**An**

**Internship Report**

**On**

# “Develop a comprehensive design for a Tie-Rod and Threaded Actuator based on the provided specifications”

**SUBMITTED TO S.P.P.U, INDIA**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS**

**FOR THE AWARD OF**

**BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING**

**BY**

## Mr. Prajwal Chandrashekhar Wani

**Under the Guidance of**

### PROF. P.K. Kale



**DEPARTMENT OF MECHANICAL ENGINEERING**

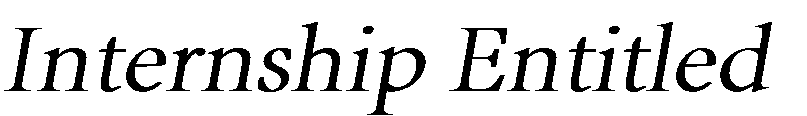
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**SPPU 2023-2024**

# INTERNSHIP APPROVAL SHEET

**S.P.P.U, INDIA**



**“** Develop a comprehensive design for a Tie-Rod and Threaded Actuator based on the provided specifications **”**

**Submitted by**

**Mr. Wani Prajwal Chandrashekhar**

**Is approved for the B-Tech in Mechanical Engineering**

**Prof. P. Kale External**

**(Internship Guide)**

**Date: / 08/2024 Place: Pune**



**INDEX**

|  |  |  |
| --- | --- | --- |
| **SR. NO** | **CONTENT** | **PAGE** |
| I. | TITLE | 1 |
| II. | CERTIFICATE | 2 |
| III. | EXAMINER CERTIFICATE | 3 |
| IV. | CONTENT | 4 |
| 1 | COMPANY DETAILS | 5 |
| 2 | INTRODUCTION | 7 |
| 3 | LITERATURE REVIEW | 12 |
| 4 | PROBLEM STATEMENT | 14 |
| 5 | METHODOLOGY | 15 |
| 6 | CALCULATIONS | 19 |
| 7 | REFERENCES | 25 |

**COMPANY DETAILS**



**Company Name: -**

**JEKUMA TOOLS AND GAUGES PVT LTD**

## About Company: -

Jekuma Tools And Gauges Pvt Ltd is a private company incorporated on 01 August 1983. It is classified as a non-govt company and is registered at Registrar of Companies, Pune. Its authorized share capital is Rs. 30,000,000 and its paid-up capital is Rs. 30,000,000. It is involved in Extra Territorial Organizations and Bodies.

Ravindra Balwant Jejurikar, Sunil Balwant Jejurikar, and Sumati Balwant Jejurikar are the directors of Jekuma Tools and Gauges Pvt Ltd.

Jekuma Tools and Gauges Pvt Ltd.’s Corporate Identification Number is (CIN) U99999PN1983PTC030533 and its registration number is 30533. Its Email address is sales@jekuma.com and its registered address is A19, BLOCK MIDC, PIMPRI, PUNE MH 411018 IN.

## Establishments Details

|  |  |  |  |
| --- | --- | --- | --- |
| **Establishment Detail** | **City** | **Pincode** | **Address** |
| JEKUMA TOOLS AND  GAUGES PVT LTD | Pune | 411018 | A-19, H-BLOCK,  MIDC, PIMPRI, A-19,  H-BLOCK, MIDC,  PIMPRI, PUNE601MH |

## Charges/Borrowing Details

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Charge ID** | **Created Date** | **Modified Date** | **Amount** | **Charge Holder** |
| 80004977 | 1994-04-06 | 2020-01-06 | 28.00,000 | State Bank of India |

## Company Details

|  |  |
| --- | --- |
| **CIN** | U99999PNI983PTC030533 |
| **Company Name** | JEKUMA TOOLS AND GAUGES PVT LTD |
| **Company Status** | Active |
| **RoC** | RoC-Pune |
| **Registration Number** | 30533 |
| **Company Category** | Company Limited by Shares |
| **Company Sub Category** | Non-Govt Company |
| **Class of Company** | Private |
| **Date of Incorporation** | 01 August 1983 |
| **Age of Company** | 43 years |

## Contact Details: -

**Email ID:** sales@jekuma.com **Website:** http://www.jekuma.com **Address:**

A-19, BLOCK MIDC, PIMPRI, PUNE MH 411018 IN

**INTRODUCTION**

## Introduction to Hydraulic Cylinder: -

Hydraulic cylinder is most important part of a hydraulic press. It develops the necessary force require to carry out a pressing operation.

