JABALPUR ENGINEERING COLLEGE, JABALPUR (M.P.)

MAJOR PROJECT REPORT ON

DESIGN AND FABRICATION OF TOGGLE JACK

Submitted

In partial fulfilment of the requirement for the award of the

BACHELOR OF ENGINEERING IN

MECHANICAL ENGINEERING

2019-2020

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CERTIFICATE

This is to certify that student of final year, Bachelor of Mechanical Engineering of this institution has satisfactorily completed the project entitled **"Design and fabrication of toggle jack"** and submitted the project report for the partial fulfilment for the award of **Bachelor of Engineering** course in **Mechanical Engineering** as prescribed by Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)

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ABSTRACT

Toggle jacks are simple mechanisms used to drive large loads short distances. The power screw design of a common Toggle jack reduces the amount of force required by the user to drive the mechanism. Most Toggle jacks are similar in design, consisting of four main members driven by a power screw. In this report, a unique design of a Toggle jack is proposed which is very easy to manufacture. Each member, including the power screw sleeves, is made of the common c-shape. This eliminates the need for machined power screw sleeves, which connect the four members and the power screw together. The manufacturability of the proposed Toggle jack lowers the cost of production.

LIST OF FIGURES

INTRODUCTION

The most basic Toggle jack design is truly engineering at its finest. With the power to magnify input forces, Toggle jacks allow us to raise vast loads using only a fraction of the force ordinarily needed. Our goal in this project is to design an efficient Toggle jack capable of raising a 10000N load. As a screw-driven mechanical system, the jack will be manually operated and have at least 7 inches under load. The design will be transportable and storable, have a removable crank handle, and operate with a factor of safety of n = 5 using standard mechanical design methods for all components. The design itself has gone through multiple stages of development. We have taken several possible failure modes into account and are confident that our design is efficient and safe.

SPECIFICATION

The Toggle jack design, shown in Figure 1, consists of four main lifting members, eight connection members, a power screw. Members 1 to 8 are all primarily bar shapes with ideal pin connections. Members 10 and 12 both have additional details to account for the contact surfaces. The power screw is double threaded with a collar at the member 12 connection. All members are EN8(C40) steel. The following is a summary of the design features for our proposed Toggle jack. Details of the design specifications and failure criteria can be found in the attached appendices.

