# DESIGN, CONSTRUCTION AND PERFORMANCE TEST OF A REMOTE CONTROLLED SCISSOR JACK

This thesis paper is submitted to Department of Mechanical Engineering, Sonargaon University of partial fulfillment in requirements for the degree of Bachelor of Science in Mechanical Engineering


Supervised By:

Minhaz Morshed
Lecturer
Department of Mechanical Engineering
Sonargaon University

Submitted By:

Ismail Hossain
ID-1602009163
Md. Jewel
ID-1602009166
Md. Ariful Islam
ID-1602009167
Md. Rashadul Hasan Sarker
ID-1602009172



Sonargaon University

147/I, Green Road, Tejgaon, Dhaka-1215

February, 2020

**ACKNOWLEDGEMENTS**

At first, we want to express gratefulness and humbleness to Almighty Allah for his immense blessing upon us for the successfulness completion of this thesis work.

We would like to express our sincere gratitude to our supervisor, Minhaz Morshed, Lecturer, Department of Mechanical Engineering, Sonargaon University for his valuable suggestions, guidance and constant encouragement during pursuit of this work.

We express our deep of gratitude and thanks to Md. Mostofa Hossain, Head, Department of Mechanical Engineering, Sonargaon University for his motivation and kind collaboration.

We also would like to express gratitude to Prof. Dr. Md. Abul Bashar, Vice-Chancellor of Sonargaon University for his support in every aspect of our academic career especially for our Mechanical Workshop.

Finally, we would like to express our sincere gratitude to our family who have given support to our study and prayed for our life.

# ABSTRACT

A Scissor Jack is a mechanical device used to easily lift a vehicle off the ground, to gain access to sections underneath vehicles or to change the wheel. The most important fact of a jack is that it gives the user a mechanical advantage by changing the rotational force on power screw into linear motion, allowing user to lift a heavy car to the required height. It is called a scissor jack as the structure consists of diagonal metal components that expand and contract in the same way as a pair of scissors.

In this project an attempt has been made to design and fabricate a power scissor jack to lift and support a load of 1ton, for typical use in Four Wheeler.

This thesis relates to design modification of crank-operated scissor jack which is generally used for lifting light motor vehicles (L.M.V) during maintenance. This project is focused on designing and finding various stresses and expected a life of various parts of scissor jack like power screw, base plate, etc.

With the increasing levels of technology, the efforts are being put to produce any kind of work that has been continuously decreasing. The efforts required in achieving the desired output can be effectively and economically be decreased by the implementation of better designs. Power screws are used to convert rotary motion into reciprocating motion. An object lifting jack is an example of a power screw in which a small force applied in a horizontal plane is used to raise or lower a large load. In this fabricated model, an electric motor will be integrated with the object lifting jack and the electricity needed for the operation.

## CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# NOMENCLATURE

| Symbol | Description | Unit |
|---|---|---|
| P | Pitch of screw thread | mm |
| L | Lead of screw thread | mm |
| $d_o$ | Nominal or, Outer diameter of screw | mm |
| $d_c$ | Core diameter of screw | mm |
| d | Mean diameter of screw | mm |
| $\alpha$ | Helix angle of screw | ◦ (Degree) |
| W | Load | N |
| N | Normal reaction | N |
| $\mu$ | Coefficient of friction | |
| p | Effort | N |
| θ | Angle made by link with horizontal | ◦ (Degree) |
| $\phi$ | Friction Angle | ◦ (Degree) |
| $\sigma_c$ | Crippling stress | $N/mm^2$ |
| F.S | Factor of safety | |
| T | Tension | N |
| a | Rankin’s constant | |
| η | Efficiency | % |
| $\sigma_t$ | Tensile stress | $N/mm^2$ |
| $\tau$ | Shear Stress | $N/mm^2$ |
| $\sigma_{\tau max}$ | Maximum Principle stress | $N/mm^2$ |
| $\tau_{max}$ | Maximum Shear stress | $N/mm^2$ |
| $\sigma_{yt}$ | Yield Stress | $N/mm^2$ |
| b | Width of nut | mm |
| n | Number of threads in engagement with the nut | |
| $P_b$ | Unit bearing pressure | $N/mm^2$ |
| R | Radius of gyration of the cross-section about its axis | mm |
| I | Moment of inertia of the cross-section about its axis | $mm^4$ |
| A | Area of the cross-section | $mm^2$ |
| $P_{cr}$ | Critical Load | N |
| E | Modulus of elasticity | $N/mm^2$ |
| Z | Section Modulus | $N/mm^3$ |

# CHAPTER-I
# INTRODUCTION

## 1.1 Jack:

Jack is a mechanical device used to lift heavy loads or apply great forces. A mechanical jack employs a square thread for lifting heavy equipment. The most common form is a car jack, floor jack or garage jack which lifts vehicles so that maintenance can be performed. Mechanical jacks are usually rated for a maximum lifting capacity (for example, 1.5 tons to 3 tons). More powerful jacks use hydraulic power to provide greater lift.

## 1.2 Problem Statement:

Available jacks present difficulties for the elderly people and women and are especially disadvantageous under adverse weather conditions. Presently available jacks further require the operator to remain in prolonged bent or squatting position to operate the jack which is not ergonomic to human body. It will give physical problems in course of time. Moreover, the safety features are also not enough for operator to operate the present jack.

Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. The purpose of this project is to overcome these problems. An electric car jack which has a frame type of design by using electricity from the car will be developed. Operator only needs to press the button from the controller without working in a bent or squatting position for a long period of time to change the tire.

## 1.3 Types of Jacks Used Today:

### 1.3.1 Scissor Jack:

Scissor jacks are mechanical devices and have been in use since 1930s. A scissor jack is a device constructed with a cross-hatch mechanism, as like a scissor, to lift up a vehicle for repair. It typically works in a vertical manner. The jack opens and folds closed, applying pressure to the bottom supports along the crossed pattern to move the lift. When closed, they have a diamond shape. Scissor jacks are simple mechanisms used to handle large loads over short distances. The power screw design of a common scissor jack reduces the amount of force required by the user to drive the mechanism. Most scissor jacks are similar in design, consisting of four main members driven by a power screw [7] [9]. A scissor jack is operated simply by turning a small crank that is inserted into one end of the scissor jack. This crank is usually "Z" shaped. The end fits into a ring hole mounted on the end of the screw, which is the object of force on the scissor jack. When this crank is turned, the screw turns, and this raises the jack. The screw acts like a gear mechanism. It has teeth (the screw thread), which turn and move the two arms, producing work. Just by turning this screw thread, the scissor jack can lift a vehicle that is several thousand pounds. A scissor jack has four main pieces of metal and two base ends. The four metal pieces are all connected at the corners with a bolt that allows the corners to swivel. A screw thread runs across this assembly and through the corners. When opened, the four metal arms contract together, coming together at the middle, raising the jack.

**Fig. 1.1:** Scissor Jack

When closed, the arms spread back apart and the jack closes or flattens out again. A scissor jack uses a simple gear drive to get its power. As the screw section is turned, two ends of the jack move closer together. Because the gears of the screw are pushing up the arms, the amount of force being applied is multiplied. It takes a very small amount of force to turn the crank handle, yet that action causes the brace arms to slide across and together. As this happens the arms extend upward. The car's gravitational weight is not enough to prevent the jack from opening or to stop the screw from turning, since it is not applying force directly to it. If a person applies pressure directly on the crank, or lean his weight against the crank, the person would not be able to turn it, even though his weight is a small percentage of the cars.

### 1.3.2 Bottle (Cylinder) Jack:

Bottle screws may be operated by either rotating the screw when the nut is fixed or by rotating the nut and preventing rotation of the screw. Bottle jacks mainly consist of a screw, a nut, thrust bearings, and a body. A stationary platform is attached to the top of the screw. This platform acts as a support for the load and also assists it in lifting or lowering of the load. These jacks are sturdier than the scissor jacks and can lift heavier loads. In a bottle jack the piston is vertical and directly supports a bearing pad that contacts the object being lifted. With a single action piston the lift is somewhat less than twice the collapsed height of the jack, making it suitable only for vehicles with a relatively high clearance.


**Fig. 1.2:** Bottle Jack

### 1.3.3 Hydraulic Jacks:

Hydraulic jacks are typically used for shop work, rather than as an emergency jack to be carried with the vehicle. Use of jacks not designed for a specific vehicle requires more than the usual care in selecting ground conditions, the jacking point on the vehicle, and to ensure stability when the jack is extended. Hydraulic jacks are often used to lift elevators in low and medium rise buildings.

A hydraulic jack uses a fluid, which is incompressible. Oil is used since it is self-lubricating and stable. When the plunger pulls back, it draws oil out of the reservoir through a suction check valve into the pump chamber. When the plunger moves forward, it pushes the oil through a discharge check valve into the cylinder. The suction valve ball is within the chamber and opens with each draw of the plunger. The discharge valve ball is outside the chamber and opens when the oil is pushed into the cylinder [9]. At this point the suction ball within the chamber is forced to shut and oil pressure builds in the cylinder.

**Fig. 1.3:** Hydraulic Jacks

For lifting structures such as houses the hydraulic interconnection of multiple vertical jacks through valves enables the even distribution of forces while enabling close control of the lift [6].

In a floor jack a horizontal piston pushes on the short end of a bell crank, with the long arm providing the vertical motion to a lifting pad, kept horizontal with a horizontal linkage. Floor jacks usually include castors and wheels, allowing compensation for the arc taken by the lifting pad. This mechanism provides a low profile when collapsed, for easy maneuvering underneath the vehicle, while allowing considerable extension.

### 1.4 Objectives:

The main objectives of this thesis are-

- To design a power scissor jack which is safe and reliable to raise and lower the load easily.
- To construct a scissor jack.
- To test the performance of a scissor jack.

# CHAPTER-II

# LITERATURE REVIEW

Screw type mechanical jacks were very common for jeeps and trucks of World War II vintage. For example, the World War II jeeps (Willis MB and Ford GPW) issued the "Jack, Automobile, Screw type, Capacity 1 1/2 ton", Ordinance part number 41-J-66. These jacks, and similar jacks for trucks, were activated by using the lug wrench as a handle for the ratchet action to the jack. The 41-J-66 jack was carried in the jeep's tool compartment. Screw type jacks continued in use for small capacity requirements due to low cost of production to raise or lower the load. A control tab is marked up/down and its position determines the direction of movement and with no maintenance. The virtues of using a screw as a machine element, which is essentially an inclined plane wound round a cylinder, was first demonstrated by Archimedes in 200BC with his device used for pumping water.

There is evidence of the use of screws in the Ancient Roman world but it was the great Leonardo da Vinci, in the late 1400s, who first demonstrated the use of a screw jack for lifting loads. Leonardo’s design used a threaded worm gear, supported on bearings, rotated by the turning of a worm shaft to drive a lifting screw to move the load.

People were not sure of the intended application of his invention, but it seems to have been relegated to the history books, along with the helicopter and tank, for almost four centuries. It is not until the late 1800s that people have evidence of the product being developed further [3].

