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Design & Analysis of Cylindrical Leakage Fixture for Inspecting Sty-Cast Material used in Electrical Devices

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Abstract: ***The main objective of the project is to Design & Analysis of the leakage fixture for inspecting Sty-cast materials used at connector part of electrical device's. Sty-cast materials are used for potting of electronic components in order to eradicate the shock's and vibration's due to movement of devices. They are also used as the sealing in electrical components for exclusion of moisture and corrosive agents as the devices are used in various temperature conditions. Generally, Sty-cast materials are inspected through water immersion method in which sty cast is inspected by pressurizing it with dry nitrogen gas and then it is dipped in a sump of water so that if there is any leak in the material bubbles start rising up in the water. The main problem in this method is it can not observe the minor leakages & it also requires a lot's of Human Effort. In order to overcome this problem we designed a leakage fixture for inspecting Sty-cast materials used at connector part of Electrical component's with the help of pressurized Dry Nitrogen Gas (or)Dry Air.***

Keywords: Sty-cast Material, Leakage Fixture, Connector Part, Dry Nitrogen Gas, Inspection

1. Introduction

A sty-cast potting material is a various component mixture of an encapsulating resin with multiple types of additives such as epoxies, silicones, poly urethanes, Amstrong. Sty-cast Potting involves filling the connector part with liquid resin, and the curing the material as the part of the component. Sty-cast Potting compounds can be mixed or dispensed for acquiring as a premixed, frozen formula. The liquid stycast potting material is turned into solid plastic by a chemical reaction. They are two types of systems

- Two part systems
- One part systems

The two-part system consists of resin and hardener when they are mixed, hardening reaction starts where as in one-part system the hardener is relatively inactive when it is exposed to U-V rays the chemical reaction starts[4]. Sty-cast Potting is used to protect circuit boards and components from moisture, high/low temperatures, physical impacts and electrical stresses it also provides heat dissipation, flame retardence and cushioning from shock.

Sty-cast potting is a process of filling a complete electronic assembly with a solid or gelatinous compound for resistance to shock and vibration, and for exclusion of moisture and corrosive agents. Thermosetting plastics or silicone rubber gels are often used[6]. Many areas recommend using silicone or epoxy to protect from impact and loose wires.

Leakage inspection is done in order to avoid the accumulation of moisture content and electrical stress.

Normally, leakage inspection is carried out by water immersion method which is a time consuming process and some of the minor leakages can't be identified by this process.

The disadvantages related to water immersion method can be overcome with the help of leakage fixture.

2. Methods & Present Practices

2.1 Sealing Test (Vacuum)

The equipment nozzle shall be connected to a vacuum pump and a pressure gauge.

The equipment temperature shall then be stabilized at 20ºC ±2 ^{0}C.

The equipment shall then be evacuated until a vacuum corresponding to one of the following test conditions, as required, is achieved:
Test condition A : Air pressure equal to 25 kPa
Test condition B : Air pressure equal to 50 kPa

The equipment shall then be sealed off from the pump and allowed to stand for 30 minutes, after which the reading in pressure gauge shall be noted. For equipment sealing to be satisfactory, the air pressure reading at the end of 30 minutes period should not have fallen by more than 10 kPa..

2.2 Water Immersion Test

Water immersion method in which sty-cast is inspected by pressurizing it with dry nitrogen gas and then it is dipped in a sump of water so that if there is any leak in the material bubbles start rising up in the water. The main problem in this method is it can not observe the minor leakages & it also requires a lot's of Human Effort[6].

Figure 2.2.1: water immersion test

2.3 Excess Pressure Test

A high air pressure chamber capable of attaining pressure differentials shall be used for this procedure. The chamber shall be capable of maintaining the required pressure for the duration specified in clause.

The chamber shall also be capable of maintaining its working space at the temperatures of -20ºC ±3 ^{0}C and 70ºC ±3 ^{0}C, and for this purpose shall meet the requirements specified in low and high temperature tests.

2.4 Rapid Decompression Test

A low air pressure chamber capable of attaining pressures, shall be used for this procedure. The chamber shall be capable of maintaining the required pressure for the duration. The chamber shall also be capable of maintaining its working space at the temperatures of -20ºC ±3 ^{0}C and 40ºC ±3 ^{0}C and for this purpose shall meet the requirements specified in low temperature and high temperature tests[6].

2.5 Explosive Decompression Test

Equipment which is normally pressurized or evacuated shall have the internal pressure adjusted to the most adverse design limit that would be experienced at ground level. The equipment shall be placed in the test chamber and orientated into its normal attitude if this is significant, as required. The test chamber shall be conditioned for a period sufficient to allow the equipment to stabilize at one of the following temperatures as required: Temperature corresponding to standard testing conditions.
-20ºC ±3 ^{0}C.
+40ºC ±3 ^{0}C.

3. Objectives of the Project

- To detect minor leakages in the sealing of sty-cast potting material.
- To improve the quality of the sealing test.
- To design varied dimensions of top covers of leakage fixture for manufacturing different dimensioned connectors.
- To design a leakage fixture to inspect sealing in sty-cast potting of electrical device connector parts.

4. System

4.1 System Working

The working medium used in this system is low pressurized dry air or dry nitrogen system about 5 – 25 psi. the atmospheric air is compressed 0.034 - 0.172 N/mm^2 & the moisture content in the in the atmospheric air is reduced by lowering air temperatures it reduces the air's ability to hold moisture.