The hydraulic cylinder is a positive displacement reciprocating hydraulic motor, which converts the energy of a fluid into the kinetic energy of the moving piston.

In other words, we can say a hydraulic cylinder is a device which converts the energy of fluid which is in a pressure form into linear mechanical force and motion.

***Type of Hydraulic Cylinders:***

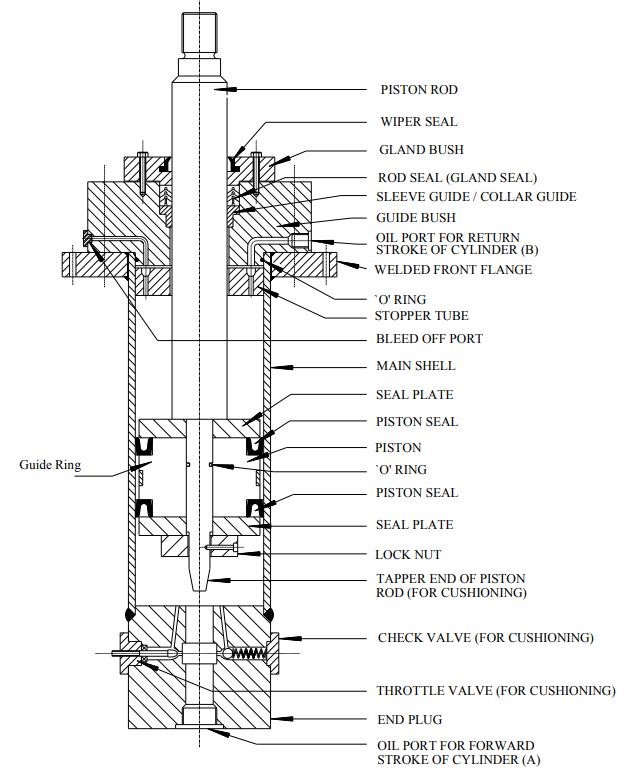
Hydraulic cylinders could be classified into two broad categories.

1. Single action cylinders.
2. Double action cylinders.

Single action cylinder can be defined as "Cylinder in which displacement in one direction is by working fluid pressure and in the other direction by external force. Single action cylinder can take power-stroke only in single direction. That is either it can develop necessary force in forward stroke of cylinder or return stroke of cylinder, depending on its construction. The non-productive direction of cylinder stroke is achieved by various means such as self-weight (gravity), spring, auxiliary cylinder etc.

Double action cylinders are those in which forward as well as reverse strokes are actuated by fluid pressure. Double action cylinder can develop power-stroke in both forward and reverse direction.

