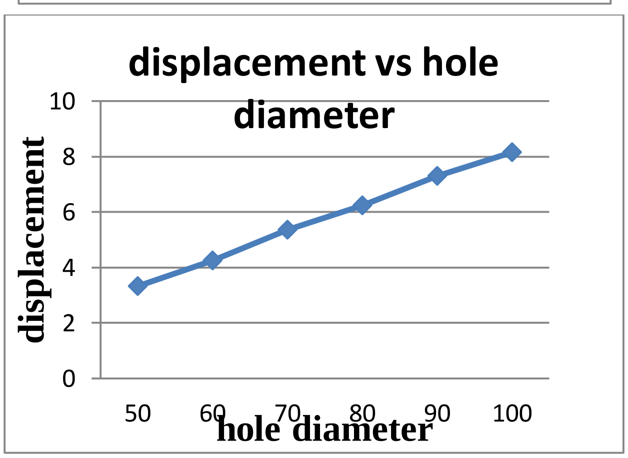
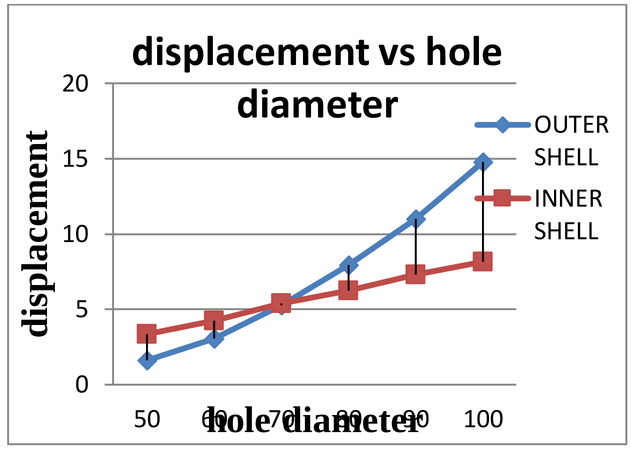


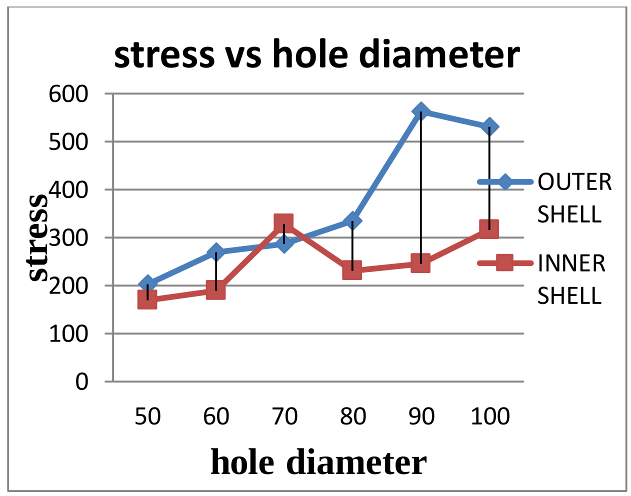
Toroidal pressure vessel with different hole diameter on inner shell:





Comparisons of displacement for outer shell and inner shell of toroidal pressure vessel:





FINITE ELEMENT ANALYSIS OF TOROIDAL PRESSURE VESSEL FOR CARBON/EPOXY MATERIAL

Table: Properties of HS Carbon/Epoxy

Property	Units	HS Carbon/Epoxy
E_{11}	GPa	134.0
E_{22}	GPa	7.0
G_{12}	GPa	5.8
ν_{12}	-	0.3
$S^t_1 = S^c_1$	MPa	880
$S^t_2 = S^C_2$	MPa	60.0
S_{12}	MPa	97.0
ρ	Kg/m^3	1600.0

Static analysis of toroidal pressure vessel with hole on outer side of shell

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RESULTS:

CASE-1: Toroidal pressure vessel with 50mm hole diameter:

Stresses:

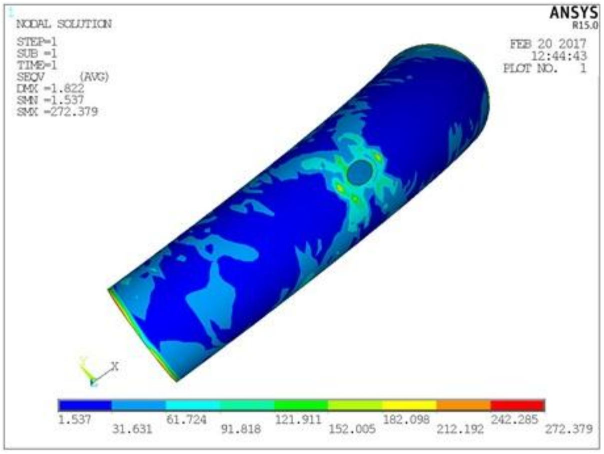

Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 272.3 MPa**.** The yield strength of Carbon/Epoxy material is 945 MPa. the von misses stress of Toroidal pressure vessel is less than the yield strength of material. Hence, the Toroidal pressure vessel is safe for pressure load.

CASE-6: Toroidal pressure vessel with 100mm hole diameter:

Stresses:

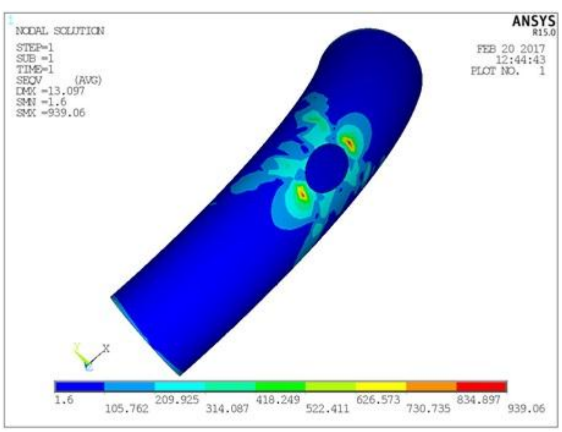

Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 939.06 MPa**.** The yield strength of Carbon/Epoxy material is 945 MPa. The von misses stress of Toroidal pressure vessel is less than the yield strength of material. Hence, the Toroidal pressure vessel with 100mm hole diameter is safe for pressure load.

Static analysis of toroidal pressure vessel with hole on inner side of shell

RESULTS:

CASE-1: Toroidal pressure vessel with 50mm hole diameter:

Stresses:

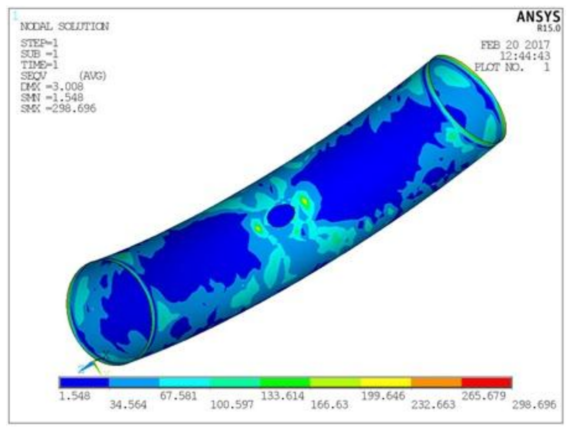

Fig shows von misses stress of Toroidal pressure vessel

From results, the von misses stress of Toroidal pressure vessel is 298.69 MPa**.** The yield strength of Carbon/Epoxy material is 945 MPa. the von misses stress of Toroidal pressure vessel is less than the yield strength of material. Hence, the Toroidal pressure vessel is safe for pressure load.

From results, the von misses stress of Toroidal pressure vessel is 515.60 MPa**.** The yield strength of Carbon/Epoxy material is 945 MPa. the von misses stress of Toroidal pressure vessel is less than the yield strength of material.

CASE-6: Toroidal pressure vessel with 100mm hole diameter:

Stresses:

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Hole diameter (mm)	Hole on outer shell		Hole on inner shell	
	Displacement (mm)	Von misses stress (MPa)	Displacement (mm)	Von misses stress (MPa)
50	1.82	272.3	3.00	298.6
60	3.07	331.6	3.82	334.1
70	4.54	515.7	5.07	409.4
80	6.61	534.7	5.97	460.5
90	9.08	738.3	6.77	515.6
100	13.09	939.06	7.45	519.26