With the industrial revolution of the late 18th and 19th centuries, came the first use of screws in machine tools, via English inventors such as John Wilkinson and Henry Maudsley. The most notable inventor in mechanical engineering from the early 1800s was undoubtedly the mechanical genius Joseph Whitworth, who recognized the need for precision as important in industry.

While he would eventually have over 50 British patents with titles ranging from knitting machines to rifles, it was Whitworth’s work on screw cutting machines, accurate measuring instruments and standards covering the angle and pitch of screw threads that would most influence our industry today.

Whitworth’s tools have become internationally famous for their precision and quality and dominated the market from the 1850s. Inspired young engineers began to put Whitworth’s machine tools to new uses. During the early 1880s in Coati cook, a small town near Quebec, a 24- year-old inventor named Frank Henry Sleeper designed a lifting jack. Like da Vinci’s jack, it was a technological innovation because it was based on the principle of the ball bearing for supporting a load and transferred rotary motion, through gearing and a screw, into linear motion for moving the load. The device was efficient, reliable and easy to operate. It was used in the construction of bridges, but mostly by the railroad industry, where it was able to lift locomotives and railway cars.

Arthur Osmore Norton spotted the potential for Sleeper’s design and in 1886 hired the young man and purchased the patent and then Norton jack was born. Over the coming years the famous Norton jacks were manufactured at plants in Boston, Coati cook and Moline, Illinois.

Meanwhile, in Alleghany County near Pittsburgh in 1883, an enterprising Mississippi river boat captain named Josiah Barrett had an idea for a ratchet jack that would pull barges together to form a tow. The idea was based on the familiar lever and fulcrum principle and he needed someone to manufacture it. That person was Samuel Duff, proprietor of a machine shop.

Together, they created the Duff Manufacturing Company, which by 1890 had developed new applications for the original Barrett Jack and extended the product line to seven models in varying capacities [10].

Over the next 30 years the Duff Manufacturing Company became the largest manufacturer of lifting jacks in the world, developing many new types of jack for various applications including its own version of the ball bearing screw jack. It was only natural that in 1928, The Duff Manufacturing Company Inc. merged with A.O. Norton to create the Duff-Norton Manufacturing Company.

Both companies had offered manually operated screw jacks but the first new product manufactured under the joint venture was the air motor-operated power jack that appeared in 1929. With the aid of the relatively new portable compressor technology, users now could move and position loads without manual effort. The jack, used predominantly in the railway industry, incorporated an air motor manufactured by The Chicago Pneumatic Tool Company. There was a clear potential for using this technology for other applications and only 10 years later, in 1940, the first worm gear screw jack, that is instantly recognizable today, was offered by Duff-Norton, for adjusting the heights of truck loading platforms and mill tables.

With the ability to be used individually or linked mechanically and driven by either air or electric motors or even manually, the first model had a lifting capacity of 10 tons with raises of 2″ or 4″ [3].

# CHAPTER-III
# PROPOSED METHODOLOGY

## 3.1 Operation:

A scissor jack is operated simply by turning a small crank that is inserted into one end of the scissor jack. This crank is usually “Z” shaped. The end fits into a ring hole mounted on the end of the screw, which is the object of force on the scissor jack. When this crank is turned, the screw turns, and this raises the jack. The screw acts like a gear mechanism. It has teeth (the screw thread), which turn and move the two arms, producing work. Just by turning this screw thread, the scissor jack can lift a vehicle that is several thousand pounds.

## 3.2 Construction:

A scissor jack has four main pieces of metal and two base ends. The four metal pieces are all connected at the corners with a bolt that allows the corners to swivel. A screw thread runs across this assembly and through the corners. As the screw thread is turned, the jack arms travel across it and collapse or come together, forming a straight line when closed. Then, moving back the other way, they raise and come together. When opened, the four metal arms contract together, coming together at the middle, raising the jack. When closed, the arms spread back apart and the jack closes or flattens out again.

## 3.3 Required Components:

1. Top Plate
2. Bottom Plate
3. Top Arm
4. Bottom Arm
5. Power Screw
6. Transformer ( AC to DC converter)
7. D.C Wiper Motor
8. Relay
9. IR Sensor
10. Rectifier
11. A.C Circuit Board
12. Control Box
13. Remote Circuit

### 3.3.1 Power Screw:

A power screw is a mechanical device used for converting rotary motion into linear motion and transmitting power. A power screw is also called translation screw. It uses helical translatory motion of the screw thread in transmitting power rather than clamping the machine components.

#### 3.3.1.1 Applications:

The main applications of power screws are as follows:

1) To raise the load, e.g. screw-jack, scissor jack,
2) To obtain accurate motion in machining operations, e.g. lead-screw of lathe.
3) To clamp a work piece, e.g. vice, and
4) To load a specimen, e.g. universal testing machine.

There are three essential parts of a power screw i.e., screw, nut and a part to hold either the screw or the nut in its place. Depending upon the holding arrangement, power screws operate in two different ways. In some cases, the screw rotates in its bearing, while the nut has axial motion. The lead screw of the lathe is an example of this category. In other applications, the nut is kept stationary and the screw moves in axial direction. Screw-jack and machine vice are the examples of this category.

#### 3.3.1.2 Advantages:

Power screws offer the following advantages:

1) Power screw has large load carrying capacity.
2) The overall dimensions of the power screw are small, resulting in compact construction.
3) Power screw is simple to design.
4) The manufacturing of power screw is easy without requiring specialized machinery. Square threads are turned on lathe. Trapezoidal threads are manufactured on thread milling machine.
5) Power screw provides large mechanical advantage. A load of 15kN can be raised by applying an effort as small as 400N. Therefore, most of the power screws used in various applications like screw-jacks, clamps, valves and vices are usually manually operated.
6) Power screws provide precisely controlled and highly accurate linear motion required in machine tool applications.
7) Power screws give smooth and noiseless service without any maintenance.
8) There are only a few parts in power screw. This reduces cost and increases reliability.
9) Power screw can be designed with self-locking property. In screw-jack application, self-locking characteristic is required to prevent the load from descending on its own.

#### 3.3.1.3 Disadvantages:

The disadvantages of power screws are as follows:

1. Power screws have very poor efficiency; as low as 40%.Therefore, it is not used in continuous power transmission in machine tools, with the exception of the lead screw. Power screws are mainly used for intermittent motion that is occasionally required for lifting the load or actuating the mechanism.
2. High friction in threads causes rapid wear of the screw or the nut. In case of square threads, the nut is usually made of soft material and replaced when worn out. In trapezoidal threads, a split- type of nut is used to compensate for the wear. Therefore, wear is a serious problem in power screws.

### 3.3.1.4 Forms of Threads:

There are two popular types of threads used for power screws viz. Square, I.S.O metric trapezoidal and Acme threads.

#### 3.3.1.4.1 Square Thread:

The square thread form is a common screw thread form, used in high load applications such as lead screws and jackscrews. It gets its name from the square cross-section of the thread. It is the lowest friction and most efficient thread form.

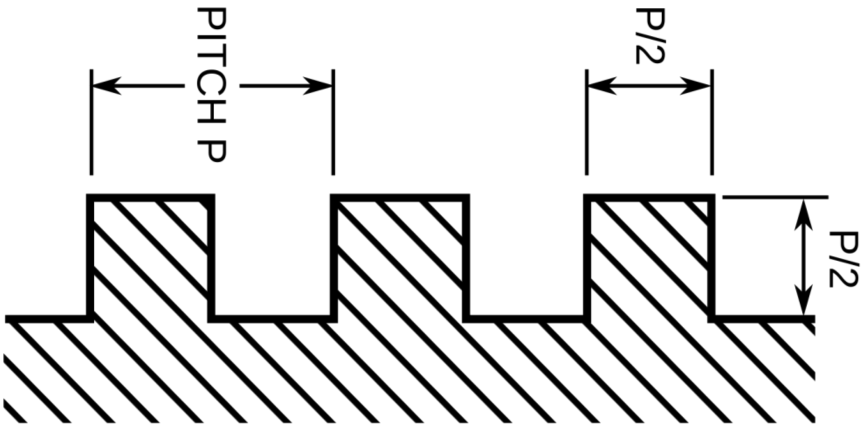



**Fig. 3.1:** Nomenclature of Square Thread

#### 3.3.1.4.2 Trapezoidal Threads:

Trapezoidal thread forms are screw thread profiles with trapezoidal outlines. It also called Acme thread. They are the most common forms used for lead screws. They offer high strength and ease of manufacture.

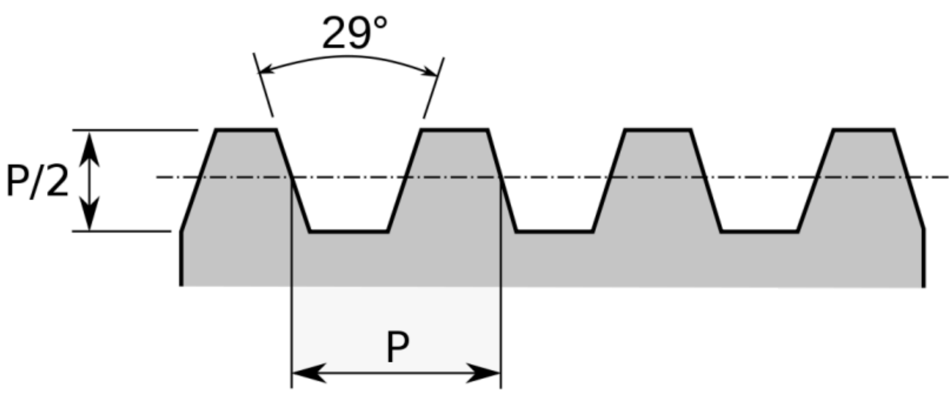



**Fig. 3.2:** Nomenclature of Trapezoidal Thread or, Acme Thread

### 3.3.1.5 Designation of Threads:

There is a particular method of designation for square and trapezoidal threads. A power screw with single-start square threads is designated by the letters 'Sq' followed by the nominal diameter and the pitch expressed in millimeters and separated by the sign 'x'. For example,

Sq 30 x 6

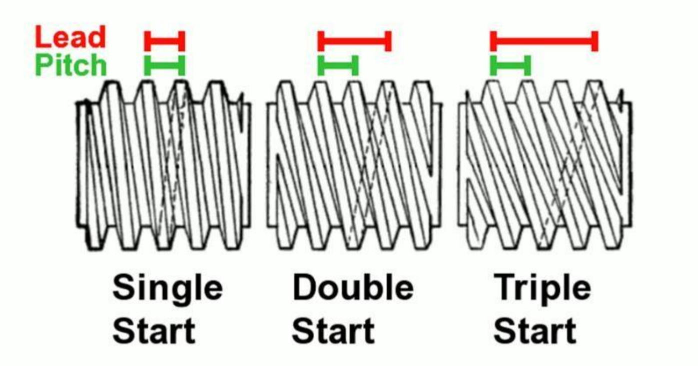
It indicates single-start square threads with 30mm nominal diameter and 6mm pitch. Similarly single-start I.S.O metric trapezoidal threads are designated by letters 'Tr' followed by the nominal diameter and the pitch expressed in millimeters and separated by the sign 'x'. For example,

Tr 40x7

It indicates single-start trapezoidal threads with 40mm nominal diameter and 7mm pitch.

