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Design and Analysis of Gunboat in Missile

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Abstract:

Gunboat is used for carrying, storing and launching of missile. During storage and launching, the Gunboat is subjected to internal pressure of 45 kgf/cm2 and external pressure of 9kgf/cm2.The Gunboat is generally placed inside the testing chamber.

Gunboat testing chamber is one of the most critical components in Defence Organization. The Primary objective of this thesis is to design a Gunboat testing chamber and predicting the failure performance of Gunboat testing chamber using ANSYS a finite element analysis package.

The structure of the missile testing chamber is determined on the basis of empirical of gun design and experimental data of Ballistic Research Laboratories (BRL).First a three- Dimensional model of a Gunboat chamber is made in Uni Graphics and then stress analysis is carried out using ANSYS. Contact analysis on Gunboat testing chamber is also carried out using ANSYS to estimate the gap between surfaces of shell end and dish end of Gunboat testing chamber.

I.INTRODUCTION:

The shell of the test setup is made from IS: 2062 plates welded to get 11 meters length and diameter of the shell is 1.5 meters. One end of the test setup will have dished end welded integrally to the cylinder. The other end shall be a hinged door with proper sealing. One of the sides dished end is provided with screw rod to press the dummy dish end for leak proof joint which shall withstand the internal pressure during testing.

The screw is actuated by a hand wheel provided through nut. The nut is fixed in a welded housing on the dished end. Between both the mating faces rubber/gasket will be provided to avoid any leak of water during pressure testing.

As per the purpose of design, the Gunboat testing chamber assembly is classified into 3 subsystems.

- Chamber shell design.
- Gunboat dished end design.
- Support legs design.

components used in gunboat testing chamber:

The following are the components which are used in Gunboat.

- Chamber shells.
- Gunboat dished ends.
- Support legs.
- Bolts.
- Pressure gauges.

Gunboat Chamber dished ends: Dishes are generally used to close the ends of Gunboat chamber. Generally they are two types

- Fixed type dishes.
- Clamped type dishes.

Fixed type dishes:

In this type, dishes welded to Gunboat chamber for providing to prevent leakage of pressure.

Clamped type:

in this type, dishes are used to open or close the Gunboat chamber through clamps and it act as a Door to loading and unloading of missile.

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Clamped type dishes are fastened by using bolts; bolts are also plays major role in designing of Gunboat chamber. For this application M12,M22 &M36 bolts are analyzed. Properties of these bolts are shown bellow.

Definition of bolt:

Bolts are defined as headed fasteners having external threads that meet an exacting, uniform bolt thread specification (such as M, MJ, UN, UNR, and UNJ) such that they can accept a no tapered nut.

M12 Bolt:

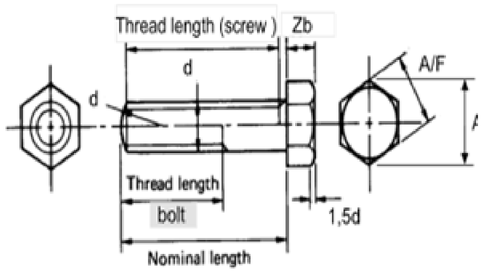


Fig 1: M12 Bolt.

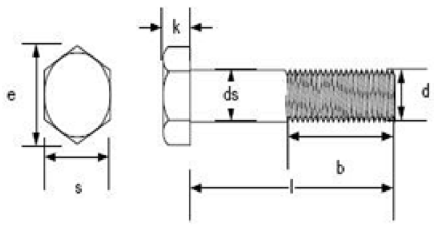


Fig 2: M36 Bolt

Standard Metric and USA Bolt Shank Dimensions

(All dimensions in units of mm or mm2 unless otherwise specified.)

M36 Bolt:

			Coarse Pitch Threads					Fine Pitch Threads				
Size Designation	Nominal (Major) Diam- eter, D_n	Nominal Shank Area, A_n	Pitch (mm per thread), p	Pitch Diameter, d_p	Minor Diameter Area, A_s	M, UNC, UNRC Tensile Stress Area, A_{ts}	MJ, UNJC Tensile Stress Area, A_{ts}	Pitch (mm per thread), p	Pitch Diameter, d_p	Minor Diameter Area, A_s	M, UNF, UNRF Tensile Stress Area, A_{ts}	MJ, UNJF Tensile Stress Area, A_{ts}
M12	12.000	113.10	1.7500	10.863	76.247	84.267	92.687	1.2500	11.188	86.037	92.072	98.311
M22*	22.000	380.13	2.5000	20.376	281.53	303.40	326.09	1.5000	21.026	319.20	333.06	347.21
M36	36.000	1017.9	4.0000	33.402	759.28	816.72	876.26	2.0000	34.701	883.85	914.53	945.74