The connector part which is to be inspected is fixed to panel cut-out of the top cover of leakage fixture. The compressed dry air (or) dry nitrogen is inserted in to the cylindrical leakage fixture though valve purge. The pressure inside the cylinder must be constant though out the process. The pressure is monitored through the sensitive pressure gauge. If there is any leakage in the sealing then we can observe a pressure drop in the cylindrical through the sensitive pressure gauge.

Main Advantages

- This process can detect minor leakages also.
- It requires less human effort.

Disadvantages

- The pressure gauge used in this system must be handled carefully.

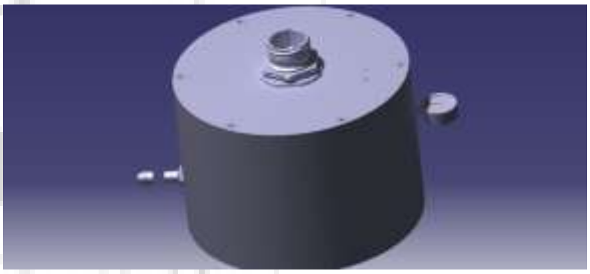

Figure 4.1.1: Assembled cylindrical leakage fixture

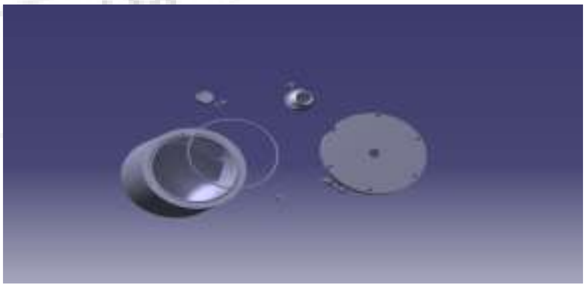

Figure 4.1.2: Dis-assembled cylindrical leakage fixture

4.2 System Components

The system procedure consists of following components:

- Pressurized dry air (or) dry nitrogen of 5 to 16.5 psi.
- Pressure gauge F100- GFS-S-L-14-L (0 to 30 psi).
- Operating temperatures
  -20ºC ±3 ^{0}C.
  +40ºC ±3 ^{0}C
- Connector part with sty-cast potting

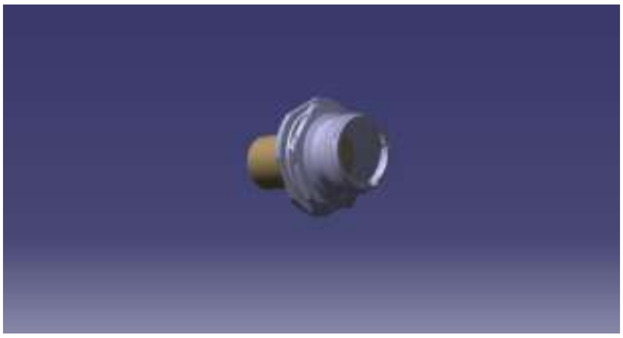

Figure 4.2.1: 3D Connector part with potting material

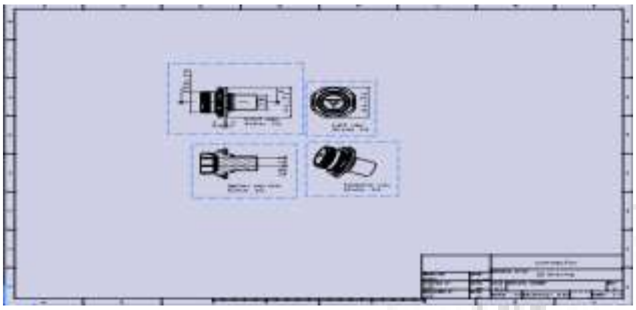

Figure 4.2.2: 2D Connector part with potting material

A connector is an electro-mechanical device used to join electrical terminations and create an electrical circuit. Electrical connectors includes plugs (male-ended) and jacks (female-ended). The connection may be temporary, as for portable equipment, require a tool for assembly and removal, or serve as a permanent electrical joint between two wires or devices.

- **Different types of cut outs in top cover for Cylindrical Fixture**

Table 1: Different types of cut outs in top cover for Cylindrical Fixture

Shell Size	M+0.25-0.00	N+0.00-0.25
13	25.65	24.26
15	28.83	27.56
23	41.53	40.26
25	44.7	43.43