### 3.3.1.6 Multiple Threaded Power Screws:

Multiple threaded power screws as shown in Fig. 3.3 are used in certain applications where higher travelling speed is required.




(a) (b) (c)

**Fig. 3.3: (a)** Single Start **(b)** Double Start **(c)** Triple Start

They are also called multiple start screws such as double- start or triple-start screws. These screws have two or more threads cut side by side, around the rod. Multiple-start trapezoidal threads are designated by letters 'Tr' followed by the nominal diameter and the lead, separated by sign 'x' and in brackets the letter 'P' followed by the pitch expressed in millimeters. For example,

$$Tr\ 40 \times 14\ (P7)$$

In above designation, Lead=14mm pitch=7mm. Therefore, No. of starts =14/7=2

It indicates two-start trapezoidal thread with 40mm nominal diameter and 7mm pitch. In case of left handed threads. The letters 'LH' are added to thread designation. For example,

Tr 40 x 14 (P7) *LH*

### 3.3.1.7 Terminology of Power Screw:

The terminology of the screw thread is given in **Fig.** 3.4:

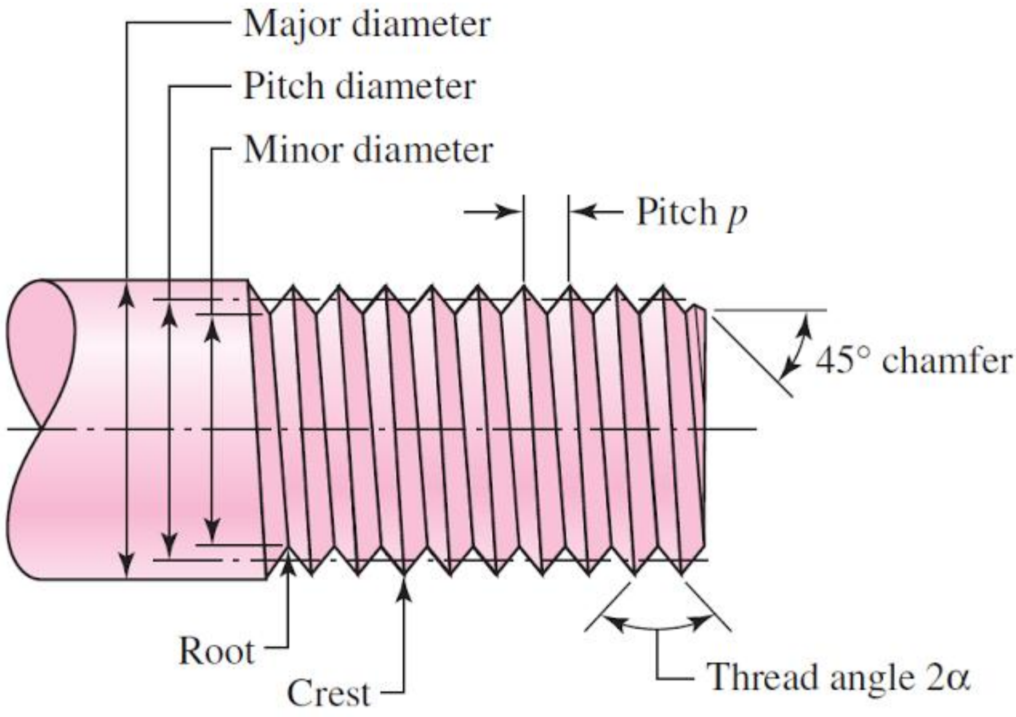



**Fig. 3.4:** Terminology of Screw Threads

**Pitch**: The pitch is defined as the distance, measured parallel to the axis of the screw, from a point on one thread to the corresponding point on the adjacent thread. It is denoted by the letter '**p**'.

**Lead**: The lead is defined as the distance, measured parallel to the axis of the screw that the nut will advance in one revolution of the screw. It is denoted by the letter '**L**'. For a single-threaded screw, the lead is same as the pitch, for a double-threaded screw, the lead is twice that of the pitch, and so on.

**Nominal diameter**: It is the largest diameter of the screw. It is also called major diameter. It is denoted by the letter **'do**'.

C**ore diameter**: It is the smallest diameter of the screw thread. It is also called minor diameter. It is denoted by the letters '**dc**'.

**Helix angle**: It is defined as the angle made by the helix of the thread with a plane perpendicular to the axis of the screw. Helix angle is related to the lead and the mean diameter of the screw. It is also called lead angle. It is denoted by $\alpha$.

### 3.3.1.8 Self Locking Screw:

It can be seen that when $\phi < \alpha$**,** the torque required to lower the load is negative. It indicates a condition that no force is required to lower the load. The load itself will begin to turn the screw and descend down, unless a restraining torque is applied. This condition is called "*overhauling*" of screw.

When $\phi > \alpha$, a positive torque is required to lower the load. Under this condition, the load will not turn the screw and will not descend on its own unless effort P is applied. In this case, the screw is said to be "self-locking". The rule for self-locking screw is as follows: "A screw will be self-locking if the coefficient of friction is equal to or greater than the tangent of the helix angle".

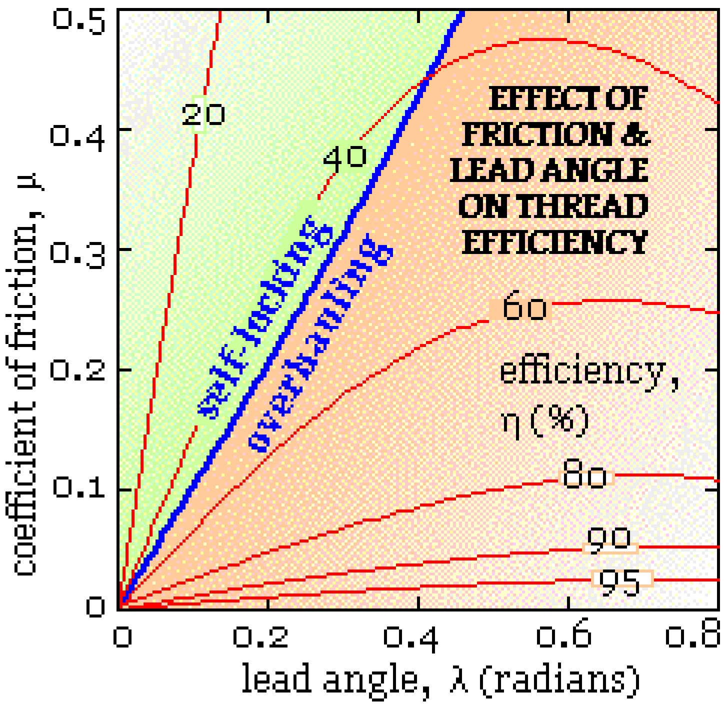



**Fig. 3.5:** Graph Between coefficient of friction and lead angle

Therefore, for a self-locking screw the following conclusions can be made -

1) Self-locking of screw is not possible when the coefficient of friction ($\mu$) is low. The coefficient of friction between the surfaces of the screw and the nut is reduced by lubrication. Excessive lubrication may cause the load to descend on its own.
2) Self-locking property of the screw is lost when the lead is large. The lead increases with number of starts. For double-start thread, lead is twice of the pitch and for triple threaded screw, three times of pitch. Therefore, single threaded is better than multiple threaded screws from self-locking considerations. Self-locking condition is essential in applications like scissor jack.

### 3.3.1.8.1 Efficiency of Self-Locking Screw:

The output consists of raising the load. Therefore,

Work output = force x distance travelled in the direction of force

$= W \times L$

The input consists of rotating the screw by means of an effort P.

Work input = force × distance travelled in the direction of force

$= P \times (\pi d)$

The efficiency η of the screw is given by,

$\eta$ = Work output/ Work input

$= W \times L / P \times (\pi d)$

$= (W/P) \times \tan(\alpha)$

$= \tan(\alpha)/\tan(\phi+\alpha)$

From the above equation, it is evident that the efficiency of the square threaded screw depends upon the helix angle α and the friction angle ϕ. The following figure shows the variation of the efficiency of square threaded screw against the helix angle for various values of coefficient of friction. The graph is applicable when the load is lifted.

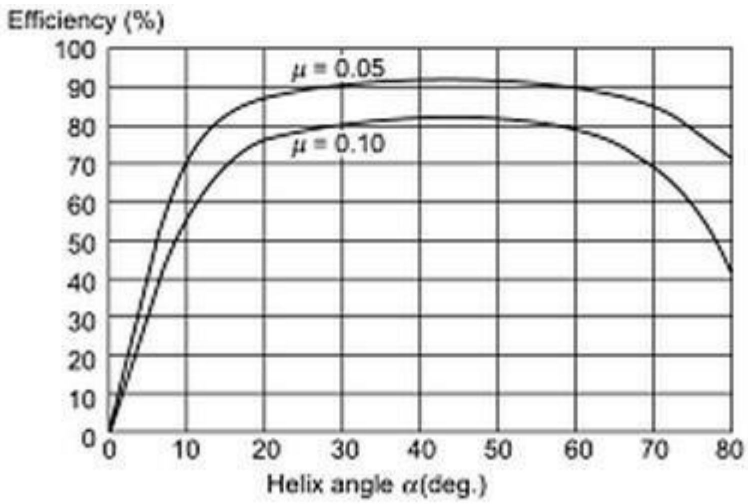



**Fig. 3.6:** Graph between Efficiency and Helix angle

Following conclusions can be derived from the observation of these graphs,

1) The efficiency of square threaded screw increase rapidly up to helix angle of 20°.
2) The efficiency is maximum when the helix angle between 40 to 45°.
3) The efficiency decreases after the maximum value is reached.
4) The efficiency decreases rapidly when the helix angle exceeds 60°
5) The efficiency decreases as the coefficient of friction increases.

There are two ways to increase the efficiency of square threaded screws. They are as follows:

1. Reduce the coefficient of friction between the screw and the nut by proper lubrication
2. Increase the helix angle up to 40 to 45° by using multiple start threads.
   However, a screw with such helix angle has other disadvantages like loss of self-locking property.

**3.3.2 Transformer:**

A transformer is a passive electrical device that transfers electrical energy from one electrical circuit to one or more circuits. A varying current in any one coil of the transformer produces a varying magnetic flux, which, in turn, induces a varying electromotive force across any other coils wound around the same core. Electrical energy can be transferred between the (possibly many) coils, without a metallic connection between the two circuits. Faraday's law of induction discovered in 1831 described the induced voltage effect in any coil due to changing magnetic flux encircled by the coil.

Transformers are used for increasing alternating voltages at low current (Step up Transformer) or decreasing the alternating voltages at high current (Step down Transformer) in electric power applications, and for coupling the stages of signal processing circuits.

Since the invention of the first constant-potential transformer in 1885, transformers have become essential for the transmission, distribution, and utilization of alternating current electric power. A wide range of transformer designs is encountered in electronic and electric power applications. Transformers range in size from RF transformers less than a cubic centimeter in volume, to units weighing hundreds of tons used to interconnect the power grid.