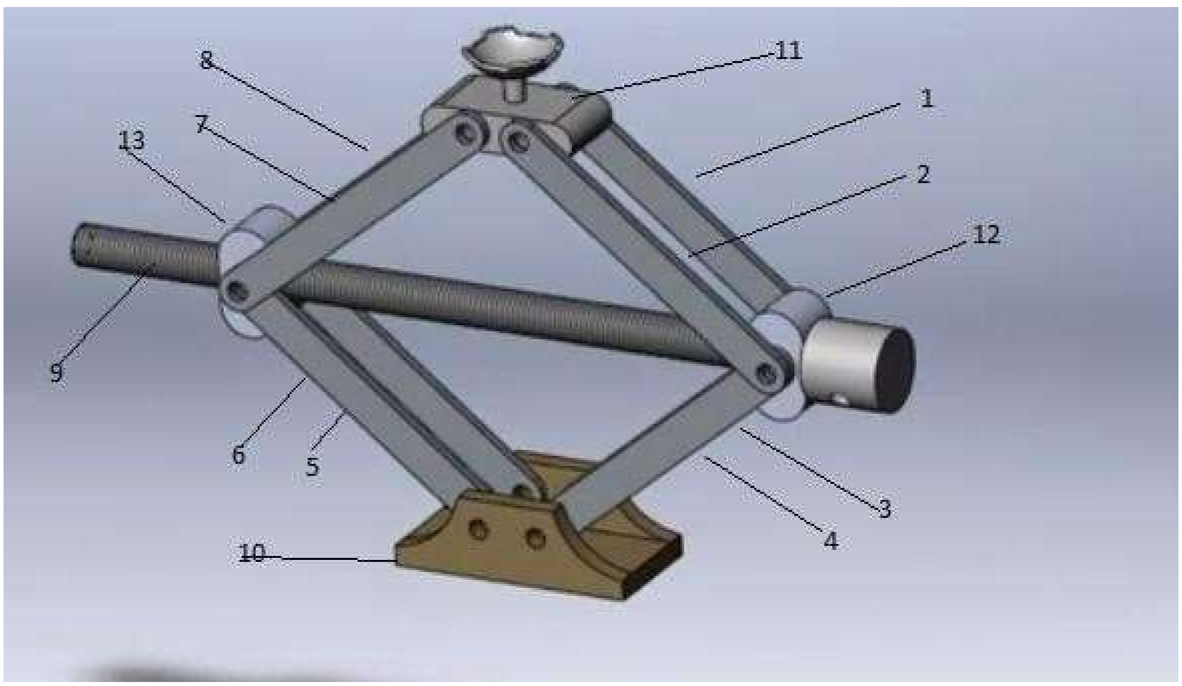


Figure 1: Toggle Jack Design

3.2 Components used in the fabrication of Toggle Jack:-

a) Power Screw

b) Nuts

c) Top plate

d) Base plate

e) Links

f) Pins

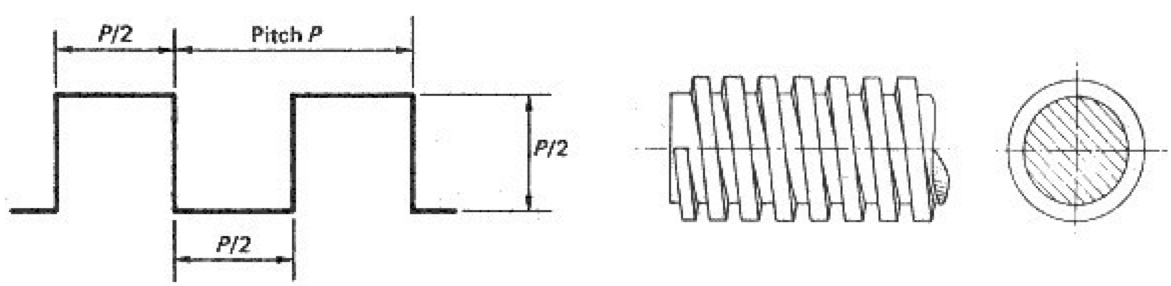
g) Spanner

3.3 Power screw

A power screw is a drive used in machinery to convert a rotary motion into a linear motion for power transmission. It produces uniform motion and the design of the power screw may be such that. Either the screw or the nut is held at rest and the other member rotates as it moves axially. A typical example of this is a screw clamp. Either the screw or the nut rotates but does not move axially. A typical example for this is a press. Other applications of power screws are jack screws, lead screws of a lathe, screws for vices, presses etc. Power screw normally uses square threads but ACME or Buttress threads may also be used. Power screws should be designed for smooth and noiseless transmission of power with an ability to carry heavy loads with high efficiency. We first consider the different thread forms and their proportions:

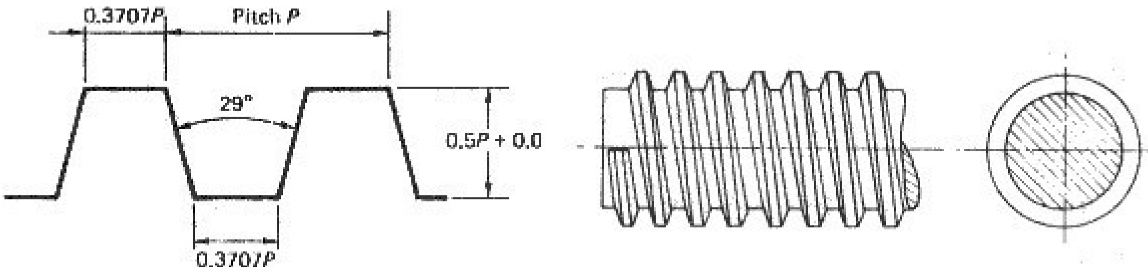
1) Square Form

This form is used for power/force transmission i.e. linear jacks, clamps. The friction is low and there is no radial forces imposed on the mating nuts. The square thread is the most efficient conventional power screw form. It is the most difficult form to machine. It is not very compatible for using split nuts-as used on certain machine tool system for withdrawing the tool carriers