1. **Piston Rod:** - When diameter of piston rod is almost equal to piston diameter then generally it is called as RAM. But in general, all large size of piston rods are called "RAM". Piston rod is a mechanical member, which transmits kinetic energy, which got developed at piston, to the work-piece. It is circular in cross-section in case of double action cylinder, as hydraulic sealing is required between piston rod and guide bush.
2. **Wiper Seal:** - These are used to avoid entry of dust particle in cylinder. When these seals softly wipe the rod then it is called wiper seal.
3. **Gland-Bush:** - Gland-bush is used to retain gland seal, accommodate wiper seal, and provide guide to piston rod. It is an optional component; it could be merged with Guidebush.
4. **Rod Seals:** - These are also called as Gland seals. It is a device which is used to avoid the leakage of working fluid or air from the periphery of piston-rod, generally it is used to stop leakage between piston rod and guide-bush of cylinder.
5. **Removable Guide Bush (Sleeve Guide):** - This is inserted in guide-bush before seals. This gives additional guide to Piston - Rod. It is also called sleeve guide or collar guide.
6. **Guide-Bush:** - It is also called as “Head End”, “Rod-end”, “front-end, or “front-Face” (of cylinder). This is a cylinder end enclosure, which covers the annular area or the differential area between the cylinder bore area and piston rod area
7. **Oil Port:** - A port is an internal or external terminus of air or fluid passage in hydraulic or pneumatic component.
8. **Cylinder-Tube-Flanges:** - These are circular or rectangular rings, threaded and welded to the outside diameter of cylinder tube. When this is fixed at front-end of cylinder then it is called Front-Tube-Flange. It may be used for bolting of guide-bush and cylinder mounting, in case of Front-Tube-Flange mounted type of cylinder. When it is fixed to the rear-end of cylinder (end-plug side), then it is called “Rear-Tube-Flange” of cylinder. It may be used for bolting of End-Plug and cylinder mounting in case of Rear-Tube Flange mounted cylinder.
9. **'O' Ring:** - it is a ring with round cross-section, and used to stop leakage between mating components.
10. **Stopper Tube:** - When cylinder has long stroke, and in fully extended condition of Piston-rod, if there is a chance of buckling of piston-rod or any damage to cylinder, then piston-rod is always kept sufficiently Design and Manufacturing of Hydraulic Cylinder inside cylinder, so that the gland-bush and piston, which provide guide to piston-rod are sufficiently apart from each other, and provide good cantilever support against bending and buckling. A piece of pipe, which floats freely between piston and guide-bush, and stop ram from taking its full stroke, is called stopper-tube.
11. **Air-Bleed-Off-Port:** - Air may get trapped in cylinder. This air may be due to cavitations and de-aeration in oil, or air present while assembling and commissioning of cylinder. Trapped air gives spongy operation, jerks, and loss of control on cylinder movement. To remove trapped air small tapped holes are provided in end-plug and guidebush, which always remains plugged. To release air these plugs are loosened allowing air to escape to atmospheres. When air is completely removed then oil started leaking-out from these plugs, then plugs are tightened again. This process of removing air till oil starts coming out is called bleeding and the port provided for this purpose is called “airbleed-off-port”.
12. **Main Shell:** - It is also called “cylinder-tube”, or “cylinder-pipe”, or “cylinder-body”. It has circular inside cross-sectional area. It receives, confines, and direct the fluid under pressure to piston or ram so that the pressure energy in fluid gets converted into kinetic energy of the moving piston or ram.
13. **Seal Plates:** - These are round rings or plates, used to retain piston-seal on piston.
14. **Piston Seal:** - These are hydraulic seals used to avoid leakage between piston and inside diameter of cylinder tube.
15. **Piston:** - Piston is circular in cross-section. It slides in main shell, and provides guide to piston rod at one-end (piston-end). Piston has provision and means to avoid leakage between cylinder and piston, and because of this feature, when fluid-under-pressure when enters in main shell in one direction, piston gets pushing force in other direction. Hence it assists in conversion of pressure energy in fluid to kinetic energy
16. **Lock Nut:** - To avoid losing of piston from piston-rod these lock nuts are provided.
17. **Guide-Ring:** - These are flat rings of plastomeric material. And used in piston, guidebush, and gland-bush to avoid metal to metal contact, and act as guide. All mechanical property of guide-rings is similar to bearing material.
18. **Cushioning:** - As per the requirement of hydraulic system, piston-rod may travel at extremely high speed in its stroke range. On completing its stroke if piston hits guidebush or end-plug with same high speed then it will damage the whole cylinder. Hence special arrangements are made in piston and end-covers to reduce the speed of piston-rod as it completes its stroke. This process of deceleration of piston or piston-rod is called cushioning.
19. **End-Plug:** - It is also called as “Cap-End” “Cover - End” or “Rear - End” (of cylinder) this is a cylinder-end enclosure which completely cover the cylinder-bore-area.