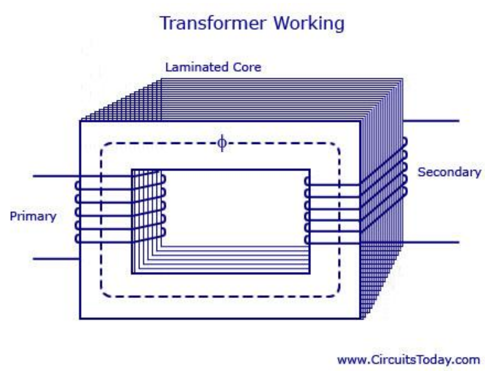



**Fig. 3.7:** Transformer

### 3.3.3 DC Motor:

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current in part of the motor.

DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Wipers have helped in many ways especially when rainy conditions kick in when water drops fall on the window shield. Seeing the wiper blades swipe the window seems simple like simple mechanism but you'd be surprised on how it functions explicitly. These smooth motions or only made possible from the key mover in windshield wiper and these are the wiper motors. Wiper motors are devices in the wiper system that functions on a power supply in order to move the wiper blades in a smooth motion. Like other motors, the wiper motor rotates continuously in one direction which is converted into a back and forth motion. Its composition entails a lot of mechanical linkages each playing a role in initiating the movement. The gear head motor is the type of wiper motor known for its abundance in torque.

Wiper may refer to:

- Windscreen wiper
- Wiper (occupation), a cleaner in the engine room of a ship
- Wiper, a term for a hybrid striped bass
- Wiper, a term for the moving contact on a potentiometer

**Fig. 3.8:** Wiper Motor

### 3.3.4 Relay:

A relay is an electrically operated switch that can be turned on or off, letting the current go through or not, and can be controlled with low voltages, like the 5V provided by the Arduino pins. Controlling a relay module with the Arduino is as simple as controlling any other output as we'll see later on.

**Fig. 3.9:** Relay Module

This relay module has two channels (those blue cubes). There are other models with one, four and eight channels. This module should be powered with 5V, which is appropriate to use with an Arduino. There are other relay modules that are powered using 3.3V, which is ideal for ESP32, ESP8266, and other microcontrollers. The high-voltage side has two connectors, each with three sockets: common (COM), normally closed (NC), and normally open (NO).

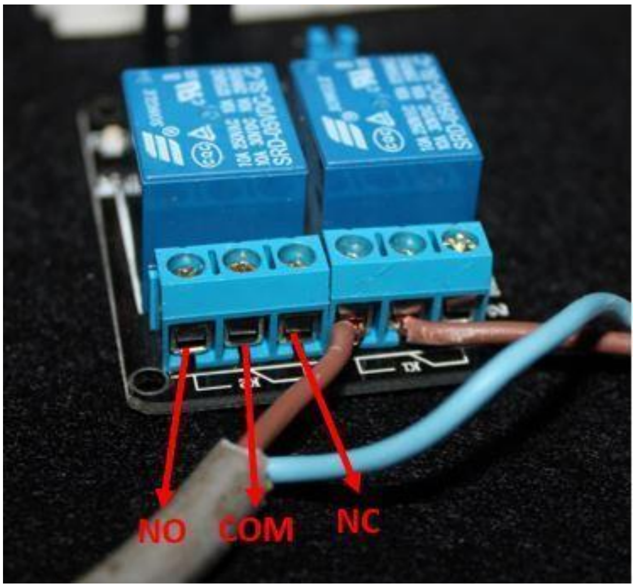



**Fig.3.10:** Main Voltage Connection

- COM: common pin
- NC (Normally Closed): the normally closed configuration is used when you want the relay to be closed by default, meaning the current is flowing unless you send a signal from the Arduino to the relay module to open the circuit and stop the current.
- NO (Normally Open): the normally open configuration works the other way around: the relay is always open, so the circuit is broken unless you send a signal from the Arduino to close the circuit.

If you just want to light up a lamp occasionally, it is better to use a normally-open circuit configuration.

### 3.3.5 IR Sensor:

IR detectors are little microchips with a photocell that are tuned to listen to infrared light. They are almost always used for remote control detection - every TV and DVD player has one of these in the front to listen for the IR signal from the clicker. Inside the remote control is a matching IR LED, which emits IR pulses to tell the TV to turn on, off or change channels. IR light is not visible to the human eye, which means it takes a little more work to test a setup.

**Fig. 3.11:** IR Sensor

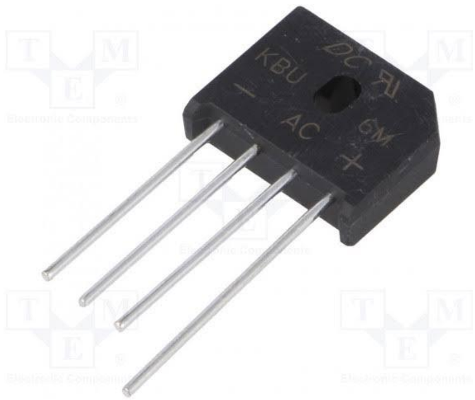



**Fig. 3.12:** Rectifier

### 3.3.6 Rectifier:

A rectifier is an electrical device that converts alternating current, which periodically reverses direction, to direct current, which flows in only one direction. The process is known as rectification, since it "straightens" the direction of current.

## 3.4 Various Developments in Lifting Devices:

### 3.4.1 Levers:

Use of the lever gives the operator much greater lifting force than that available to a person who tried to lift with only the strength of his or her own body. Types of levers are first, second and third order.

### 3.4.2 Screw thread:

A screw is a mechanism that converts rotational motion to linear motion, and a torque to a linear force. The most common form consists of a cylindrical shaft with helical grooves or ridges called threads around the outside. The screw passes through a hole in another object or medium, with threads on the inside of the hole that mesh with the screw's threads. When the screw is rotated relative to the stationary threads, the screw moves along its axis relative to the medium surrounding it. For example rotating a wood screw forces it into wood. In screw mechanisms, either the screw can rotate through a threaded hole in a stationary object, or a threaded collar such as a nut can rotate around a stationary screw. Geometrically, a screw can be viewed as a narrow inclined plane wrapped around a cylinder [7].

### 3.4.3 Gears:

The jack will lift a load in contact with the load platform when the power screw is rotated through its connecting gear with the pinion gear when connected to the motor, plugged to the automobile 12V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the pinion gear meshing with the bigger gear connected to the power screw to be rotated with required speed reduction and increased torque to drive the power screw. The power screw rotates within the threaded hole of its connecting members in the clockwise direction that will cause the connecting members to be drawn along the threaded portion towards each other during a typical load-raising process. During the typical load- raising process, the jack will first be positioned beneath the load to be lifted such that at least a small clearance space will exist between the load platform and the object to be raised. Next, power screw will be turned so that the load platform makes contact with the object and the clearance space is eliminated. As contact is made, load from the object will be increasingly shifted to the load platform and cause forces to be developed in and transmitted through lifting members and connecting members. The force transmitted through the connecting members will be transferred at the threaded bore to the lead Acme threads, there within. A switch button connected to the motor is used to regulate the lifting and lowering process.

## 3.5 Necessity of Jack:

In the repair and maintenance of automobiles (car), it is often necessary to raise an automobile to change a tire or access the underside of the automobile. Accordingly, a variety of car jacks have been developed for lifting an automobile from a ground surface. Available car jacks, however, are typically manually operated and therefore require substantial laborious physical effort on the part of the user. Such jacks present difficulties for the elderly and handicapped and are especially disadvantageous under adverse weather conditions.

Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. In addition, to the difficulties in assembling and setting up jacks, such jacks are generally not adapted to be readily disassembled and stored after automobile repairs have been completed. Car jacks must be easy to use for women or whoever had problem with the tire in the middle of nowhere. In light of such inherent disadvantages, commercial automobile repair and service stations are commonly equipped with large and hi-tech car lift, wherein such lifts are raised and lowered via electrically-powered systems. However, due to their size and high costs of purchasing and maintaining electrically-powered car lifts, such lifts are not available to the average car owner. Engineering is about making things simpler or improving and effective. Such electrical- powered portable jacks not only remove the arduous task of lifting an automobile via manually-operated jacks, but further decrease the time needed to repair the automobile. Such a feature can be especially advantageous when it is necessary to repair an automobile on the side of a roadway or under other hazardous conditions. There also reports on car jacks which lead to a serious number of accidents [7] [12] [13].

A specified jack purposed to hold up to 1000 kilograms, but tests undertaken by Consumer Affairs has revealed that is fails to work after lifting 250 kilograms and may physically break when it has a weight close to its 1000 kilograms capacity. Whilst no injuries have been reported to date, Ms. Rankine has expressed concerned about the dangers associated with the use of a vehicle jack that does not carry the weight it is promoted to hold. Tests have proven that the jack has the property to buckle well under the weight it is promoted to withstand, and it doesn't meet the labeling or performance requirements of the Australian Standard for vehicle jacks.

### 3.6 Operational Considerations of a screw jack [11]:

i. Maintain low surface contact pressure Increasing the screw size and nut size will reduce thread contact pressure for the same working load. The higher the unit pressure and the higher the surface speed, the more rapid the wear will be.

ii. Maintain low surface speed. Increasing the screw head will reduce the surface speed for the same linear speed.

iii. Keep the mating surfaces well lubricated .The better the lubrication, the longer is the service life. Grease fittings or other lubrication means must be provided for the power screw and nut.

iv. Keep the mating surfaces clean dirt can easily embed itself in the soft nut material. It will act as a file and abrade the mating screw surface. The soft nut material backs away during contact leaving the hard dirt particles to scrap away the mating screw material.

v. Keep heat away. When the mating surfaces heat up, they become much softer and are more easily worn away. Means to remove the heat such as limited duty cycles or heat sinks must be provided so that rapid wear of over-heated materials can be avoided.

## CHAPTER-IV

## PROPOSED DESIGN

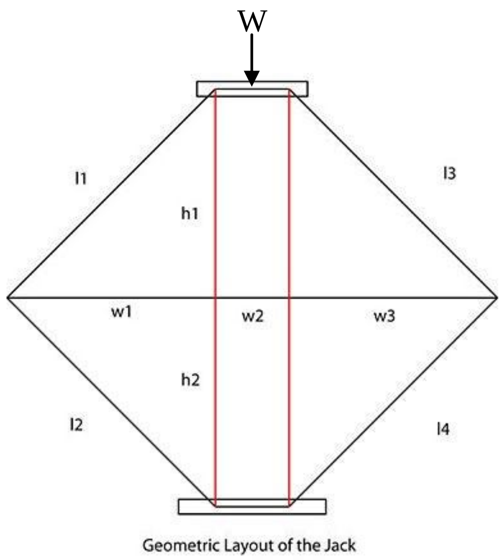



**Fig.4.1:** Layout of Scissor Jack

### 4.1 Power Screw:

**Material selected:** Mild Steel

Assumptions:

The weight of the car is considered as 1 ton. The weight acting on front and rear axle is 55% and 45% of total weight respectively, hence the weight acting on front axle i.e.; 550 kg is considered for designing the jack. A weight of 275kg acts on each wheel. And the maximum load on screw act when jack is at its lowest position. We assumed the thread on screw is a Single Start Square thread and coefficient of friction between threads is 0.20.