Figure 4.2.3: 3D Top cover of leakage fixture of 13 Shell

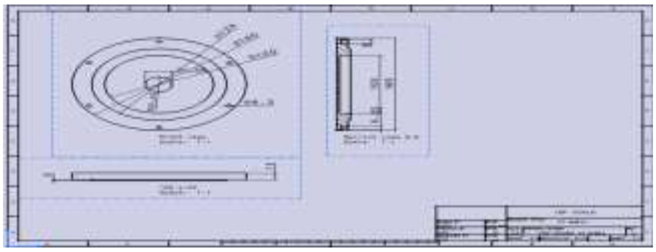

Figure 4.2.4: 2D Top cover of leakage fixture of 13 Shell

Figure 4.2.5: 3D Top cover of leakage fixture of 15 Shell

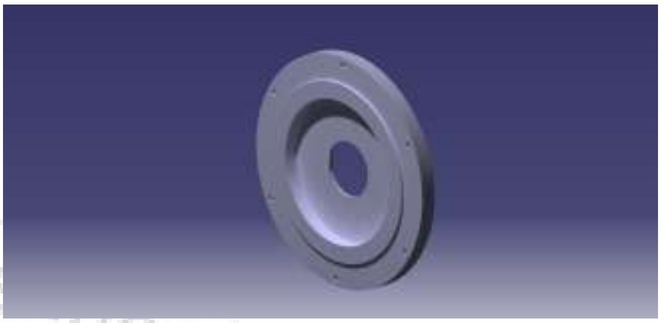

Figure 4.2.6: 3D Top cover of leakage fixture of 23 Shell

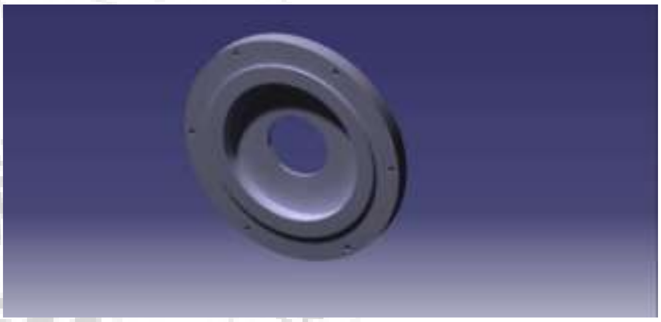

Figure 4.2.7: 2D Top cover of leakage fixture of 25 Shell

- **Bottom housing**

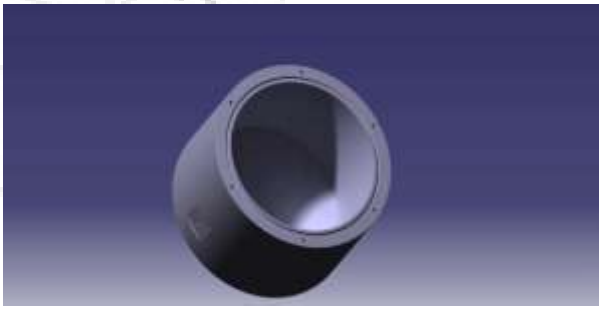

Figure 4.2.8: 3D bottom housing of the leakage fixture

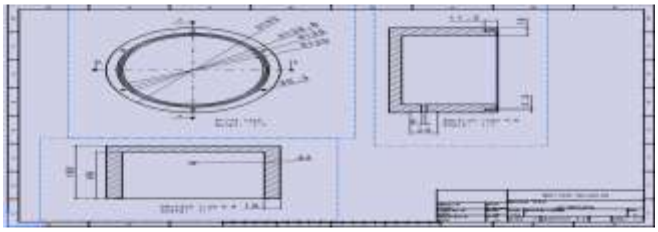

Figure 4.2.9: 2D bottom housing of the leakage fixture

Materials Used For Top Cover & Bottom Housing

Aluminium 6063 alloy is used for manufacturing top cover and bottom housing of leakage fixture.

Aluminium 6063 Alloy

AA 6063 is an aluminium alloy, with magnesium and silicon as the alloying elements. The standard controlling its composition is maintained by The Aluminium Association. It has generally good mechanical properties and is heat treatable and weld able. It is similar to the British aluminium alloy HE9[8].

6063 is the most common alloy used for aluminium extrusion. It allows complex shapes to be formed with very smooth surfaces fit for anodizing and so is popular for visible architectural applications such as window frames, door frames, roofs, and sign frames. Applications requiring higher strength typically use 6061 or 6082 instead.

Mechanical Properties of AA6063

The mechanical properties of 6063 depend greatly on the temper, or heat treatment, of the material.

1) 6063-O

Un-heat-treated 6063 has maximum tensile strength no more than 130 MPa (19,000 psi), and no specified maximum yield strength. The material has elongation (stretch before ultimate failure) of 18%.

2) 6063-T1

T1 temper 6063 has an ultimate tensile strength of at least 120 MPa (17,000 psi) in thicknesses up to 12.7 mm (0.5 in), and 110 MPa (16,000 psi) from 13 to 25 mm (0.5 to 1 in) thick, and yield strength of at least 62 MPa (9,000 psi) in thickness up to 13 millimetres (0.5 in) and 55 MPa (8,000 psi) from 13 mm (0.5 in) thick. It has elongation of 12%.

3) 6063-T5

T5 temper 6063 has an ultimate tensile strength of at least 140 MPa (20,000 psi) in thicknesses up to 13 millimetres (0.5 in), and 130 MPa (19,000 psi) from 13 mm (0.5 in) thick, and yield strength of at least 97 MPa (14,000 psi) up to 13 millimetres (0.5 in) and 90 MPa (13,000 psi) from13 to 25 mm (0.5 to 1 in). It has elongation of 8%.

4) 6063-T6

T6 temper 6063 has an ultimate tensile strength of at least 190 MPa (28,000 psi) and yield strength of at least 160 MPa (23,000 psi). In thicknesses of 3.15 millimetres (0.124 in) or less, it has elongation of 8% or more; in thicker sections, it has elongation of 10%.