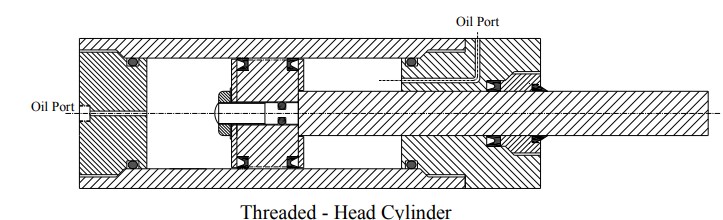
## Classification of Hydraulic Cylinders

Basically, there are only two types of hydraulic cylinder, namely single action cylinder and double action cylinder.

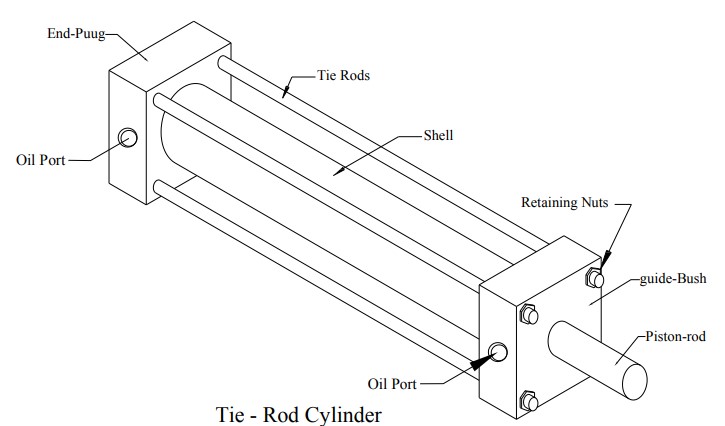
Classification based on Body Construction of Hydraulic Cylinder: - On construction basis hydraulic cylinders could be divided in to five categories.

1. Tie - Rod Construction.
2. Threaded Construction.
3. Bolted Construction.
4. One Piece welded construction.
5. Costume Build Cylinder with combination of above-mentioned constructions.

**1. Threaded Construction: -** This construction is similar to tie-rod construction, but more compact, stronger, and requires more accuracy and care in manufacturing and quality control. In this design both ends are assembled with cylinder tube by threading, as shown in following design. These are used for medium to heavy-duty operation, and widely used in earth moving machinery.



**2.Tie - Rod Construction: -** This type of construction is most widely used in industry. ISI standard also generally refers to one of this type of construction. As all the components are only machined and assembled together and not welded. Hence planning manufacturing, quality control, assembly, and maintenance are more convenient than other types of construction. As long tie rods are used to hold all the component together hence special care required to tighten them, and safe guard against loosening in operation. Like standard valves and pumps, these types of cylinders are also manufactured as standard hydraulic component, and used for low to medium pressure and low to medium duty operation for general purpose, and machine tool industry.



## LITERATURE REVIEW

1. **Yevgeniy Slivinskiy, Sergey Radin (2020)** Recent advances in hydraulic system design, particularly for agricultural machinery, have focused on enhancing the reliability and efficiency of hydraulic cylinders. Innovative sealing mechanisms, such as those using permanent magnets, have been developed to improve load distribution, leading to greater seal durability and overall system reliability. Additionally, new gear hydraulic unit designs have emerged that reduce fluid pulsation, boost productivity, and decrease material usage. These improvements are not only beneficial for domestic agricultural practices but are also gaining attention internationally. Collaboration between researchers and manufacturers is paving the way for these innovations to be prototyped and tested in real-world conditions, highlighting their potential for widespread adoption.

1. **H A J Sadiq Sha (2020)** The manufacturing of hydraulic cylinder rods is a detailed process, crucial for ensuring the durability and performance of these components in industrial and agricultural machinery. Starting with the selection of C45 steel for its strength, the process involves heat treatment to enhance hardness, followed by straightening for proper alignment.

The rod is then cut to size, slot-milled for grooves, and precision-ground for a smooth surface. Welding attaches any necessary components, after which the rod is polished to reduce friction. Electroplating is applied as the final step to protect against corrosion. Quality checks are conducted at each stage to ensure the rod meets all required specifications, resulting in a reliable and high-performing product.