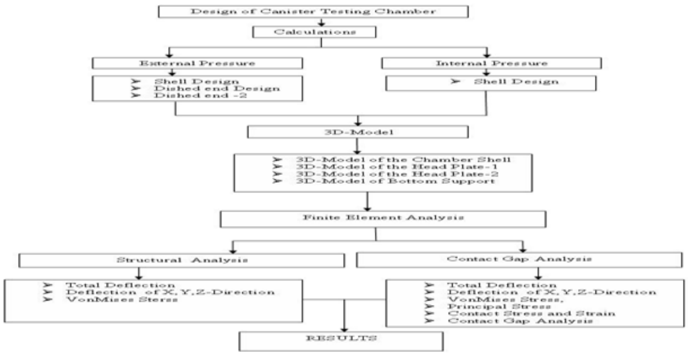
Table 1.2 Standard Metric and USA Bolt Shank Dimensions

Pressure gauge: Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure pressure are called pressure gauges or vacuum gauges.
Types of pressure gauges:

- Air Pressure Gauges.
- Oil Pressure Gauges.
- Differential Pressure Gauges.
- Digital Pressure Gauges.
- Diaphragm Pressure Gauges.

II.PROBLEM DESCRIPTION AND METHODOLOGY:

It has been reported that the development of Gunboat testing chamber consists of three stages. In the first stage the basic structural shape dimension are determined based on the required effect of fragment and range. The second stage consists of the development of 3-D structures. The third stage includes validity of the structure by considering the factor of safety. There have been some efforts made to integrate the various areas of Gunboat testing chamber design; the software ANSYS comes closest to achieving this. Important aspects of these models are: geometry, loading that mimic the actual loading conditions and interface conditions with the Gunboat structures. The focus in this study will be on designing, analyzing at each design phases and modeling of Gunboat testing chamber.



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DESIGN CONSTRAINTS AND MODELLING:

The Gunboat testing chamber is designed for an internal pressure of 9kgf/ cm2.

Design Formulas:

The design formulas used in the "design by rule" method are based on the principal stress theory and calculate the average hoop stress. The principal stress theory of failure states that failure occurs when one of the three principal stresses reaches the yield strength of the material. Assuming that the radial stress is negligible, the other two principal stresses can be determined by simple formulas based on engineering mechanics.

Shell Design Calculations for internal pressure:

Formulas for calculation of cylindrical shell Thickness
t1 = (PR_(i))/((SE-0.6P))
Where
t1 = Minimum required thickness (cm)
P = Operating pressure (kgf/cm2)
Ri = Shell Inside radius (cm)
S = Allowable stress (kg/cm2)
E = Weld joint efficiency factor

Inputs:

Operating pressure (P) = 9 kgf/cm2
Shell Inside radius (Ri) = 75 cm
Allowable stress (S) = 1200 kg/cm2
Weld joint efficiency factor (E) = 0.6
t1 = Minimum required thickness (cm) =
9 X 75.1200 X0.6-0.6X9 = 0.944584 cm
t1 = Minimum required thickness= 9.44584 mm
Standard nominal thickness considered (t) =16 mm
Milling tolerance (m) = 0.06 x t = 0.96 mm
Modification in weld portion (w) = 1.5+if (t<12)0 .6 else 0 .8
(Considering Only One side welding with no backup plate) w = 2.3 mm
Bending Tolerance (b) = 0.002 t
(Considered at 0.2% of the Nominal Thickness) b = 0.032 mm
Final Thickness (T1) = t1+m+w+b+CA
T1 = 13.73784 mm
Final Standard Thickness = 16 mm

Dished End-1 Design Calculations

Formulas for calculation of Dished End Thickness
t1 = (PR_(i))/((SE-0.6P))
Where
t1 = Minimum required thickness (cm)
P = Operating pressure (kgf/cm2)
Ri = Shell Inside radius (cm)
S = Allowable stress (kg/cm2)
E = Weld joint efficiency factor

Inputs:

Operating pressure (P) = 9 kgf/cm2
Shell Inside radius (Ri) = 75 cm
Allowable stress (S) = 1200 kg/cm2
Weld joint efficiency factor (E) = 0.6
t1 = Minimum required thickness (cm) =
9 X 75.1200 X0.6-0.6X9 = 0.944584 cm
t1 = Minimum required thickness= 9.44584 mm
Standard nominal thickness considered (t)=16 mm
Milling tolerance (m) = 0.6 x t = 0.96 mm
Modification in weld portion
(w = 1.5+if (t<12)0 .6 else 0 .8)
(Considering Only One side welding with no backup plate)
w = 2.3 mm
Bending Tolerance (b) = 0.002 t
(Considered at 0.2% of the Nominal Thickness) b = 0.032 mm
Final Thickness (T1) = t1+m+w+b+CA
T1 = 13.73784 mm
Final Standard Thickness with Margin = 16 mm

Dished End-2 Design Calculations

Formulas for calculation of Dished End Thickness
t1 = (PR_(i) W)/((2SE-0.2P))
Where
t1 = Minimum required thickness (cm)
P = Operating pressure (kgf/cm2)
Ri = Shell Inside radius (cm)
S = Allowable stress (kg/cm2)
E = Weld joint efficiency factor

4.3.1 Our inputs:

Operating pressure (P) = 9 kgf/cm2
Shell Inside radius(Ri) = 75 cm
Allowable stress (S) = 1200 kg/cm2
Weld joint efficiency factor (E) = 1
Dished end factor (W) =0.25*(3+√(Ri/0.1Ri))

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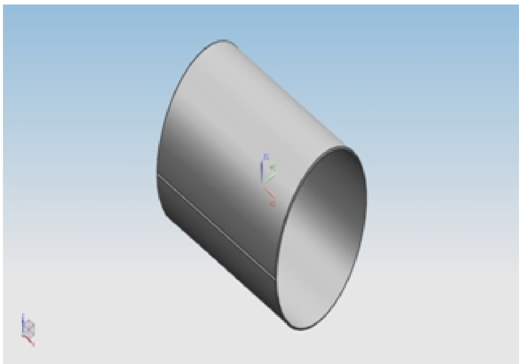
W = 1.5405
t1 = Minimum required thickness (cm) = (9*75*1.5405)/(2*1200*1-0.2*9) = 0.43361 cm
t1 = Minimum required thickness = 4.3361 mm
Standard nominal thickness considered (t) =16 mm
Milling tolerance (m) = 0.6 x t = 0.96 mm
Modification in weld portion (w) = 1.5+if (t<12)0 .6 else 0 .8
(Considering Only One side welding with no backup plate) w = 2.3 mm
Bending Tolerance (b) = 0.002 t
(Considered at 0.2% of the Nominal Thickness)
b = 0.032 mm
Final Thickness (T1) = t1+m+w+b+C
T1 = 8.6281 mm
Final Standard Thickness with Margin = 16 mm

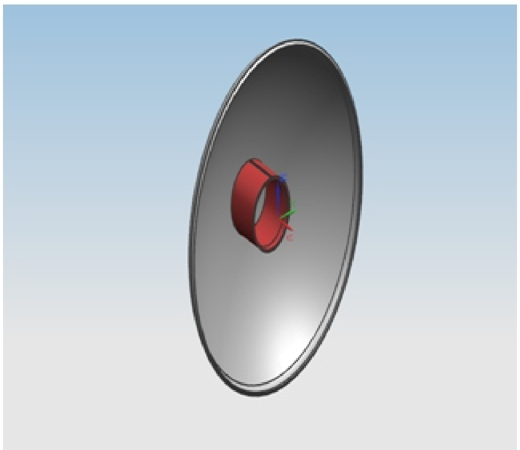
IV.3D MODEL OF A GUNBOAT TESTING CHAMBER:

The modeling of Gunboat testing chamber is done in Unigraphics NX. It is one of the world's most advanced and tightly integrated CAD/CAM/CAE product development solutions. Spanning the entire range of product development, NX delivers immense value to enterprises of all sizes. It simplifies complex product designs, thus speeding up the process of introducing products to the market.