5) Other temperatures

6063 is also produced in tempers **T52**, **T53**, **T54**, **T55**, and **T832**, with various improved desired properties.

Chemical Composition of AA6063

The alloy composition of 6063 is:

- Silicon minimum 0.2%, maximum 0.6% by weight
- Iron no minimum, maximum 0.35%
- Copper no minimum, maximum 0.10%
- Manganese no minimum, maximum 0.10%
- Magnesium minimum 0.45%, maximum 0.9%
- Chromium no minimum, maximum 0.10%
- Zinc no minimum, maximum 0.10%
- Titanium no minimum, maximum 0.10%
- Other elements no more than 0.05% each, 0.15% total
- Remainder Aluminium

- **O-RING**

O-ring is a circular ring made of a soft, resilient material and normally having a circular cross-section. In specific cases, the cross-section may be square or rectangular or any special shape, where fluids, temperature pressure and geometry permit its use, it is the most satisfactory choice of seal. Because of its round cross-section, it can be squeezed readily to establish the seal-line and the load required to do this is lighter compared to any other cross- section. These seals are broadly categorized into static and dynamic seals. Static seals are those in which there is no relative motion between the mating surfaces. Dynamic seals are those seals which function between surfaces with definite relative motion[7].

A variety of Elastomers are used for making O-ring. Elastomers are materials which at room temperature can be stretched repeatedly to at least twice the original length and which upon release of the stress will return to its original length. The choice of specific type of elastomer depends on the operational requirements. Some of the most commonly used elastomers are

- Natural Rubber
- Polychloroprene rubber
- Nitrile rubber
- Silicone Rubber

Natural Rubber

Though this was being used very commonly for decades ago, its proportion is decreasing with the advent of synthetic rubber. Natural rubber has very poor resistance to atmospheric oxygen as well as to petroleum fluids. It is still used in some applications because of low cost and very good wear resistance properties.

Polychloroprene Rubber

It is the best known synthetic rubber and also the earliest. It has got good resistance to petroleum fluids. It is quite cheap compared to the other synthetic rubbers. It is best suited for all kinds of general applications where operating conditions are moderate.

Nitrile Rubber

Nitrile rubber finds its use because of its excellent resistance to petroleum products. It has got useful working temperature range -40 to +93 centigrade. Due to its poor weather resistance, it has to be stored properly.

Silicone Rubber

Silicone rubber finds wide use because of its wide temperature range. This is best suited for static seals subjected to extremes of temperature. It has got excellent weather resistance properties and but poor dynamic properties.

Material Used For Bolts

Chromium-vanadium steel is a group of steel alloys incorporating carbon, manganese, phosphorus, sulphur, silicon, chromium and vanadium. Some forms can be used as high speed steel. Chromium and vanadium both make the steel more hardenable.

5. Numerical Analysis

Calculations of Hoop Stress or Circumferential Stress
Thickness of the cylinder (t) = 15 mm
Internal diameter of the cylinder (d) = 130 mm

$$\frac{t}{d} = \frac{15}{130} = 0.115 > 0.05$$

If $\frac{t}{d}$ ratio is greater than $\frac{1}{20}$ (0.05) then it is considered as thick cylinder case
Therefore in our project we consider thick cylinder case
Internal diameter (d) = 130 mm
Internal radius (r_1) = 65 mm
External diameter (D) = d + 2t = 130 + 2 t
= 130 + 2* 15 = 160 mm
Fluid pressure = 25 psi =0.172 N/mm^2

The radial pressure (p_x) is given by [2]

$$\mathbf{p_x = \frac{b}{x^2} - a} \text{ ----------------- } \mathbf{(1)}$$

Now applying the boundary conditions to the above equation
The boundary conditions are
1. At x = r_1 = 65 mm , p_x = 25 psi = 0.172 N/mm^2
2. At x = r_2 = 80 mm , p_x = 0

Substituting these boundary conditions in eq. (1)

$$0.172 = \frac{b}{65^2} - a$$

$$0.172 = \frac{b}{4225} - a \text{ ----------------- } (2)$$

And

$$0 = \frac{b}{80^2} - a$$

$$0 = \frac{b}{6400} - a \text{ ---------------- } (3)$$

$$a = \frac{b}{6400}$$

$$0.172 = \frac{b}{4225} - \frac{b}{6400}$$

$$0.172 = \frac{6400b - 4225b}{4225 * 6400}$$

$$b = \frac{0.172 * 27040000}{2175}$$

b = 2138.33

$$a = \frac{b}{6400} = \frac{2138.33}{6400} = 0.334$$

a = 0.334

The values of a and b are substituted in the hoop stress
Now hoop stress at any radius (x) is given by eq[2].