1. **M. Antony Maria Thomas Benny, U.S. Chavan (2017)** The design of piston-rod joints in hydraulic cylinders is crucial for ensuring their performance in heavy industrial applications, where they must endure significant tensile loads and preload conditions. Research has explored various joint configurations to identify the most effective design for these demanding environments. Among the designs studied, the piston-rod bolt joint (Case II) using an M30x3.5x100, 10.9 grade bolt demonstrated superior performance, withstanding tensile loads up to 480 kN without failure, well within the yield limits of EN 19 material. This joint met all design acceptance criteria, indicating its suitability for high-stress applications. In contrast, the piston-rod nut joint (Case I) exhibited higher stress levels, suggesting that the bolt joint design is more reliable for handling high tensile loads. These findings highlight the importance of joint selection in the design of hydraulic cylinders to ensure their durability and reliability under extreme conditions.

1. **Puqing Luo, Jianzhong Hu, Shijun Tan (2017)** The paper provides an overview of hydraulic cylinders, including their components, design considerations, and applications in various industries. Hydraulic technology is widely used in various industries for mechanical transmission and control. - Hydraulic cylinders can be classified into different types based on their action and structure. - Hydraulic cylinders are the working mechanism of piston rods in hydraulic systems and are commonly used in construction, transportation, mining, and other machinery.

1. **G. Senthil Kumar, Mariya Sunil Joshi., Narendran.K, Raveendar. V (2021)** The Paper Present the Selecting the right material for hydraulic cylinders in heavy machinery, such as JCB equipment, is crucial for optimizing cost, strength, and durability. Recent research highlights ductile cast iron 60-4018 as a superior alternative to stainless steel 304. This material offers high strength and durability while significantly reducing costs. Analysis of double-acting hydraulic cylinders shows that ductile cast iron meets performance standards and provides economic benefits over stainless steel. Given its advantageous properties and cost-effectiveness, ductile cast iron 60-4018 is recommended for use in JCB machinery, leading to more efficient and economical production of hydraulic cylinders.

1. **Roemen, Jacob and Webber, Donald (2013)** Strength and fatigue analysis of tie rod hydraulic cylinder bolts is critical for ensuring durability under high load conditions. Research shows that using four 0.5-inch bolts with at least nine threads engaged is necessary to prevent fatigue failure. The analysis confirmed that the hydraulic cylinder can withstand a constant load of up to 22,704 pounds without failure. Safety factors of 4.11 for proof load strength and 2 for fatigue failure were calculated, indicating a robust design. These findings highlight the importance of precise bolt specifications to ensure the long-term reliability of hydraulic cylinders under maximum load conditions.
2. **Marek Lubecki, Michał Stosiak, Mykola Karpenko (2023)** A study investigated the potential of PET plastic for reducing the weight of hydraulic cylinders**.** Researchers designed and analyzed the base and gland components using finite element methods, considering both preload and internal pressure. Experimental testing with strain gauges validated the numerical model, though discrepancies were observed. Strain gauge placement significantly impacted measurement accuracy, highlighting the need for precise sensor positioning. The findings contribute to the development of lightweight hydraulic components while emphasizing the challenges of FEA validation and experimental testing.

1. **ThankGod E. Boye, Adeyemi, I. Olabisi,Eyere E (2017)** The paper details the design and finite element analysis of a double-acting, double-ended hydraulic cylinder intended for industrial automation applications. The hydraulic cylinder's key dimensions include an external diameter of 55mm, an internal diameter of 48mm, a piston diameter with seal of 48mm, a piston rod diameter of 12mm, and a stroke length of 140mm. The finite element analysis (FEA) confirmed the designed hydraulic cylinder's reliability, functionality, and safety. This double-acting, double-ended hydraulic cylinder is suitable for various industrial automation tasks, such as cutting and crimping hydraulic hoses, as well as providing power steering for heavy machinery.
2. **Pritish Tapare , Ajitabh Pateria , yugesh Kharche (2015)** The paper presents a study on the dynamic analysis of a hydraulic cylinder using the finite element method and ANSYS Parametric Design Language (APDL) to model the cylinder and analyze its vibration response under dynamic pressure loading. The dynamic magnification value of the hydraulic cylinder is dependent on the piston velocity. - Finite element programs like ANSYS can be used to create dynamic loading models of hydraulic or pneumatic cylinders, and the effects of damping were investigated. - The dynamic loading of hydraulic cylinders can be classified as a moving load problem, which has been studied extensively by engineers and researchers.