Design Calculations:

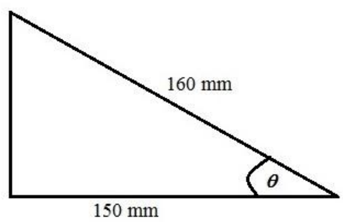
Length of each arm = $L_1 = L_2 = L_3 = L_4 = 160mm$

Length of the power screw = $(w_1+w_2+w_3)$

= 350mm

Where, $w_1 = w_3 = 150$ mm

$w_2 = 50$ mm




Maximum lift of the jack = $(h_1+h_2)$

= (75+75) mm

= 150 mm

Now, θ is the angle made by link with horizontal when jack is at its lowest position.

$$\cos(\theta) = \frac{w1}{L1}$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{150}{160}\right)$$

$$\therefore \theta = 20.36^{\circ}$$

The tension load 'F' acting on the power screw is shown in the above Fig 4.1.

$$\text{Load, } F = \frac{\frac{W}{2}}{\tan\theta}$$

$$\text{Total Load, } F = \frac{W}{2\tan\theta} = \frac{275 \times 9.81}{2 \times \tan\ 20.36^{\circ}} = 3634.78 \text{ N}$$

Since a similar pull acts on the other nut, total tensile load pull on the square thread,

$$W_1 = 2\,F = 2 \times 3634.78$$
$$= 7269.56 \text{ N}$$

For a power screw under tension we can take $\sigma_t$ = 124 N/mm$^2$ for mild steel.

Let '$d_c$' be the core diameter of the screw. But load on the screw is,

Load = Stress × Area

⇨ $W_1 = \sigma_t \times (\pi\, dc^2 / 4)$

⇨ $7269.56 = 124 \times (\pi\, dc^2 / 4)$

$\therefore d_c = 8.63$ mm

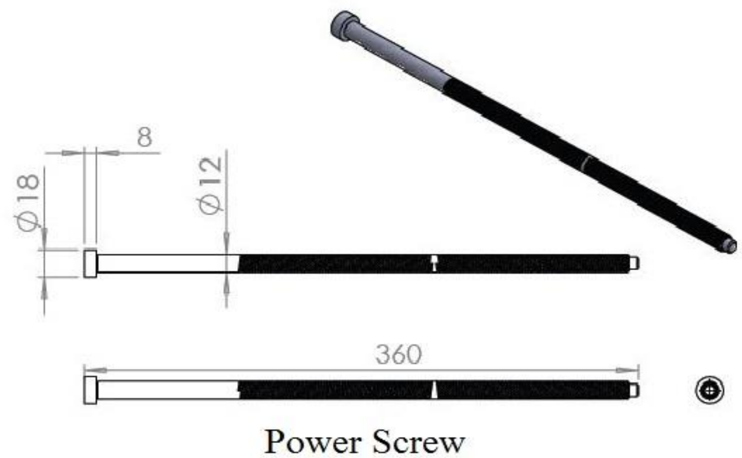



**Fig.4.2:** Power Screw

**Table. 4.1:** Diameter and Areas of Coarse-pitch and Fine Pitch

| Nominal Major Diameter d (mm) | Pitch P (mm) | Coarse-Pitch Series | | Fine-Pitch Series | | |
|---|---|---|---|---|---|---|
| | | Tensile stress Area, A ($mm^2$) | Minor Diameter Area, A ($mm^2$) | Pitch P (mm) | Tensile stress Area, A ($mm^2$) | Minor Diameter Area, A ($mm^2$) |
| 1.6 | 0.35 | 1.27 | 1.07 | | | |
| 2 | 0.40 | 2.07 | 1.79 | | | |
| 2.5 | 0.45 | 3.39 | 2.98 | | | |
| 3 | 0.5 | 5.03 | 4.47 | | | |
| 3.5 | 0.6 | 6.78 | 6.00 | | | |
| 4 | 0.7 | 8.78 | 7.75 | | | |
| 5 | 0.8 | 14.2 | 12.7 | | | |
| 6 | 1 | 20.1 | 17.9 | | | |
| 8 | 1.25 | 36.6 | 32.8 | 1 | 39.2 | 36.0 |
| 10 | 1.5 | 58.0 | 52.3 | 1.25 | 61.2 | 56.3 |
| 12 | 1.75 | 84.3 | 76.3 | 1.25 | 92.1 | 86.0 |
| 14 | 2 | 115 | 104 | 1.5 | 125 | 116 |
| 16 | 2 | 157 | 144 | 1.5 | 167 | 157 |
| 20 | 2.5 | 245 | 225 | 1.5 | 272 | 259 |
| 24 | 3 | 353 | 324 | 2 | 384 | 365 |
| 30 | 3.5 | 561 | 519 | 2 | 621 | 596 |
| 36 | 4 | 817 | 759 | 2 | 915 | 884 |
| 42 | 4.5 | 1120 | 1050 | 2 | 1260 | 1230 |
| 48 | 5 | 1470 | 1380 | 2 | 1670 | 1630 |
| 56 | 5.5 | 2030 | 1910 | 2 | 2300 | 2250 |
| 64 | 6 | 2680 | 2520 | 2 | 3030 | 2980 |
| 72 | 6 | 3460 | 3280 | 2 | 3860 | 3800 |
| 80 | 6 | 4340 | 4140 | 1.5 | 4850 | 4800 |
| 90 | 6 | 5590 | 5360 | 2 | 6100 | 6020 |
| 100 | 6 | 6990 | 6740 | 2 | 7560 | 7470 |
| 110 | | | | 2 | 9180 | 9080 |

Ref: Table 8.1 of Mechanical Engineering design by Shigley's , From table. 8.1 of Mechanical Engineering design by Shigley's ,

Core diameter, $d_c$ = 10 mm and,

Pitch = 1.5 mm.

Outer diameter, do = dc + P = (10+1.5) = 11.5mm ≈ 12 mm

Mean diameter, d = do - $\frac{P}{2}$ = 12 – $\frac{1.5}{2}$ = 11.25 mm

**Check for self-locking:**

$\tan(\alpha) = \frac{\text{Lead}}{\pi d}$; Where, α = helix angle

⇨ $\tan(\alpha) = \frac{1.5}{\pi \times 11.25}$

⇨ $\alpha = \tan^{-1}\left(\frac{1.5}{\pi \times 11.25}\right)$

∴ α = 2.43°

[∵ Screw has a single start square thread then,

Lead = Pitch

And, Screw has a double start square thread then,

Lead = 2 × Pitch]

Coefficient of friction, $\mu = \tan(\phi) = 0.20$

∴ Friction angle, $\phi = 11.3^\circ$

$\phi > \alpha$, hence the screw is self-locking.

Now,

Effort required to support the load = $W_1 \times \tan(\phi+\alpha)$

$$= W_1 \times \left(\frac{\tan\phi + \tan\alpha}{1-\tan\phi \times \tan\alpha}\right)$$

$$= 7269.56 \times \left(\frac{\tan 11.3^\circ + \tan 2.43^\circ}{1-\tan 11.3^\circ \times \tan 2.43^\circ}\right)$$

= 1776.16 N

Torque required to rotate the screw = effort × $\frac{d}{2}$

$$= 1776.16 \times \frac{11.25}{2}$$

= 9990.90 N-mm

Shear stress in the screw due to torque, $\tau = \frac{16\,T}{\pi dc^3}$

$$= \frac{16 \times 9990.90}{\pi \times 10^3} = 50.88 \text{ N/mm}^2$$

But, tensile stress, $\sigma_t = \frac{W1}{\pi dc^2/4} = \frac{7269.56}{(\pi \times 10^2)/4} = 92.56$ N

Maximum principal stress, $\sigma_{t\,max} = (\sigma_t/2) + \sqrt{(\sigma_t^2 + \tau^2)}/2$

$$= (92.56/2) + \sqrt{((92.56^2 + 50.88^2)/2)}$$

$$= 120.96 \text{ N/mm}^2$$

Maximum shear stress, $\tau_{max} = \sqrt{(\sigma_t^2 + \tau^2)}/2$

$$= \sqrt{((92.56^2 + 50.88^2)/2)}$$

$$= 74.68 \text{ N/mm}^2$$

Since the maximum stresses $\boldsymbol{\sigma_{t\,max}}$ and $\boldsymbol{\tau_{max}}$ within the safe limits, the design of single started square threaded screw is satisfactory.

**4.2 Trunnion:**

Material Selected: Mild Steel

Design Calculations:

Let, n be the number of threads in contact with the screw assumed that load is Uniformly Distributed over the cross section area of the nut. Allowable Bearing pressure between the threads (Pb) is assumed as 15 N/mm$^2$.

$$\text{Bearable Pressure, Pb} = \frac{\textbf{Load}}{\textbf{Projected Area}}$$

$$\Rightarrow 15 = \frac{W1}{(\pi/4) \times (do^2 - dc^2) \times n}$$

$$\Rightarrow 15 = \frac{7269.561}{(\pi/4) \times (12^2 - 10^2) \times n}$$

$$\therefore n = 14$$

In order to have good stability let, n = 14

Thickness of Nut, t = n × P= 14 × 1.5 = 21mm

Width of Nut, b =1.5 × do = 1.5 × 12 = 18 mm

To control the movement of nuts beyond 300 mm the rings of 8 mm thickness are fitted on the screw with the help of set screw

The length of screw portion = 300 + (8 × 2) + 22

= 338 mm ≈ 350 mm Total length of screw is 350 mm.

**Fig.4.3:** Trunnion

### 4.3 Top Arm:

Material selected: Mild Steel

Design calculations:

Length of Arm, L = 160mm

Yield Stress for Mild Steel, $\sigma_{yt}$ = 248 N/mm$^2$

Factor of safety (F.S) = 2.5

Allowable Stress, $\sigma_{t\ allow} = \frac{\sigma yt}{F.S} = \frac{248}{2.5} = 99.2$ N/mm$^2$

Compression Stress, $\sigma_c = 1.25 \times \sigma_{t\ allow} = 1.25 \times 99.2 = 124$ N/mm$^2$

Cross section area, A = (25 × 4) + {(31-8) × 4} + (25 × 4) = 292 mm$^2$

Moment of Inertia of Solid Bar:

$$I_{x1} = \frac{bh^3}{12} = \frac{31 \times 25^3}{12} = 40364.58 \text{ mm}^4$$

$$I_{y1} = \frac{b^3h}{12} = \frac{31^3 \times 25}{12} = 62064.58 \text{ mm}^4$$

Moment of Inertia of cut area :

$$I_{x2} = \frac{bh^3}{12} = \frac{23 \times 21^3}{12} = 17750.25 \text{ mm}^4$$

$$I_{y2} = \frac{b^3h}{12} = \frac{23^3 \times 21}{12} = 21292.25 \text{ mm}^4$$

Now,

$I_{xx} = I_{x1} - I_{x2} = (40364.58 - 17750.25) = 22614.33 \text{ mm}^4$

$I_{yy} = I_{y1} - I_{y2} = (62064.58 - 21292.25) = 40772.33 \text{ mm}^4$

Radius of Gyration, $K_x = \sqrt{\left(\frac{Ixx}{A}\right)} = \sqrt{\left(\frac{22614.33}{292}\right)} = 8.8$ mm