$$\sigma_x = \frac{b}{x^2} + a$$

$$\sigma_x = \frac{2138.33}{x^2} + 0.334$$

At x =65, $\sigma_{65} = \frac{2138.33}{65^2} + 0.334$

$\boldsymbol{\sigma_{65}}$ **= 0.8401 N/mm^2 =121.46 ≈ 122 psi**

At x=80, $\sigma_{80} = \frac{2138.33}{80^2} + 0.334$

$\boldsymbol{\sigma_{80}}$ **=0.668 N/mm^2 = 96.885 ≈ 97 psi**

Therefore maximum load is taken in to considerations=122 psi

Calculations of Bolt Diameter

Pressure (P) = 122 psi =0.841 N/mm^2
Factor of safety = 1.5
Pressure (p) = 122*1.5 = 183 psi = 1.261 N/mm^2
Diameter (D) =130 mm
Number of bolts (n) = 6
Considering Bolt Material = Cr-Va steel
Allowable Tensile stress (s_t) = 1565 N/mm^2 (From Data Book)
Force exerted by gas on top cover of the fixture

$$\mathbf{F = \frac{\pi}{4} D^2 p}$$

$$F = \frac{\pi}{4} * 130^2 * 1.261$$

F =16737.54 N

This force is resisted by 6 bolts
Hence the force acted on one bolt = $\frac{16737.54}{6}$ = 2789.59 N
Since the joint is a leak proof joint, the bolts undergo **initial tightening** apart from **external load**

The Resultant load acting on each bolt is given by

$$\mathbf{P = P_1 + K\, P_2}$$

Where K = $\frac{a}{1+a}$, a= the ratio of elasticity of connected parts to the elasticity of bolts.

Modules of Elasticity of
Connected parts (Aluminium) = 69GPa
Modules of Elasticity of bolt material (Steel) = 200GPa

$$a = \frac{69}{200} = 0.345$$

$$K = \frac{0.345}{1+0.345} = 0.25$$

P_1 = Force due to initial tightening = 2840 d N
P_2 = External force = 2789.59 N
P = 2840 d +0.25 * **2789.59**
P= 2840 d + 697.39
Now tensile strength of each bolt

$$F_t = \frac{\pi}{4} * d_c^2 * S_t$$

$$= \frac{\pi}{4} * d_c^2 * 1565$$

$$= 1229.148\, d_c^2$$

To overcome the failure, the tensile strength of bolts should be more than the load acted on it.

$1229.148\ d_c^2 \geq 2840\ d + 697.39$
$1229.148\ (0.84\ d)^2 - 2840\ d - 697.39 \geq 0$
$867.28\ d^2 - 2840\ d - 697.39 \geq 0$
$d^2 - 3.27d - 0.804 \geq 0$
$d \geq 3.504 \approx 4$ mm
Therefore diameter of the bolt is M4

6. Formulas

Calculations of Hoop Stress[1]

The radial pressure (p_x) is given by

$$p_x = \frac{b}{x^2} - a$$

Now hoop stress at any radius (x) is given by eq.

$$\sigma_x = \frac{b}{x^2} + a$$

Calculations of Bolt Diameter[2]

Force exerted by gas on top cover of the fixture

$$F = \frac{\pi}{4} D^2 p$$

The Resultant load acting on each bolt is given by

$$P = P_1 + K\ P_2$$

Where $K = \frac{a}{1+a}$, a= the ratio of elasticity of connected parts to the elasticity of bolts.

Now tensile strength of each bolt

$$F_t = \frac{\pi}{4} * d_c^2 * S_t$$

7. Analysis of Cylindrical Leakage Fixture[5]

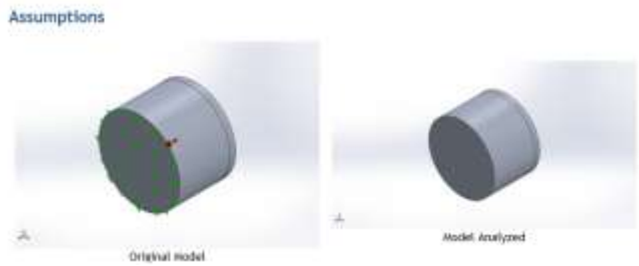

Figure 7.1: Original model of cylindrical leakage fixture[5]

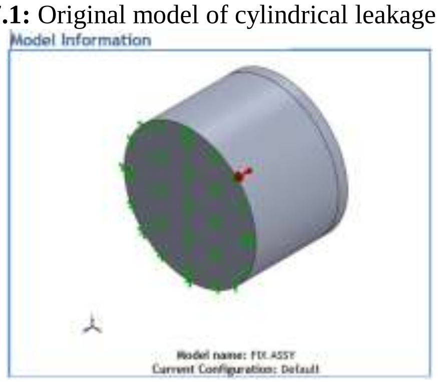

Figure 7.2: Fixing one end

Table 2: Study Properties of Analysis

Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	Automatic
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	On
Compute free body forces	Off
Friction	On
Friction Coefficient	5.000000e-002
Use Adaptive Method:	Off

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

Model Reference	Properties	Components
	Name: 6063 (AA) Model type: Linear Elastic Isotropic Default failure criterion: Unknown Yield strength: 2.75e+008 N/m^2 Tensile strength: 3.1e+008 N/m^2 Elastic modulus: 6.9e+010 N/m^2 Poisson's ratio: 0.33 Mass density: 2700 kg/m^3 Shear modulus: 2.6e+010 N/m^2 Thermal expansion coefficient: 2.4e-005 /Kelvin	Solid Body 1(CirPattern1)(BOTTOM HOUSING-1), Solid Body 1(Boss-Extrude3)(TOP COVER 17 SHELL -1)
	Name: AISI 316 Annealed Stainless Steel Bar (SS) Model type: Linear Elastic Isotropic Default failure criterion: Max von Misses Stress Yield strength: 1.37895e+008 N/m^2 Tensile strength: 5.5e+008 N/m^2 Elastic modulus: 1.93e+011 N/m^2 Poisson's ratio: 0.3 Mass density: 8000 kg/m^3 Thermal expansion coefficient: 1.6e-005 /Kelvin	Material_ComponentList1 (BOLTS)
Curve Data:N/A		

Table 3: Shows the Material properties of different components used in cylindrical leakage fixture.