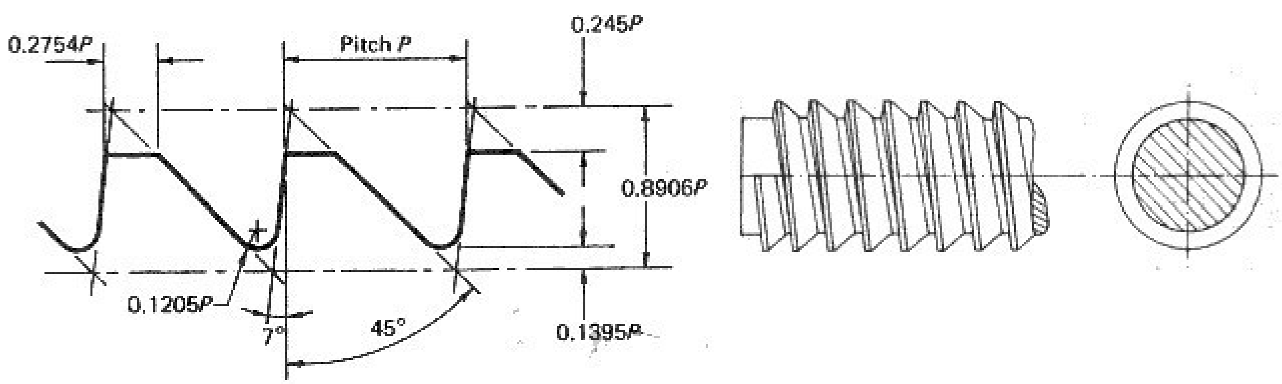
2) Acme Form

Used for power transmission i.e. lathe lead screws. Is easier to manufacture compared to a square thread. It has superior root strength characteristics compared to a square thread. The acme screw thread has been developed for machine tool drives. They are easy to machine and can be used with split nuts. The thread has an optimum efficiency of about 70% for helix angles between 25° and 65°. Outside this range the efficiency falls away.



3) Buttress Form

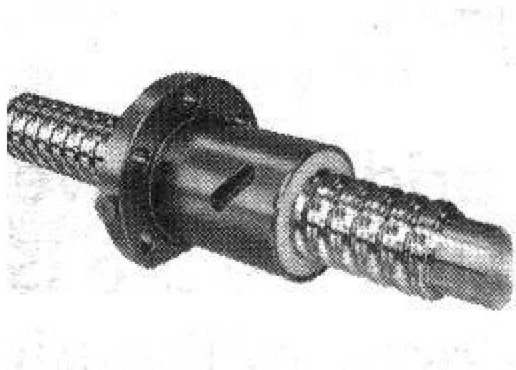
A strong low friction thread. However it is designed only to take large loads in on direction. For a given size this is the strongest of the thread forms. When taking heavy loads on the near vertical thread face this thread is almost as efficient as a square thread form.

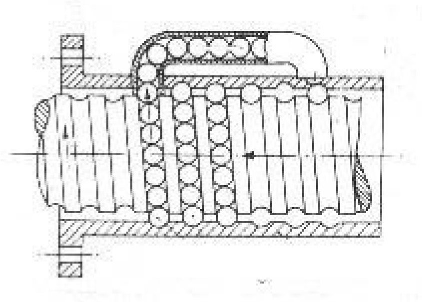


4) Recirculating Ball Screw

This type of power screw is used for high speed high efficiency duties. The ball screw is used for more and more applications previously completed by the conventional power screws.

The ball screw assembly is as shown below and includes a circular shaped groove cut in a helix on the shaft. The ball nut also includes an internal circular shaped groove which matches the shaft groove. The nut is retained in position on the shaft by balls moving within the groove. When the nut rotates relative to the shaft the balls move in one direction along the groove supporting any axial load. When the balls reach one end of the nut they are directed back to the other end via ball guides. The balls are therefore being continuously recirculated.





Nut

The sleeve channels are to open inwards as shown in Figure 2. This is so the flanges are subjected to tension instead of compression. The bending moment from the power screw creates tension on the inner edge of the sleeve and compression on the outside edge. Tension along flanges on the inside prevents the possibility of localized bucking in the flanges from compressive forces.