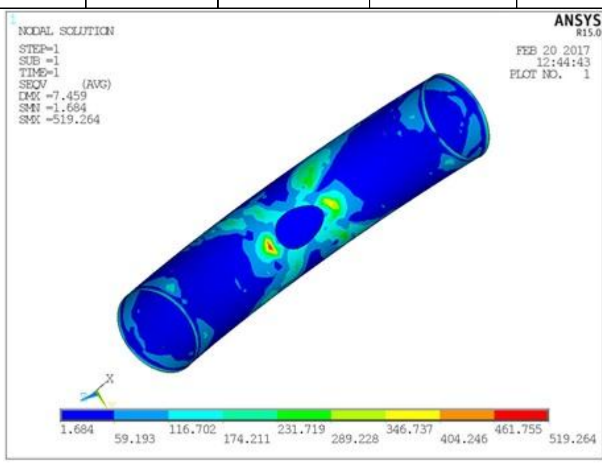


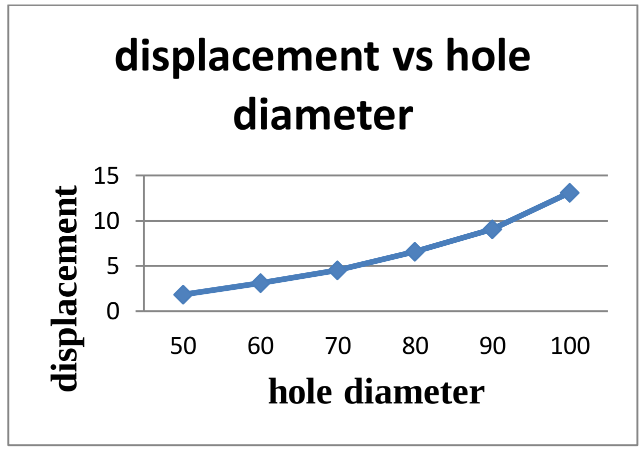
Fig shows von misses stress of Toroidal pressure vessel

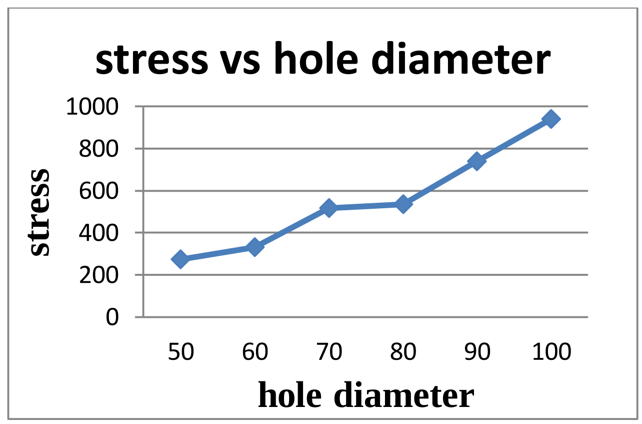
From results, the von misses stress of Toroidal pressure vessel is 519.26 MPa**.** The yield strength of Carbon/Epoxy material is 945 MPa. the von misses stress of Toroidal pressure vessel is less than the yield strength of material. Hence, the Toroidal pressure vessel with 100mm hole diameter is safe for pressure load.

Comparison of Toroidal pressure vessel for different hole diameters and different type of hole

GRAPHS:

Toroidal pressure vessel with different hole diameter on outer shell:





Toroidal pressure vessel with different hole diameter on inner shell:

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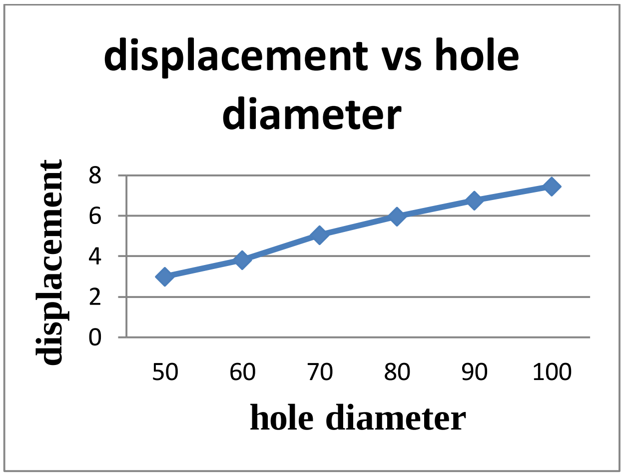
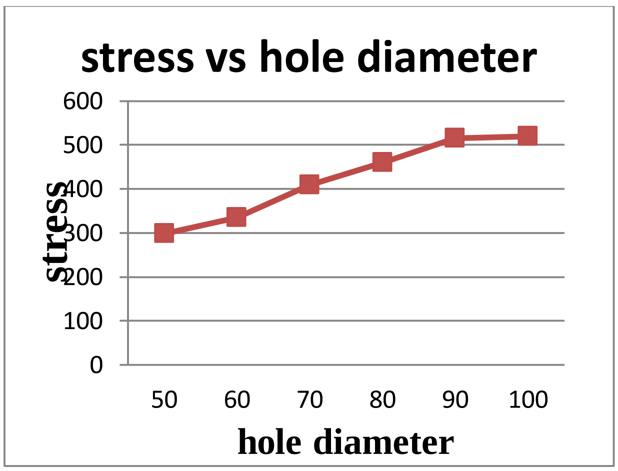
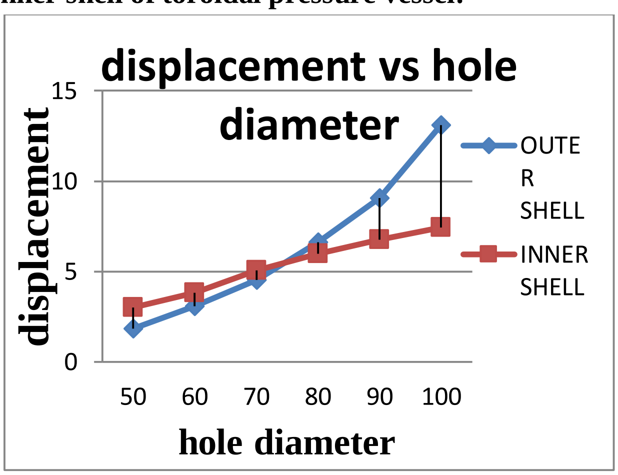
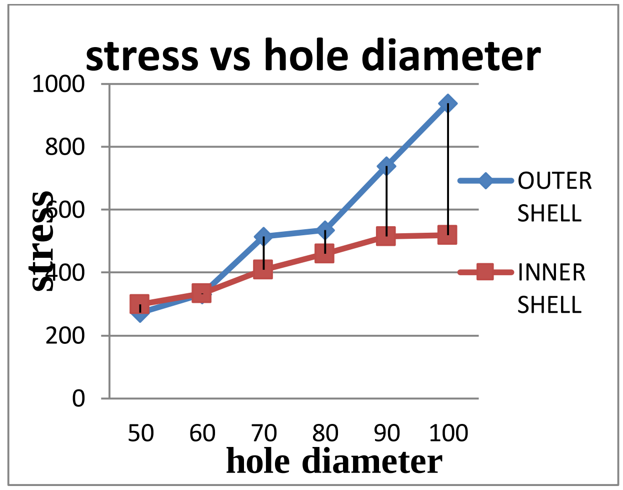




Comparisons of displacement for outer shell and inner shell of toroidal pressure vessel:

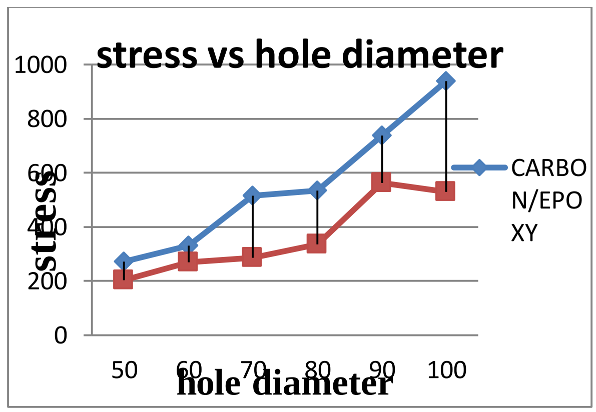




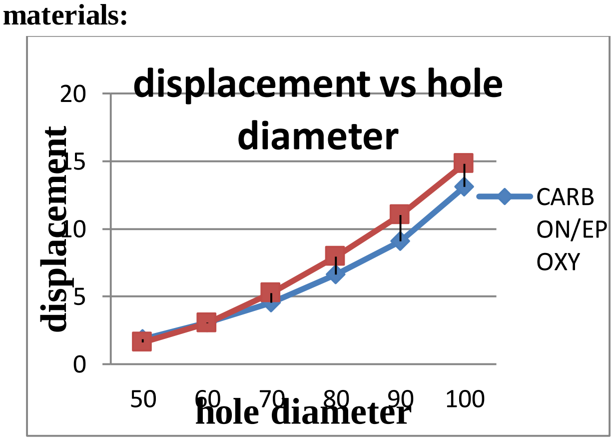
RESULTS AND CONCLUSION

GRAPHS:

1. Comparison of stress values of toroidal pressure vessel with hole on outer shell for two materials:



2. Comparison of displacement values of toroidal pressure vessel with hole on outer shell for two materials:



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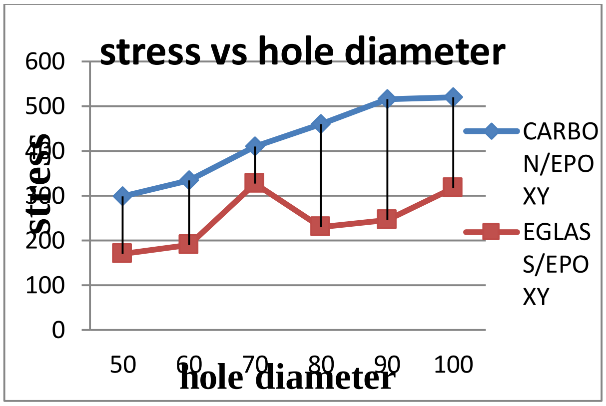
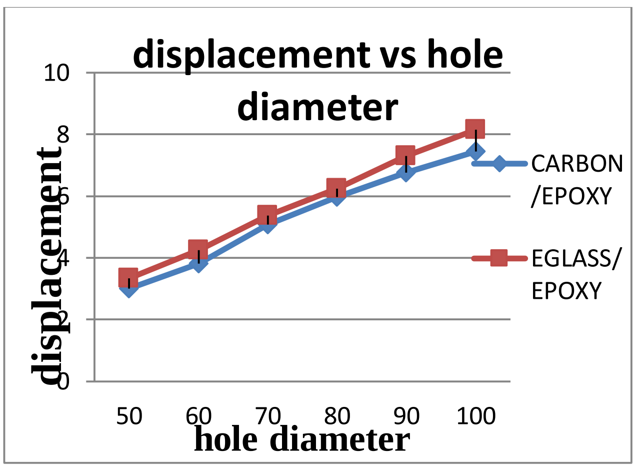
3. Comparison of stress values of toroidal pressure vessel with hole on inner shell for two materials:



3. Comparison of displacement values of toroidal pressure vessel with hole on inner shell for two materials:



CONCLUSION:

Toroidal pressure vessel was developed in NX-CAD SOFTWARE. Static analysis was performed on toroidal pressure vessel for two different locations of hole on shell. Toroidal pressure vessel was also studied for two composite materials (i.e. Eglass/Epoxy and Carbon/Epoxy materials). Based on results, Eglass/Epoxy material for different locations have less displacement values than Carbon/Epoxy material. The von misses stresses of Eglass/Epoxy material at different locations for different hole diameters were less comparative to Carbon/Epoxy material. hence, Eglass/Epoxy material was best suitable for Toroidal pressure vessel.

REFERENCES

1. Finite Element Analysis of Toroidal Pressure Vessel Using FEASTSMT/PreWin by Rakendu R, MK Sundaresan and PinkyMerin Philip
2. Stability analysis of a toroidal pipe-reducer under uniform external pressure by PrashantaDutta, Md. Raisuddin Khan, Md. Abdus Salam Akanda and Md. WahhajUddin
3. Simplified theoretical solution of circular toroidal shell with ribs under uniform external pressure by Qinghai Du ,GuangZou , Bowen Zhang, Zhengquan Wan.
4. Design and Analysis of Filament Wound Composite Pressure Vessel with Integrated-end Domes by M. Madhavi, K.V.J.RaoandK.NarayanaRao.
5. Application of isotensoid-based cross sections to filament-wound toroidal pressure vessels by L. Zu, S. Koussios and A. Beukers.
6. Pattern design for non-geodesic winding toroidal pressure vessels by Lei Zu, Qin-Xiang He, Qing-Qing Ni.