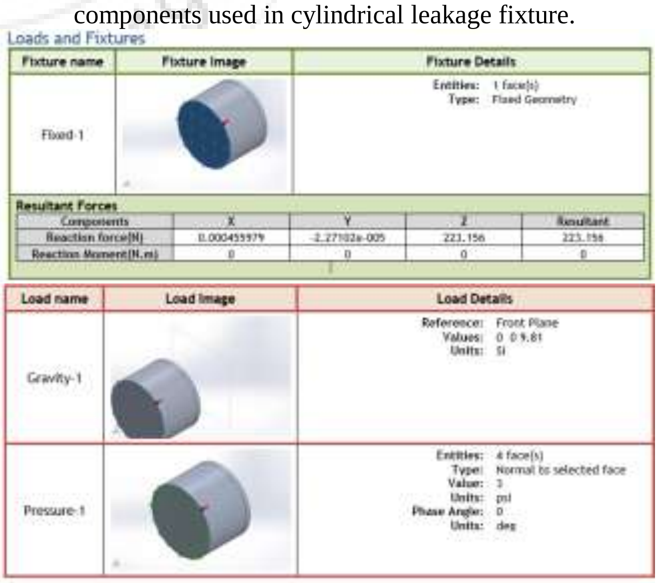

Figure 7.3: Types of Loads Acting

Table 4: Meshing Information

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Curvature-based mesh
Jacobian points	29 Points
Maximum element size	20.04 mm
Minimum element size	4.008 mm
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	Off

Mesh information - Details

Total Nodes	241921
Total Elements	162568
Maximum Aspect Ratio	19.068
% of elements with Aspect Ratio < 3	99
% of elements with Aspect Ratio > 10	0.0172
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:08

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Mesher Used:	Curvature-based mesh
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Maximum element size	20.04 mm
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Mesh Quality Plot	High
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Total Nodes	241921
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Maximum Aspect Ratio	19.068
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% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:08

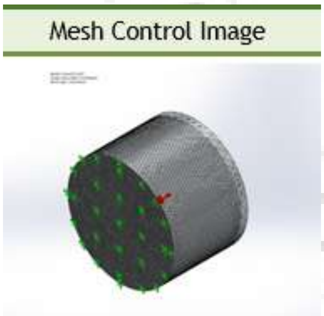


Figure 7.4: Mesh Control

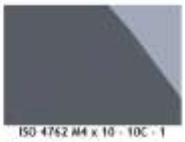
Mesh Control Information:

Mesh Control Name	Mesh Control Image	Mesh Control Details
Control-1		Entities: 7 component(s) Units: mm Size: 3.82013 Ratio: 1.5

Mesh Quality Plots

Name	Type	Min	Max
Mesh Quality Plot1	Aspect Ratio	1.033 Element: 4119	19.068 Element: 160382

Pin/Bolt/Bearing Connector

Model Reference	Connector Details	Strength Details
 ISO 4762 M4 x 10 - 10C - 1	Entities: 1 edge(s), 1 face(s) Type: Bolt(Head/Nut diameter)(Counterbore screw) Head diameter: 7 mm Nominal shank diameter: 4 Preload (Axial): 181.581 Young's modulus: 1.93e+011 Poisson's ratio: 0.3 Preload units: N	Bolt Check: OK Calculated FOS: 4.69239 Desired FOS: 2 

Connector Forces

Type	X-Component	Y-Component	Z-Component	Resultant
Axial Force (N)	0.0019097	0.00096538	-191.31	191.31
Shear Force (N)	5.5217	3.1994	7.127e-005	6.3817
Bending moment (N.m)	-0.024084	0.041177	-3.2717e-008	0.047703

Model Reference	Connector Details	Strength Details
 ISO 4762 M4 x 10 - 10C - 2	Entities: 1 edge(s), 1 face(s) Type: Bolt(Head/Nut diameter)(Counterbore screw) Head diameter: 7 mm Nominal shank diameter: 4 Preload (Axial): 181.581 Young's modulus: 1.93e+011 Poisson's ratio: 0.3 Preload units: N	Bolt Check: OK Calculated FOS: 4.71055 Desired FOS: 2 

Connector Forces

Type	X-Component	Y-Component	Z-Component	Resultant
Axial Force (N)	7.365e-005	0.0021452	-190.98	190.98
Shear Force (N)	-0.055922	6.2968	7.0761e-005	6.2971
Bending moment (N.m)	-0.04723	-0.00061671	-2.5361e-008	0.047234

Model Reference	Connector Details	Strength Details
 ISO 4762 M4 x 10 - 10C - 3	Entities: 1 edge(s), 1 face(s) Type: Bolt(Head/Nut diameter)(Counterbore screw) Head diameter: 7 mm Nominal shank diameter: 4 Preload (Axial): 181.581 Young's modulus: 1.93e+011 Poisson's ratio: 0.3 Preload units: N	Bolt Check: OK Calculated FOS: 4.7137 Desired FOS: 2 