Radius of Gyration, $K_y = \sqrt{\left(\frac{Iyy}{A}\right)} = \sqrt{\left(\frac{40772.33}{292}\right)} = 11.81$ mm

Rankine's constant, $a = \frac{1}{7500}$

As, Ends are hinged ($L_{eff} = L$)

Crippling stress, $\sigma_{cr} = 0.75 \times \sigma_{yt}$

$= 0.75 \times 248 = 330 \text{ N/mm}^2$

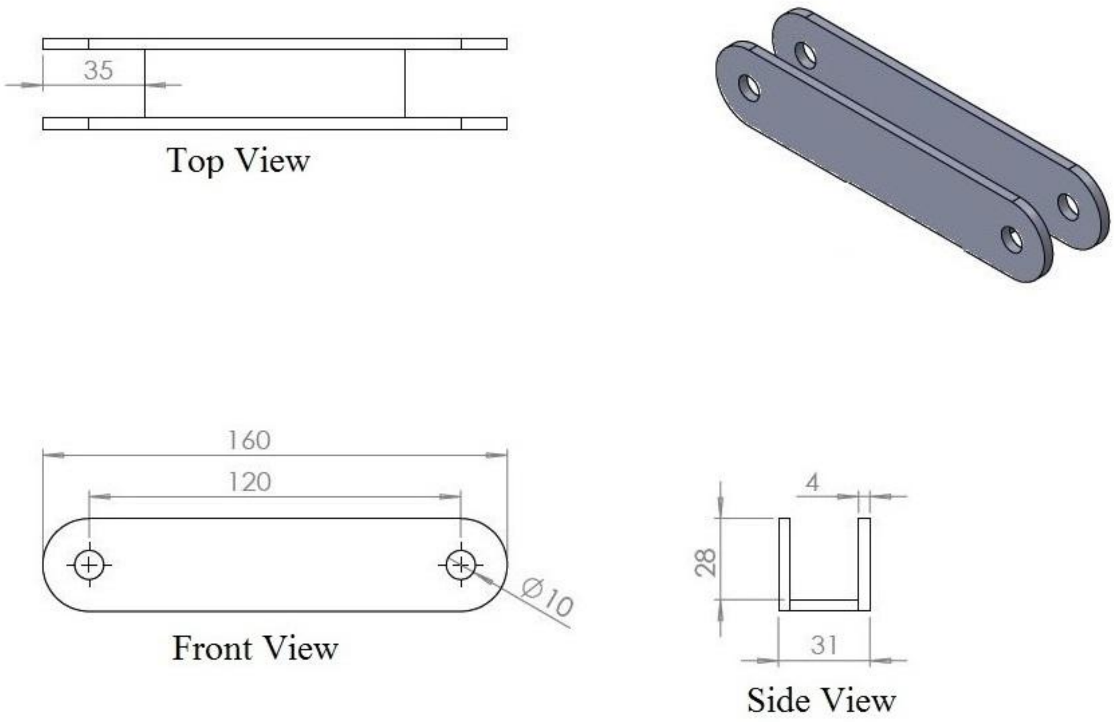



**Fig. 4.4**: Top Arm

$P_{cr}$ in Vertical Plane = $\frac{\sigma cr \times A}{1+a \times (L \div Ky)^2}$ = $\frac{330 \times 292}{1+(1\div 7500) \times (160 \div 11.81)^2}$

= 94058.16 N

$P_{cr}$ in Vertical Plane = $\frac{\sigma cr \times A}{1+a \times (L \div Kx)^2}$ = $\frac{330 \times 292}{1+(1\div 7500) \times (160 \div 8.8)^2}$

= 92292.03 N

Since Buckling load is more than Design load the dimensions of the link safe.

### 4.4 Bottom Arm:

Material selected Mild Steel

Design calculations:

Length of Arm, L = 160mm

Yield Stress for Mild Steel, $\sigma_{yt}$ = 248 N/mm$^2$

Factor of safety (F.S) = 2.5

Allowable Stress, $\sigma_{t\ allow} = \frac{\sigma yt}{F.S} = \frac{248}{2.5}$ = 99.2 N/mm$^2$

Compression Stress, $\sigma_c = 1.25 \times \sigma_{t\ allow}$ = 1.25 × 99.2 = 124 N/mm$^2$

Cross section area, A = (28 × 4) + {(39.5 -8) × 4} + (28 × 4) = 350 mm$^2$

Moment of Inertia of Solid Bar :

$$I_{x1} = \frac{bh^3}{12} = \frac{39.5 \times 28^3}{12} = 72258.67 \text{ mm}^4$$

$$I_{y1} = \frac{b^3h}{12} = \frac{39.5^3 \times 28}{12} = 143803.04 \text{ mm}^4$$

Moment of Inertia of cut area:

$$I_{x2} = \frac{bh^3}{12} = \frac{31.5 \times 24^3}{12} = 36288 \text{ mm}^4$$

$$I_{y2} = \frac{b^3h}{12} = \frac{31.5^3 \times 24}{12} = 62511.75 \text{ mm}^4$$

Now,

$$I_{xx} = I_{x1} - I_{x2} = (72258.67 - 36288) = 35970.67 \text{ mm}^4$$

$$I_{yy} = I_{y1} - I_{y2} = (143803.04 - 62511.75) = 81291.29 \text{ mm}^4$$

Radius of Gyration, $K_x = \sqrt{(\frac{Ixx}{A})} = \sqrt{(\frac{35970.67}{350})} = 10.14$ mm

Radius of Gyration, $K_y = \sqrt{(\frac{Iyy}{A})} = \sqrt{(\frac{81291.29}{350})} = 15.24$ mm

Rankine's constant, $a = \frac{1}{7500}$

As, Ends are hinged ($L_{eff} = L$)

Crippling stress, $\sigma_{cr} = 0.75 \times \sigma_{yt}$

$= 0.75 \times 248$

$= 330$ N/mm$^2$

$P_{cr}$ in Vertical Plane $= \frac{\sigma cr \times A}{1+a \times (L \div Ky)^2} = \frac{330 \times 350}{1+(1\div 7500)\times(160 \div 15.24)^2}$

$= 113827.16$ N

$P_{cr}$ in Vertical Plane $= \frac{\sigma cr \times A}{1+a \times (L \div Kx)^2} = \frac{330 \times 350}{1+(1\div 7500)\times(160 \div 10.14)^2}$

$= 111788.91$ N

**Since Buckling load is more than Design load the dimensions of the link safe.**

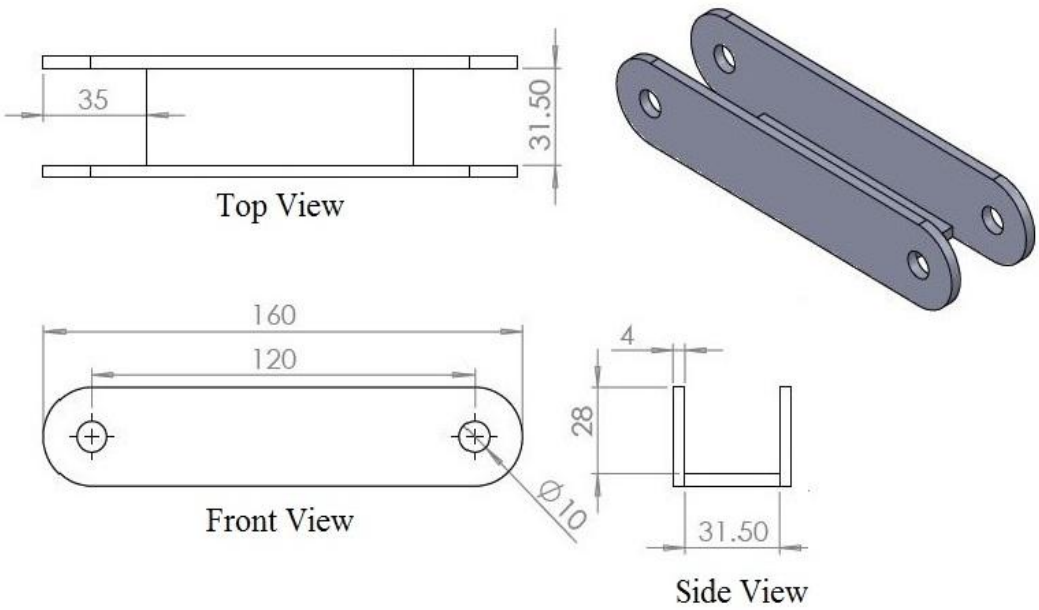



**Fig. 4.5:** Bottom Arm

### 4.5 Top Plate:

Material used: Mild Steel

Design calculations:

Moment, $M = \frac{P \times L2}{4} = \frac{2697.75 \times 50}{4}$ = 33721.88 N/mm

Here, P = 275 kg = 275 × 9.81 = 2697.75 N

$L_2$ = 50 mm

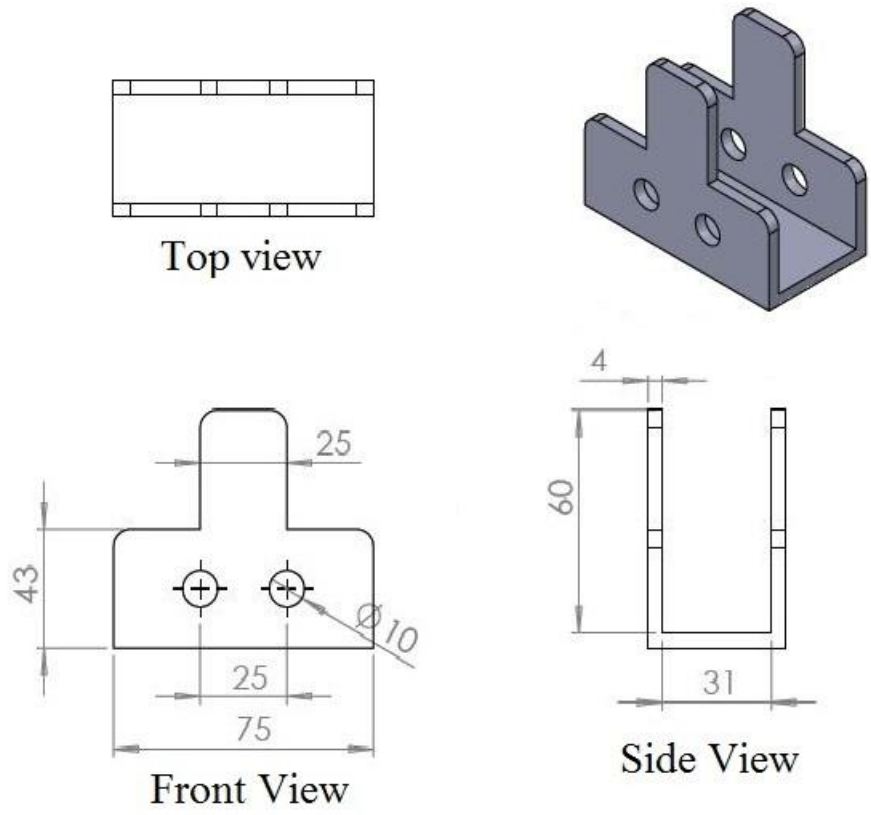



**Fig. 4.6**: Top plate

Now,

Section Modulus, $Z = \frac{bh^2}{6}$ $mm^3$

$= \frac{31.5 \times 25^2}{6}$

= 3281.25 $mm^3$

| Where, | b = 31.5 mm, |
|---|---|
| | h = 25 mm |

Bending Stress, $\sigma_b = \frac{M}{Z} = \frac{33721.88}{3281.25}$ = 10.28 $N/mm^2$

Hence, the permissible stress for mild steel is 124 $N/mm^2$ and it is greater than $\sigma_b$ = 6.51 $N/mm^{2.}$

So, the top plate design is safe.