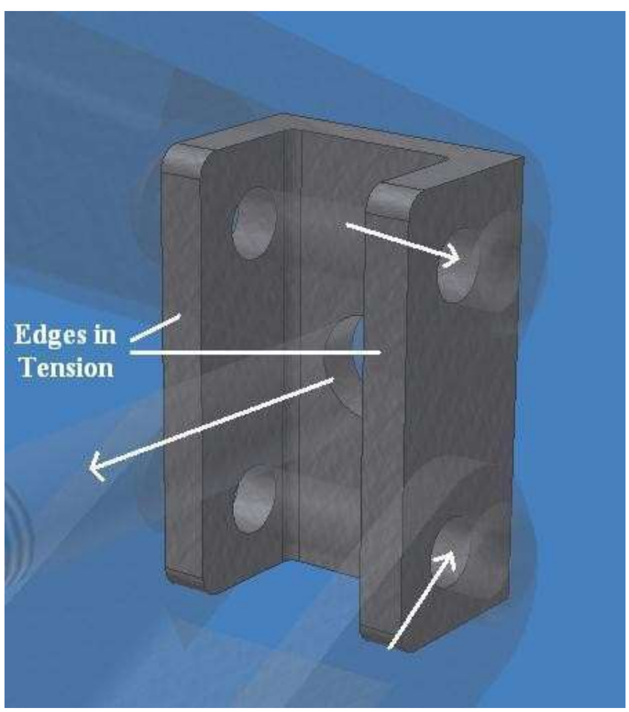


Fig. of NUT

Figure 2: Orientation of Sleeve Channels to Prevent Localized Buckling.

Additionally, the threaded sleeve section is to have additional thread surface area, shown in Figure 3. These additional threads safely transmit the stress from the power screw to the sleeve. Threading the thickness of the web of the channel would not be sufficient for reasonable power screw diameters. This addition is only made on the threaded sleeve section and not on the collared sleeve section. The collar transmits the stress safely to the c-shape.

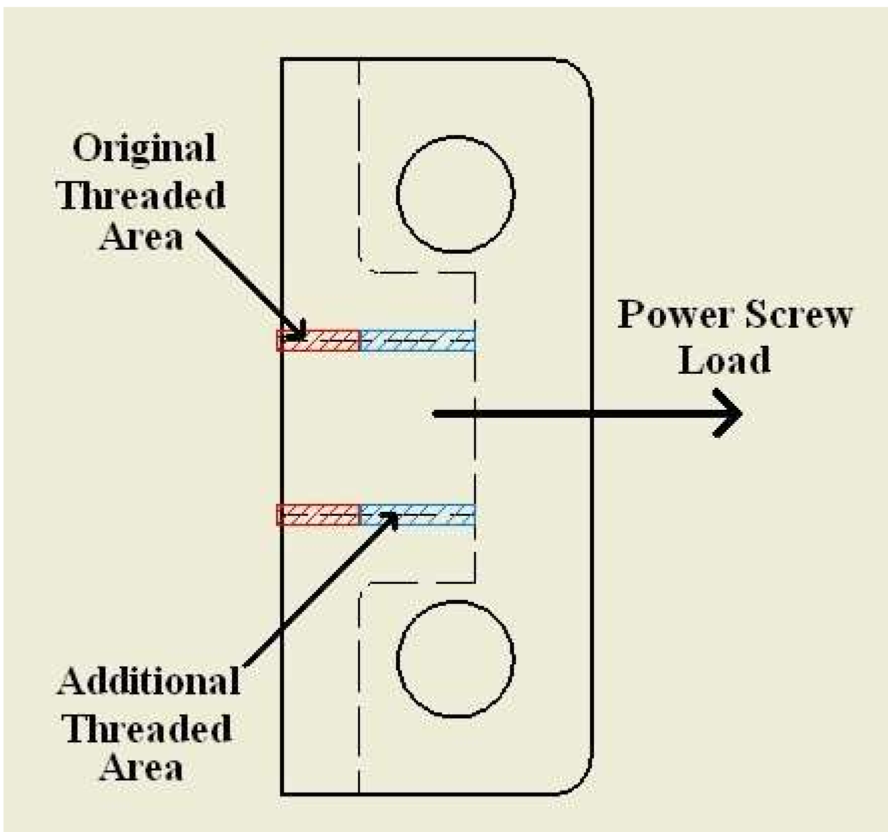


Figure 3: Addition to C-Shape to Provide Adequate Threaded Area.