Connector Forces

Type	X-Component	Y-Component	Z-Component	Resultant
Axial Force (N)	-0.0018788	0.0010319	-190.98	190.98
Shear Force (N)	-5.4567	3.1845	7.0875e-005	6.318
Bending moment (N.m)	-0.023866	-0.040616	1.5114e-008	0.047109

Model Reference	Connector Details	Strength Details
 ISO 4762 M4 x 10 - 10C - 4	Entities: 1 edge(s), 1 face(s) Type: Bolt(Head/Nut diameter)(Counterbore screw) Head diameter: 7 mm Nominal shank diameter: 4 Preload (Axial): 181.581 Young's modulus: 1.93e+011 Poisson's ratio: 0.3 Preload units: N	Bolt Check: OK Calculated FOS: 4.73464 Desired FOS: 2 

Connector Forces

Type	X-Component	Y-Component	Z-Component	Resultant
Axial Force (N)	-0.001803	-0.0011462	-190.76	190.76
Shear Force (N)	-5.3912	-3.1299	6.9746e-005	6.2339
Bending moment (N.m)	0.023147	-0.040272	2.3116e-008	0.04645

Model Reference	Connector Details	Strength Details
 ISO 4762 M4 x 10 - 10C - 5	Entities: 1 edge(s), 1 face(s) Type: Bolt(Head/Nut diameter)(Counterbore screw) Head diameter: 7 mm Nominal shank diameter: 4 Preload (Axial): 181.581 Young's modulus: 1.93e+011	Bolt Check: OK Calculated FOS: 4.69507 Desired FOS: 2

	Poisson's ratio: 0.3 Preload units: N	

Connector Forces

Type	X-Component	Y-Component	Z-Component	Resultant
Axial Force (N)	1.7305e-005	-0.0021861	-191.1	191.1
Shear Force (N)	0.030496	-6.3651	7.2813e-005	6.3652
Bending moment (N.m)	0.047753	0.00023273	1.6629e-009	0.047753

 ISO 4762 M4 x 10 - 10C - 6	Entities: 1 edge(s), 1 face(s) Type: Bolt(Head/Nut diameter)(Counterbore screw) Head diameter: 7 mm Nominal shank diameter: 4 Preload (Axial): 181.581 Young's modulus: 1.93e+011 Poisson's ratio: 0.3 Preload units: N	Bolt Check: OK Calculated FOS: 4.70886 Desired FOS: 2 

Connector Forces

Type	X-Component	Y-Component	Z-Component	Resultant
Axial Force (N)	0.0018416	-0.0011532	-190.95	190.95
Shear Force (N)	5.351	-3.1853	7.0848e-005	6.2274
Bending moment (N.m)	0.024158	0.040684	-1.2723e-008	0.047316

Contact Information

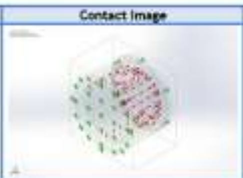
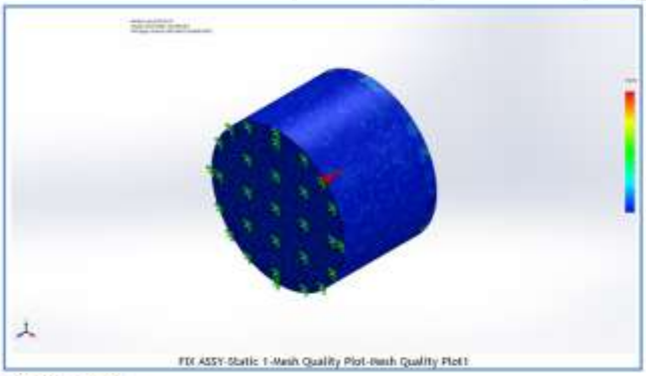
Contact	Contact Image	Contact Properties
Global Contact		Type: No penetration (Surface to surface) Components: 1 component(s)

Figure 7.5: Analysis Information of Bolts



Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	0.000455979	-2.27102e-005	223.156	223.156

Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

Figure 7.6: Mesh Quality plot

Name	Type	Min	Max
Stress1	VON: von Mises Stress	82.428 N/m^2 Node: 1059	4,467,568.500N/m^2 Node: 1001

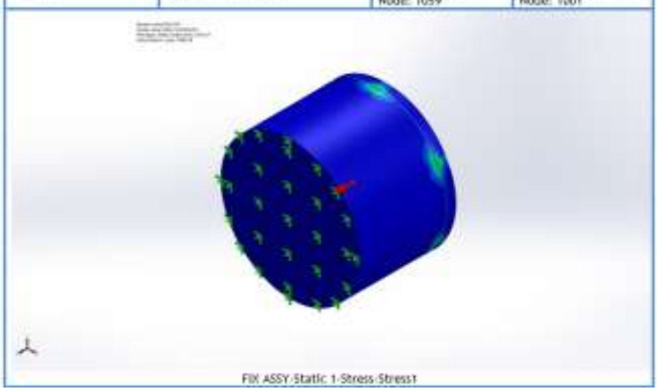


Figure 7.7: Von-Mises Stress

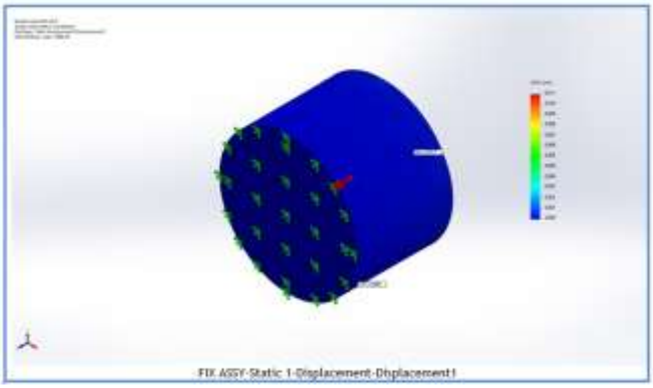


Figure 7.8: Displacement

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	2.116e-009 Element: 67299	4.155e-005 Element: 161002