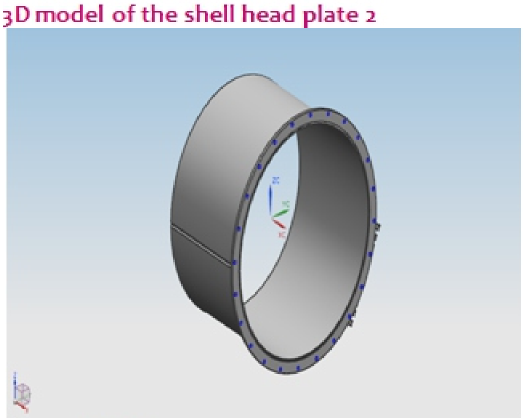


3D model of the chamber shell

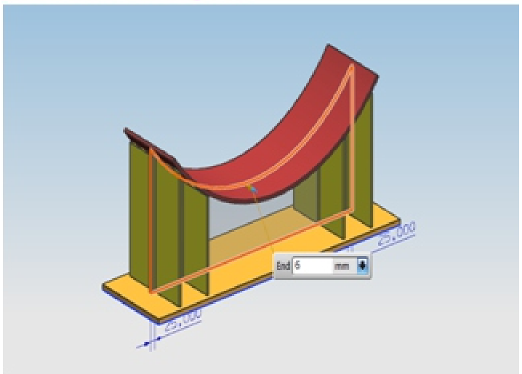
3D model of the shell head plate 1



3D model of the shell head plate 2



3D model of the spacer



3D model of the bottom supports

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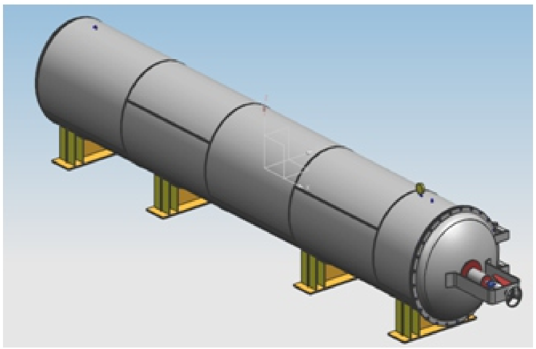
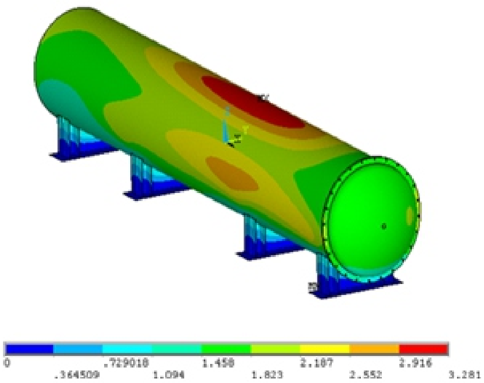
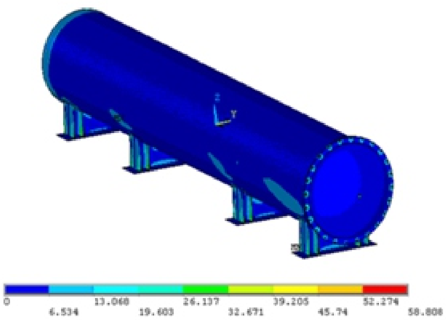


3D model of a Gunboat testing chamber assembly

V.RESULTS AND DISCUSSION:



Total deflection of the Gunboat testing chamber. Maximum total deflection of 3.2 mm is seen on the Gunboat testing chamber.

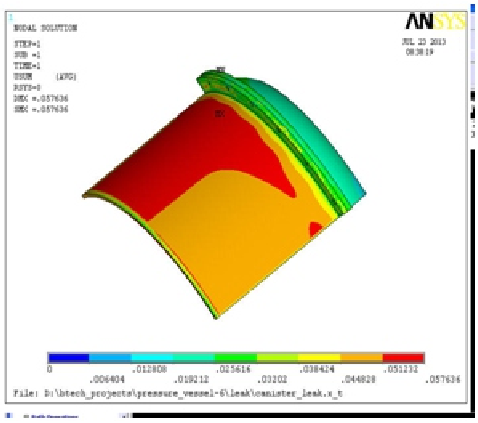


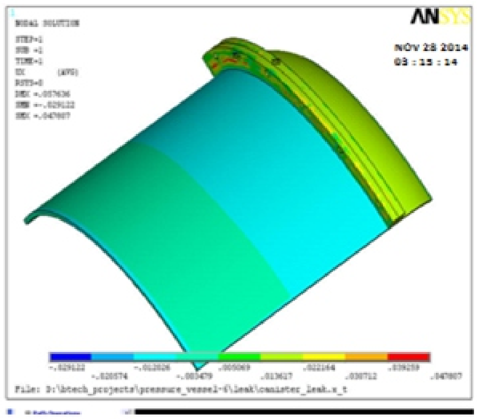
5 VonMises Stress on the Gunboat testing chamber. Maximum Stress of 58N/mm2 is seen on the Gunboat testing chamber From the results obtained for pressure analysis of Gunboat testing chamber, the maximum total deflection is 3.2 mm and the maximum stress is 58N/mm2.