### 4.6 Bottom Plate:

Material used: Mild Steel

The size and shape of the bottom plate have been selected to provide the stability to the power Scissor Jack.

The sizes of bottom plate has been fixed as = (120× 70 × 4) all in mm.

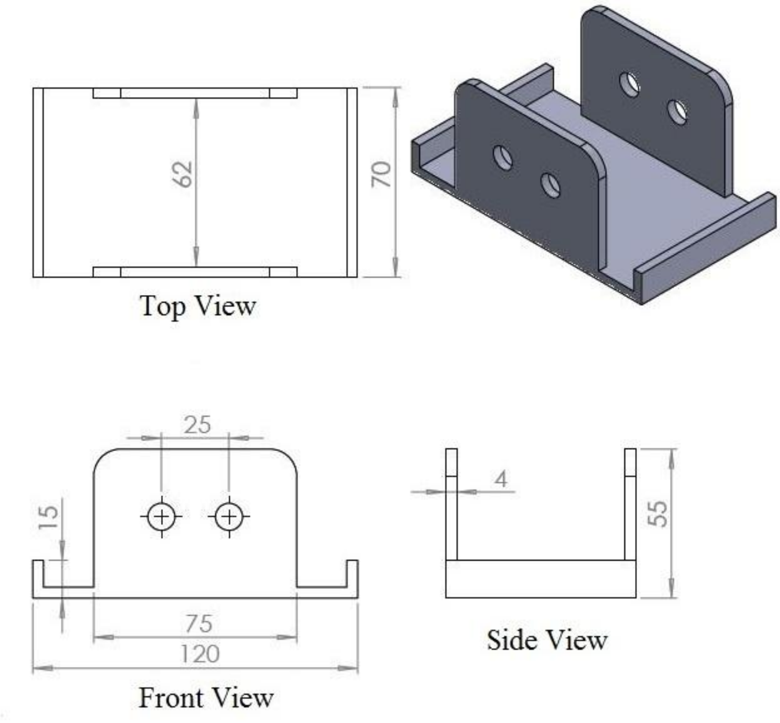



**Fig. 4.7:** Bottom Plate

### 4.7 Motor Base:

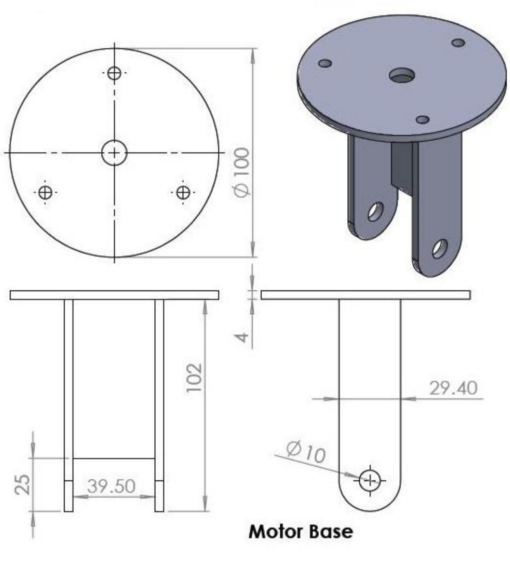



**Fig. 4.8**: Motor Base

## 4.8 Drawing of a Scissors Jack:

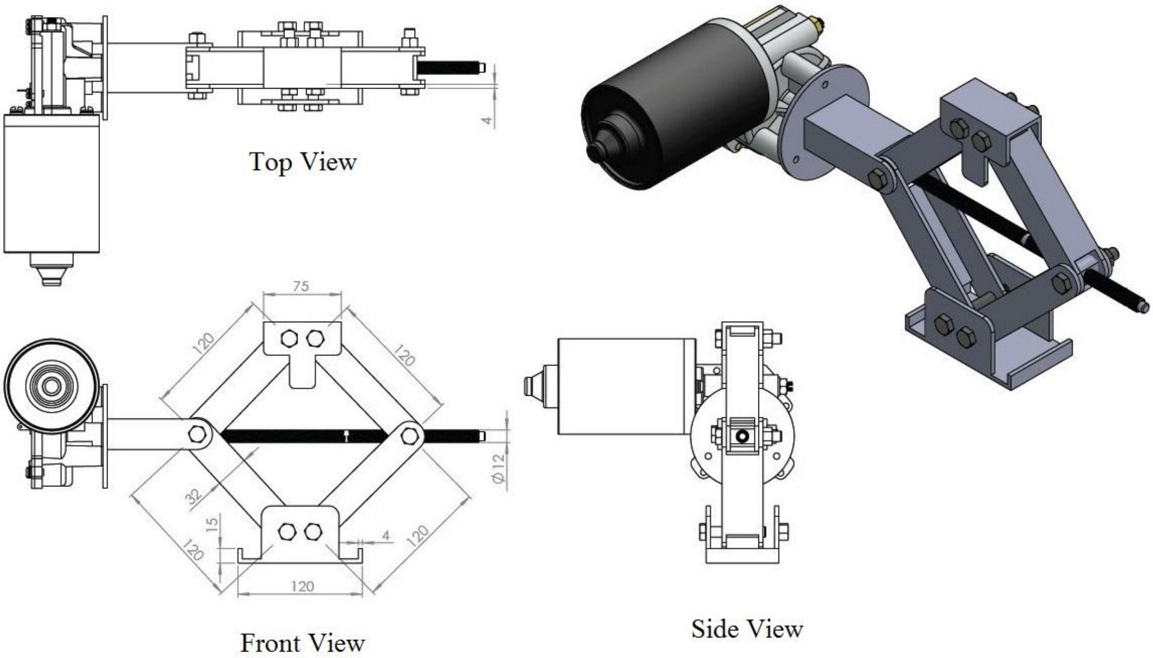



**Fig. 4.9:** Drawing of a Scissors Jack

## CHAPTER-V

## CONSTRUCTED PROJECT

The fabrication process started with identification of suitable materials which are used for prototype and designing of various parts.

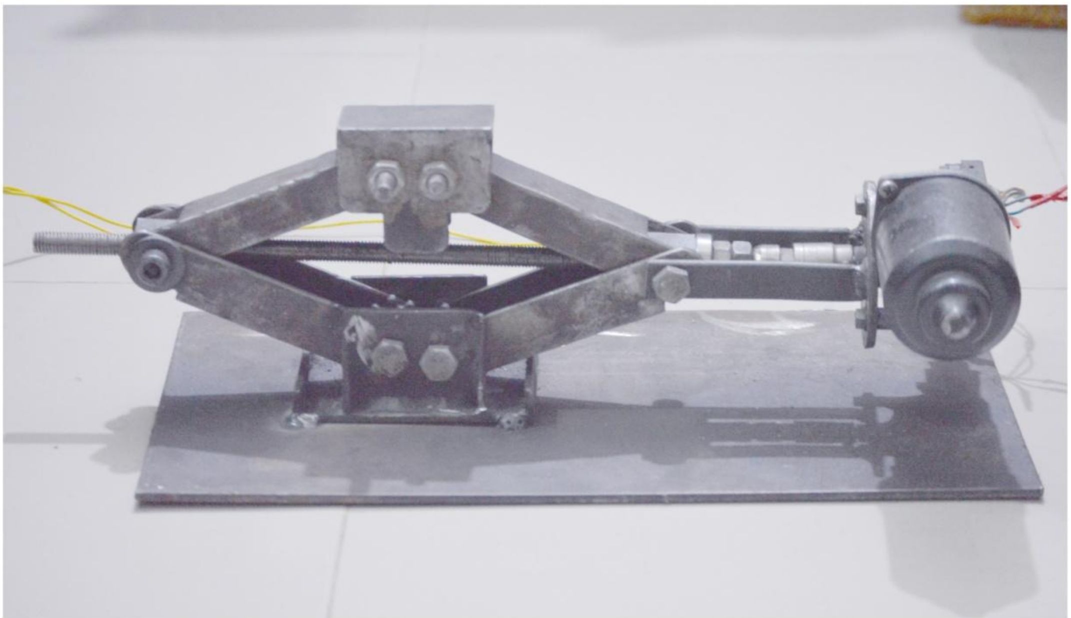


**Fig. 5.1:** A scissors jack

### 5.1 Power Screw:

A circular rod was turned to the required dimensions in a lathe machine and then we have adjusted the lathe machine in order to obtain external square threads and thus the external square threads of required dimensions were obtained as shown in the Fig. 5.2

**Fig. 5.2:** Fabrication of power screw on lathe

**Table 5.1** Sequence of operations on power screw

| Sl no. | Machine | Operation | Tools |
|---|---|---|---|
| 1 | Stores | Check the raw material | Outer calipers, steel rule |
| 2 | Sawing machine | Cutting the length of the rod as per requirement | Hack saw |
| 3 | Lathe machine | Turning the diameter to 12 mm | Single point cutting tool |
| 4 | Lathe machine | Threading of square thread | Threading tool |
| 5 | Shop Floor | Inspection | Vernier calipers |

## 5.2 Top Arms and Bottom Arms:

As per the calculations and the drawings the cross section of arms is selected as Channel Section. The availability of the Channel section of the required dimensions was low in our locality. so, we have grinded the edges of arms to obtain the required curvatures and drilled two holes to each of the arms as per the dimensions as shown in the Fig. 5.3

**Fig. 5.3:** Arm of Scissor Jack

**Table 5.2 Sequence** of operations on top and bottom arms

| Sl no. | Machine | Operation | Tools |
|---|---|---|---|
| 1 | Stores | Check the raw material | Try square, steel rule, and dot punch |
| 2 | Welding shop | Welding of a flat plate to the angular to obtain Channel section. | Welding gun, Files and Emery paper |
| 3 | Grinding machine | Grinding the plate in vice | Grinding wheel |
| 4 | Radial Drilling machine | Drilling 10 mm holes at both the ends of the plate | Drill bit, dot punch , hammer and steel rule |

**5.3 Trunnions:**

A circular rod was drilled to form a through hole. Then the hole has been finished to form internal square threads corresponding to the external threads of the power screw so that the internal square threads of the trunnions mate with the external threads of the power screw as shown in the Fig. 5.4

**Fig. 5.4:** Trunnions with internal threading

**Table 5.3** Sequence of operations on Trunnion

| Sl no. | Machine | Operation | Tools |
|---|---|---|---|
| 1 | Stores | Check the raw material | Inner calipers, steel rule |
| 2 | Sawing machine | Cutting the length of the rod as per requirement | Hack saw |
| 3 | Lathe machine | Turning the outer diameter to 24 mm | Single point cutting tool |
| 4 | Lathe machine | Boring the Trunnions to 16 mm diameter | Boring tool |
| 5 | Lathe machine | Threading of square thread | Internal Threading tool |
| 6 | Shop Floor | Inspection | Vernier calipers |

## 5.4 Top and Bottom Plates:

The left out pieces of the channel sections of the arms have been used for the top plate and then holes were drilled to the plate for fasteners connecting top plate and the arms. The top plate is fabricated in order to act as a loading platform as shown on the Fig. 5.5.