## PROBLEM STATEMENT

1. Develop a comprehensive design for a Tie-Rod and Threaded Actuator based on the provided specifications. The design should ensure structural integrity and performance under expected operational conditions.

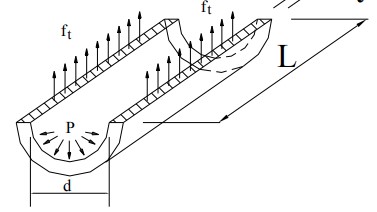
## METHODOLOGY

***Brief Introduction***

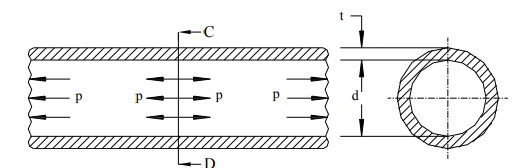
1] a) Circumferential or hoop tress.

b) Longitudinal stress.

a) ***Circumferential or hoop stress****:* Consider thin cylinder subjected to internal pressure. Tensile stress acting in a direction tangential to the circumference is called circumferential stress or hoop stress. It is a tensile stress in longitudinal section. And expressed as P = Intensity of Pressure (Kg/cm²) d = Inside diameter of cylinder (cm) t = Thickness of cylinder(cm) ft = Circumferential stress or hoop stress in the cylinder (Kg/cm²)

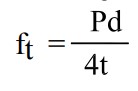


In a closed vessel, tensile stress acting in the direction of the axis is the called longitudinal stress. It is stress acting on the circumferential section CD as shown in following figure



Longitudinal Stress (ft ) could be expressed as = f

***Thin Spherical Shells:*** - Sometime the end cover of casted cylinder is in spherical shape. When thin spherical shell subjected internal pressure tensile stress get developed in its wall, the thickness is calculated by following equation.



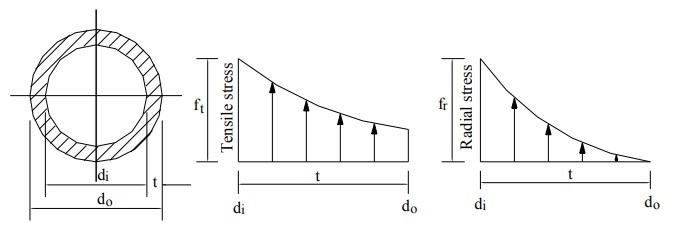
When P = Intensity of Pressure ( Kg/cm² )

d = Inside diameter of shell ( cm )

t = Thickness of shell ( cm )

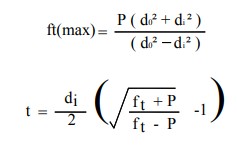
ft = permissible Tensile stress in shell material ( Kg/cm²)

***Design Of Thick Cylinder:*** - In case of thin cylinder, stress assumed to be uniformly distributed over the section of wall, but in case of thick cylinder same assumption cannot be made. In case of thick cylinder stress distribution are as follow



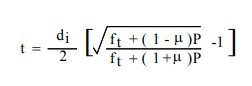
Maximum radial stresses are generally equal to the internal pressure, and it is maximum at inner surface of cylinder. fr (max) = -p. For calculating tangential stress following four equations are used.

1. ***Lame's equation*:** - Lame's equation is used for designing cylinder of brittle material and it depends on maximum-stress theory of failure, and could be used for open as well as closed cylinder.



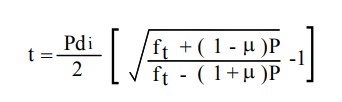
Lame's equation is used for designing cylinder of brittle material and it depends on maximum-stress theory of failure, and could be used for open as well as closed cylinder.