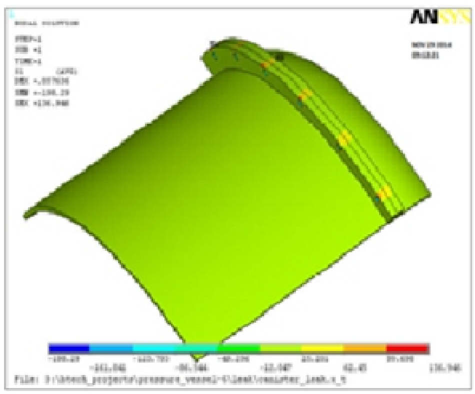
VI. CONTACT GAP ANALYSIS:

For M12 Bolts

Total Deformation (Usum) and Displacement in X-dir(Ux)







Principal stress

From the above figure shows maximum principal stress is 198N/mm2

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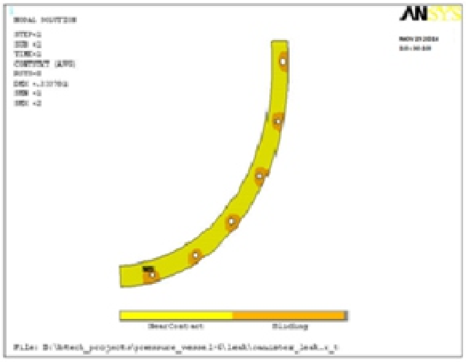
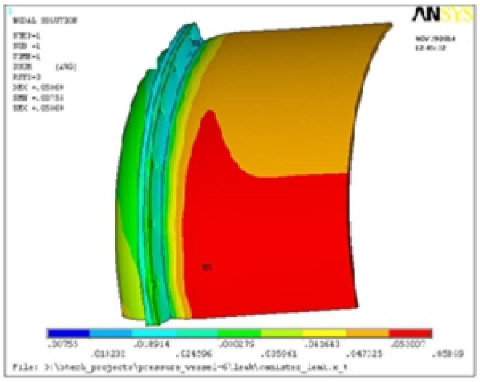


Contact Status for M12 bolt.

From the above Fig it can be observed that the Von-Mises stress is very high at bolt region and also there is an opening of 0.00328mm at the bolt locations. So It is recommended to check for the higher bolt diameter. so,the gap analysis is performed again for M22 bolt diameter.

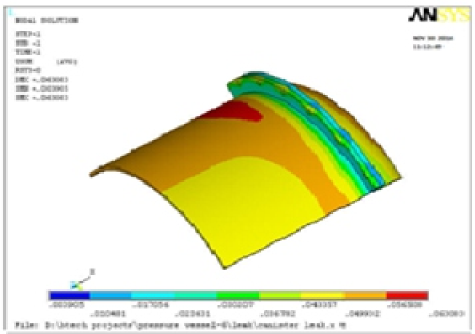
Contact Gap Analysis for M22 bolts:



Total Deformation

Total deformation of 0.58mm is observed on the chamber

Contact Gap Analysis for M36 bolts



Total Deformation

Deformation of 0.06mm is observed on the chamber

VII.CONCLUSION:

The maximum vonMises Stress observed on the Gunboat testing chamber is 58 Map. The maximum deflection observed on the Gunboat testing chamber is 3.2mm. The Designed horizontal Gunboat testing chamber is safe of the internal pressure of 9kgf/cm2 as the yield strength of material used for Gunboat testing chamber is 260N/mm2. Nonlinear Contact Gap analysis performed on the Gunboat testing chamber shows free from Leakage of pressure. Contact gap analysis is suggests to use M36 Bolts which is gives a gap opening of 0mm and henceM36 bolts recommended for Gunboat testing chamber to avoid the pressure leakage to the atmosphere.

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