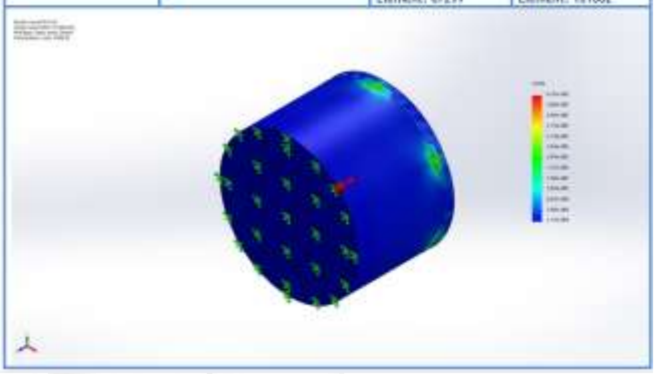


Figure 7.9: Equivalent Strain

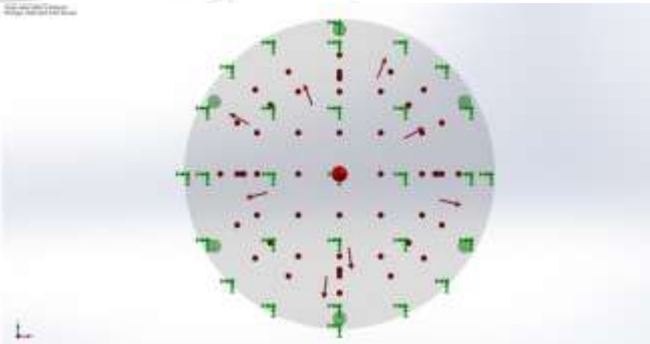


Figure 7.10: View from Fixed End

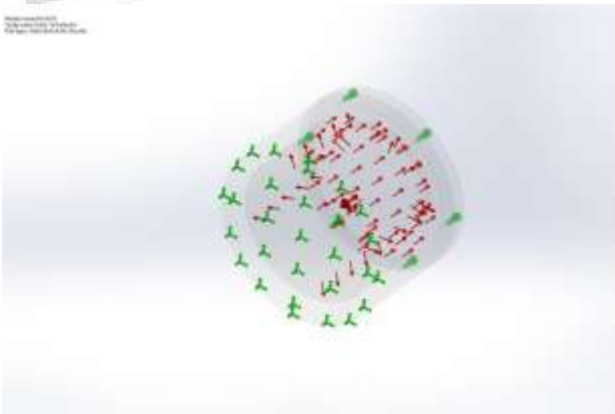


Figure 7.11: Isometric view showing forces acting on cylindrical fixture

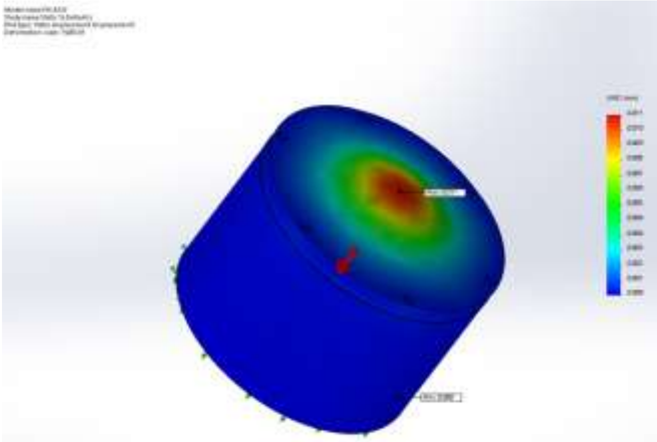


Figure 7.12: Effect of Maximum Pressure

8. Results

	Minimum value	Maximum value
Von Mises Stress	82.428 N/mm2	4,467,568.5 N/mm2
Displacement	0	0.011
Equivalent Strain	2.116e-009	4.155e-005

9. Conclusion

The study was conducted on the water immersion method, Rapid Decompression Test, Explosive Decompression Test, sealing test (vaccum), we would like develop a device which help to find very minor leakage in the sealing part of connector very easily and we can overcome the disadvantages of Immersion method to find the leak in the connector part. It also takes less time and effort to find the leak in the connector with the help of cylindrical leakage fixture. Dry nitrogen gas (or) Dry air is used to check the leak in the connector part which has many advantages like easy storage, non-reaction and thermal inertness. Accuracy of finding the leak with the help of leakage fixture is more when compared to immersion method. the device is optimized in terms of cost, size & time.

10. Acknowledgement

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