1. ***Brinie's equation:*** - Brinie's equation depends upon the maximum strain theory of failure. That is failure will occur when the strain reaches a limiting value. According to this theory the wall thickness of cylinder is.

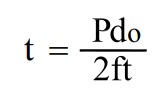


This equation is generally used for open-end cylinder made of ductile material, such as gun-barrels.

1. ***Clavarino's equation:*** - This equation is similar to Birnie's equation, but applies to closed-end cylinder made of ductile material. According to this equation the thickness of a cylinder.



1. ***Barlow's equation:*** - This equation is generally used for high pressure oil and gas pipes. According to this equation, the thickness of a cylinder.



***Design of Cylinder End-Plug (Cover Plate)*:** - Cylinder end-plug may be, threaded, bolted, welded or integral part of cylinder shell. When end-plug is flats in shape, then its minimum thickness can be calculated by following emperical formula.

When

di = Inside diameter of cylinder (cm) k = An empirical cofficient and equal to 0.162 P = Pressure inside cylinder (kg/cm²) ft = Permissible tensile stress for the materal of the plate (Kg/cm²)

Design And Welding Procedure: -

Step 1. Calculate and decide the thickness of end-plug by equation.

Step 2. First end-plug is threaded and fitted in cylinder then welded.

Calculate the number of thread required to takes the full load coming on end-plug.

Load on end-plug (W) = 0.785xdi²xp Load on end-plug is support by threads.

W = dt x 3.14 x Pt x n x fs

Where,

di = Inside diameter of cylinder (cm) P = Working pressure (kg/cm²) dt = Pitch circle diameter (cm) Pt = pitch of thread on end-plug n = Number of thread required fs = Permissible shear stress



**Problem Statement: - Design a Hydraulic Cylinder Based on the Given Specification**

**Data given: -**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cylinder Bore | 250mm | 225mm | 100mm | 100mm |
| Cylinder Pressure | 100Bar | 100Bar | 100Bar | 100Bar |
| Threading Size | M256 | M231 | M104 | M306 |
| Pitch | 2 | 2 | 2 | 2 |
| Threading Engagement Length | 28mm | 28mm | 20mm | 25mm |

Tube Material ST52 and End Cover Material IS2062 E250

**Types Of Cylinder**

1. Thin Cylinder

* Bore/Thickness > 10
* Low Pressure

1. Thick Cylinder

* Bore/Thickness < 10
* High Pressure

Specification: -

ST52

Tensile Strength = 630mpa = 630N/mm2

Yield Strength = 380Mpa = 380N/mm2

Shear Strength = 380Mpa

*Check the Cylinder*

Hoop Stress t = = 0.40 = 0.5cm

Bore/Thickness > 10

25/0.5 > 10

By the Calculation it is Thin Cylinder Because of the High Pressure we take it as Thick Cylinder

1. Lame’s Equation:- It is only used for Brittle Material. (ST52)
2. Brinie’s Equation: - This equation is generally used for open-end cylinder made of ductile material, such as gun-barrels.
3. Clavarino's equation: - Applies to closed-end cylinder made of ductile material.
4. Barlow's equation: - This equation is generally used for high pressure oil and gas pipes. According to this equation, the thickness of a cylinder.

**Design of Cylinder: -**

Therefore, We are Using Clavarinos Equation: -

t = -1]

Where;

r = Internal Radius = 125mm

= Permissible Tensile Stress = 630 N/mm2 but we are taking 50% Due to manufacturing.

= Poisson’s Ratio = 0.3

= Internal Pressure = 10N/mm2

t = -1]

t = 40.72 mm = 4.072cm

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 40.72mm | 39.91 | 16.29 | 48.87 |