The bottom plate was fabricated by welding two L-angles so that the bottom arms fit into the bottom plate. The bottom plate is fabricated in order to obtain maximum stability to the Power Scissor Jack.

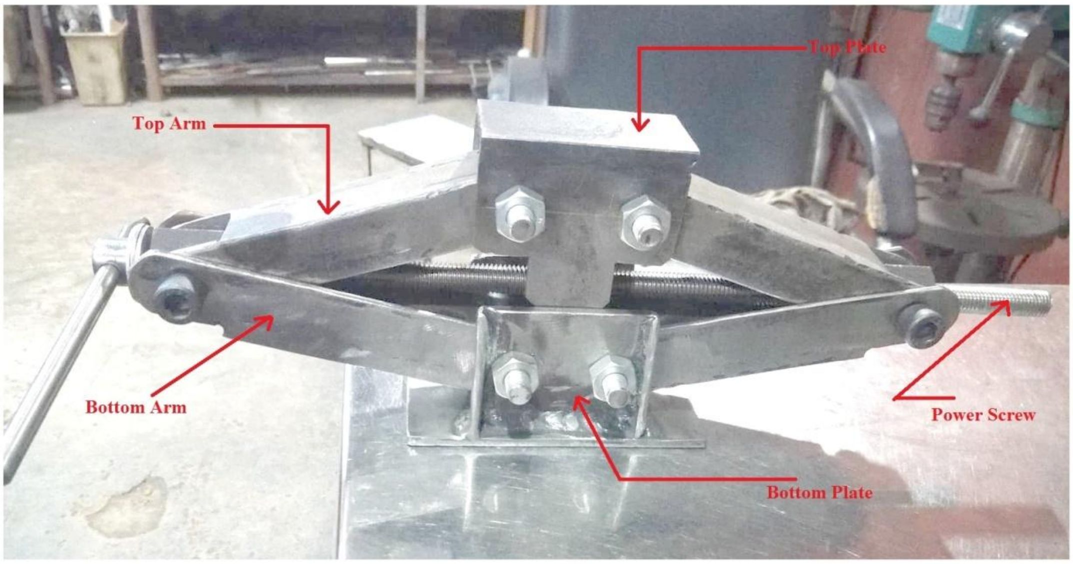



**Fig. 5.5:** Top and Bottom Plates

### 5.5 Circuit Diagram:

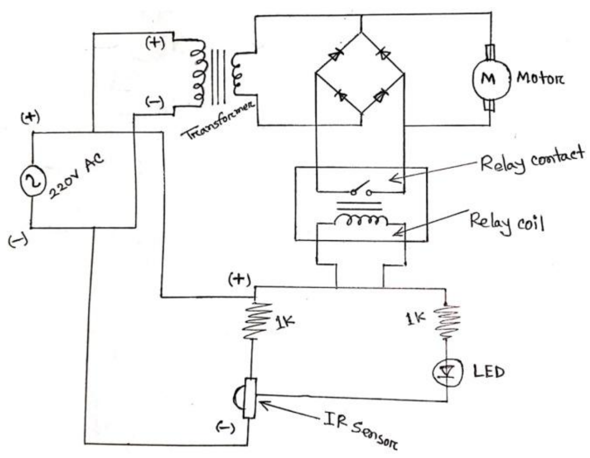



**Fig. 5.6:** Circuit Diagram of a Remote controlled Jack

### 5.6 Working Process:

A scissor jack is operated simply by turning a small crank that is inserted into one end of the scissor jack. One end of the screw fitted on a nut and a motor mounted on the other end of the screw, which is the object of force on the scissor jack. When the motor rotate, the screw turns, and this raises the jack. The screw acts like a gear mechanism. It has teeth (the screw thread), which turn and move the two arms, producing work. Just by turning this screw thread, the scissor jack can lift a vehicle that is several thousand pounds.

When we plugged in the power supply cable then the power start to flow towards transformer and remote control circuits. The transformer converts 220V AC current into 12V AC current. Then it converted 12V AC to 12V DC by using bridge rectifier and supplies it motor through relay. When remote switch 'ON' then it contact relay coil and the 1st relay command the motor to rotate clockwise then the jack start to up. And second times when the switch 'ON' then the 2nd relay command the motor rotate anti-clockwise direction. Then the jack starts to down.

# CHAPTER-VI

# RESULT & DISCUSSION

## 6.1 Important Terms:[15]

- Mechanical advantage of a machine (M.A.):
  It is the ratio of the weight lifted (W) to the effort applied (P).

$$M.A. = \frac{\text{Load}}{\text{Effort Applied}} = \frac{W}{P}$$

- Velocity ratio (V.R.)
  It is the ratio of the distance (y) moved by the effort to the distance (x) moved by the load.

$$V.R = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}} = \frac{y}{x} = \frac{2\pi L}{p}\text{; Here ,p = pitch}$$

- Input of a machine:

  It is the work done on the machine. In a lifting machine, it is measured by the product of effort and the distance through which it has moved (i.e., P.y).

- Output of a machine:

  It is the actual work done by the machine. In a lifting machine it is measured by the product of the weight lifted and the distance through which it has been lifted i.e., (W.x).

- Efficiency of a machine (η):
  It is the ratio of output to the input of a machine.

$$\eta = \frac{\text{Output}}{\text{Input}}$$

- Ideal machine:
  A machine is said to be ideal if its efficiency is 100%. In this case, output is equal to input.

**Whereas:**

W= Load lifted by the machine;

P = Effort required to lift the load;

p = Pitch;

y = Distance moved by the effort, in lifting the load;

x = Distance moved by the load;

η = Efficiency of the machine.

### 6.2 Calculations:

It is a device employed for lifting heavy loads which are usually centrally loaded upon it.

Load lifted, W = 70kg = 70×9.81 =686.7 N

Lead, l = 1.5 mm [∵ pitch = lead = 1.5mm]

Lead Angle ($\alpha$):

$$\tan\alpha = \frac{l}{\pi \times d}$$

$$\Rightarrow \tan(\alpha) = \frac{1.5}{\pi \times 11.25}$$ [∵ mean diameter, d=11.25 mm]

$$\Rightarrow \alpha = \tan^{-1}(0.042)$$

$$\therefore \alpha = 2.405°$$

And,

Co-efficient of friction, $\mu$=0.20

$$\Rightarrow \tan\phi = 0.20$$

$$\Rightarrow \phi = \tan^{-1}(0.20)$$

$$\therefore \phi = 11.31°$$

Effort applied, P = W × tan ($\phi$+$\alpha$)

$$= W \times \left(\frac{\tan\phi + \tan\alpha}{1 - \tan\phi \times \tan\alpha}\right)$$

$$= 686.7 \times \frac{\tan 11.31° + \tan 2.405°}{1-(\tan 11.31° \times \tan 2.405°)}$$

= 167.41 N

Mechanical Advantage, M.A = $\frac{W}{P}$ = $\frac{686.7}{167.41}$ = 4.108

Suppose, screw has taken one full revolution,

Then, Distance moved by the effort = 2πl

$$\text{Velocity Ratio, V.R} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}} = \frac{2\pi l}{p} = \frac{2\pi l}{\tan\alpha \times \pi d}$$

$$= \frac{2 \times l}{\tan\alpha \times d}$$

$$= \frac{2 \times 1.5}{\tan(2.405) \times 11.25}$$

= 6.36

Efficiency, η = $\frac{M.A}{V.R} \times 100\%$ = $\frac{4.108}{6.36} \times 100$ = 64.59%

### 6.3 Experimental Data:

| Serial No | Time (sec) | Height (mm) | Rate of Lifting (mm/sec) |
|---|---|---|---|
| 1 | 30 | 19 | 0.633 |
| 2 | 30 | 19 | 0.633 |
| 3 | 30 | 16 | 0.533 |
| 4 | 30 | 17 | 0.567 |
| 5 | 30 | 15 | 0.50 |
| **Total** | | | **2.866** |

∴ Average Rate of lifting = $\frac{2.866}{5}$ = 0.573 mm/sec.

### 6.4 Results:

Mechanical Advantage, M.A = 4.108

Efficiency, η = 64.59%

Rate of lifting = 0.573 mm/sec.

## CHAPTER-VII

## CONCLUSION AND SCOPE

### 7.1 Conclusion:

In this project a prototype of power scissor jack which can be operated by a power gun has been designed and fabricated. The jack has been designed to a pay load of 2.7kN. The salient features of the present fabrication are elimination of human effort to operate the jack, through a simple electrical device which can be actuated by a 12 V battery and provision of a light source to facilitate convenient operation during night time. All the elements of the jack are fabricated in the machine shop. Another feature of the unit is provision of two trunions on both the sides of the jack to ensure jerk free operation. The elements which are useful are readily available commercially for each and early replacement of failed components if required.

### 7.2 Scope for future work:

- We are currently working on small commercial vehicles but in future it can be used for heavy duty vehicles by making small changes.
- As a development the web part of the arms can be replaced by stiffening ribs to reduce the overall weight the top and base plates can be made foldable to make the unit more compact.
- Permanently mounted jacks on the vehicle can be developed so that tire change can be completely automated.

## REFERENCES


[1] http://powerjacks.com/about-us/powerjacks-what-we-do.php

[2] RS Khurmi, "A text book of Machine Design", 3rd Edition, Eurasia publishing house, New Delhi, India, 2005.

[3] Msmillar.hubpages.com/hub/The-Hydraulic-Jack

[4] Powerjacks.com/downloads/Design%20Guides/PJLMPT-02/S1-Screw-Jacks PJLMPTDG-02.pdf

[5] Scholarsresearchlibrary.com/EJAESR-vol1-iss4/EJAESR-2012-1-4-167-172.pdf

[6] INPRESSCO-GERNAL ARTICLE; E-ISSN2277-4106, AUTOMATED CAR JACK.

[7] Academia.edu/6167889/Modification_of_the_Existing_Design_of_a_Car_Jack.

[8] http://en.wikipedia.org/wiki/Jackscrew

[9] http://scholarsresearchlibrary.com/EJAESR-vol1-iss4/EJAESR-2012-1-4-167-172.pdf

[10] http://www.duffnorton.com/productmenu.aspx?id=7898

[11] http://www.ehs.utoronto.ca/Assets/ehs+Digital+Assets/ehs3/documents/Lifting+Devices+Standard.pdf

[12] Design and fabrication of motorized automated object lifting jack; IOSRJEN.ISSN

[13] http://www.ijceronline.com/papers/Vol4_issue07/Version-1/A0470101011.pdf

[14]https://www.academia.edu/37133833/Module_7_Screw_threads_and_Gear_Manufacturing_Methods

[15] http://engineering.myindialist.com/2009/lab-manual-to-calculate-the-efficiency-of-simple-screw-jack/#.XjCY7zIzbIU