Contact Members:

The members that make contact with ground and the service load are members 10 and 11 respectively. Member 10 has additional flanges to provide a stable base for the mechanism while servicing the load. Member 11 has an attached plate atop to provide sufficient contact area. Most Toggle jacks have ridges which lower the area of contact. This causes stress concentrations which can damage the underside of a car.

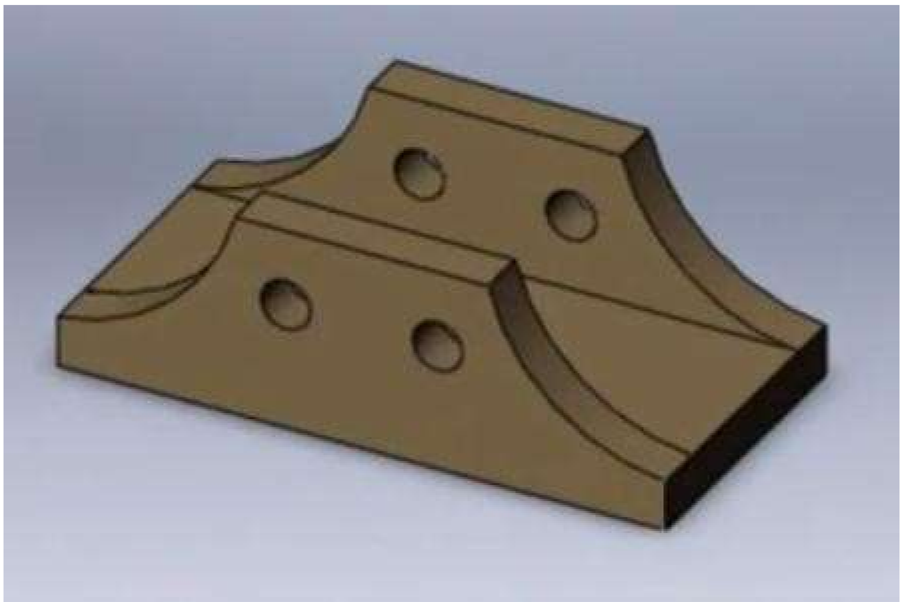


Fig. of Base plate

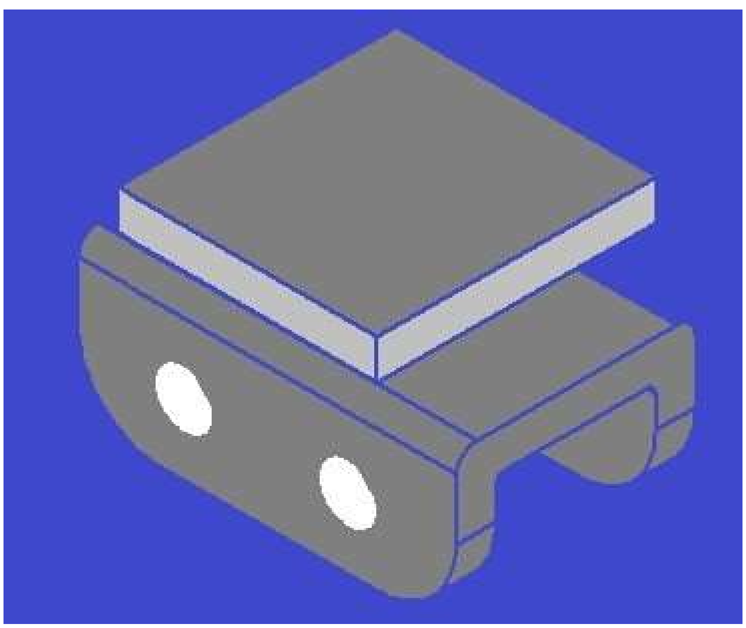


Fig .of top plate

Links

These members are made from simple bar-shapes. The web of the members is cut out near the pin connections to allow proper serviceability of the Toggle jack at its maximum and minimum heights. Members 2 and 7 have ideal gear connections to balance the load between the left and right side