**Design of Cylinder End-Plug (Cover Plate): -**

Material: - IS2062 E250

Permissible Tensile Stress is 410 mpa = 410N/mm2

For 2 Factor of Safety = 205N/mm2

t = di

When di = Inside diameter of cylinder (cm) = 25cm = 250

k = An empirical cofficient and equal to 0.162

P = Pressure inside cylinder (kg/cm²) = 10N/mm2

ft = Permissible tensile stress for the materal of the plate (Kg/cm²) = 250N/mm2

t = 250

t = 22.25 mm

Threaded Enlargement Length = 28mm

As we are providing oil port on end plug so the calculation will be

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ratio of R/r | 1.25 | 1.5 | 2 | 3 | 4 | 5 |
| Value of C | 0.592 | 0.976 | 1.44 | 1.88 | 2.08 | 2.195 |

t2 =

Where,

t = Thickness of Guide Bush

C = Emperical Constant

W = load acting on Guide Bush (This is Equal to Force Developed by the Cylinder)

Ft = Permissible Tensile Stress = 205N/mm2

W =

W =

W = 490873.85 N

t2 = 2.19 based on 250 Diameter =R , Oil Port 50 = r

t = 72.47 mm

**Threading Specification:-**

Pitch = 2mm

Threading Size = M256

End Plug Specification:-

We take more 5mm at Threading , 8mm at G at 10mm and Depth depends on Seal

**Piston Rod Design : -**

F =

F =

F = 490873.85mm

F =

490873.85 =

d = 44.54mm minimum

We are taking 100 because to calculate the further oil details

**Euler (Bulking Load): -**

**Case 2 :- One End is Fixed and other pinned**

Material: - ST52 , E = 410Gpa

Pcr =

Pcr =

=262654760.1N

Pcr < P Creeping load is More Than Normal Load so the Shaft does not go under Bulking.

|  |
| --- |
| Where, I = Moment of Inertia E = Modulus of Elasticity Le = Effective Length |
|  |
|  |
|  |

I=

= 78539816.34 mm^4

**Design of Piston Thickness: -**

t =

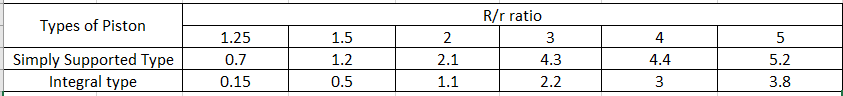
t =

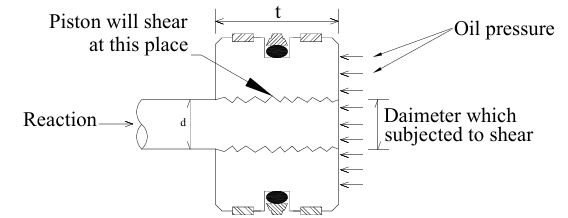
t = 8mm = 10mm

Piston Thickness for Bending Stress:-

t2 =

|  |  |  |
| --- | --- | --- |
| |  | | --- | | t = | |  | |
| C = R/r = 250/100 = 2.5 = 3.2 |





**Flange Design: -**

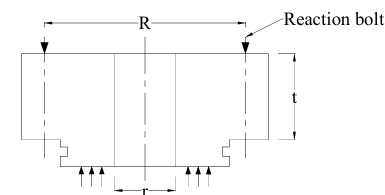
t2 =

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ratio of R/r | 1.25 | 1.5 | 2 | 3 | 4 | 5 |
| Value of c | 0.592 | 0.976 | 1.44 | 1.88 | 2.08 | 2.195 |

R= 521.44mm, r = 331.44mm

t2 = = 25.27mm

**Design of Guide Bush: -**

****

t2 =

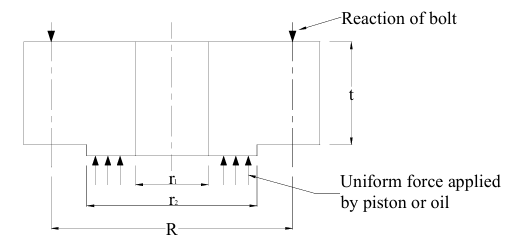
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ratio of R/r | 1.25 | 1.5 | 2 | 3 | 4 | 5 |
| Value of c | 0.592 | 0.976 | 1.44 | 1.88 | 2.08 | 2.195 |

R = 441.44mm, r= 100mm C = R/r

t2 =

t = 58.41mm

**Gland Bush: -**

****

R = 250 mm

r = 100mm

C = 2.5

t2 =

t = 57.20mm

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