The flanges of the channels are to wrap around the flanges of the sleeve members. The lifting members are greater in length and are subjected to compression. Lifting member flanges on the outside of the sleeve flanges is to compensate for slenderness ratio by increasing the moment of inertia of the lifting members

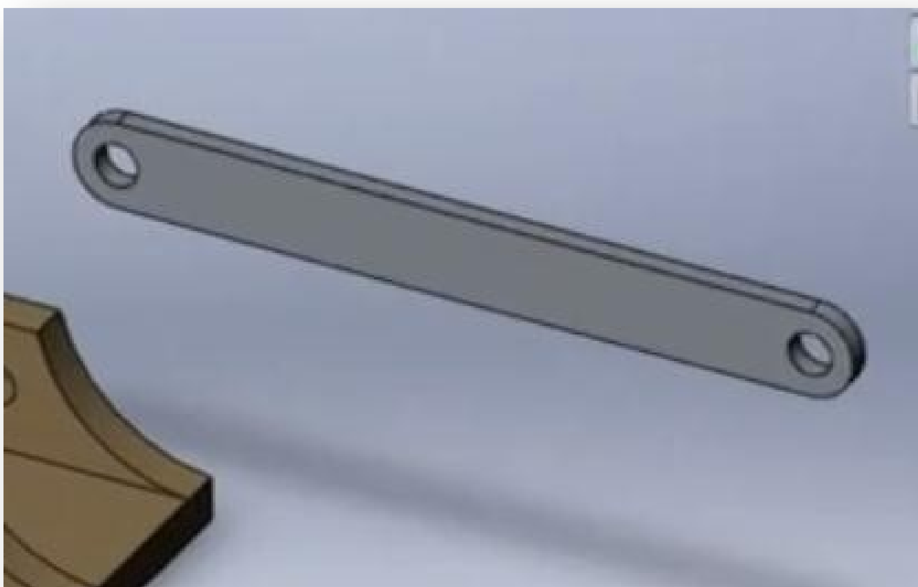


Fig. of Link

DESIGN AND CALCULATION

CALCULATION:-

Toggle jack to lift a load of W=10000N.

The eight links are symmetrical l= 112 mm.

The screw is square threaded.

Permissible tensile stress is limited to σ=90 N/mm ^{2}.

Bearing pressure is limited to 10 N/mm^2.

The co efficient of thread friction is 0.15.

1. The distance between the nuts 218 mm the jack is in the bottom position .At 100 mm the jack is in the top position.
2. The distance between the top plate and base plate160 mm is in bottom position. At 250 mm the jack at top position.
3. Hence the total lift 90mm.
4.

POWER SCREW DESIGNING

Force Acting On Screw:-

Angle=90 -33 =57

Force acting on element first=_=9180.3N

Total force acting on screw=2×9180.3×cos33

=15398.6N

Tensile Load=15398.6N.

[N

[×90=15398.6

d_c=14.76

d_c=23 (standard)

Pitch p=5mm

Dimensions of three different series of square thread form

Fine Series					Normal Series					Coarse Series				
Nominal Dia (mm)	Steps (mm)	Pitch (mm)	a (mm)	b (mm)	Nominal Dia (mm)	Steps (mm)	Pitch (mm)	a (mm)	b (mm)	Nominal Dia (mm)	Steps (mm)	Pitch (mm)	a (mm)	b (mm)
10-22	2	2	0.25	0.25	22-28	2	5	0.25	0.5	22-28	2	8	0.25	0.5
22-62	2	3	0.25	0.25	30-36	2	6	0.25	0.5	30-38	2	10	0.25	0.5
115-175	5	6	0.25	0.5	115-145	5	14	0.5	1	115-130	5	22	0.5	1
250-300	10	12	0.25	0.5	240-260	10	22	0.5	1	250-280	10	40	0.5	1
420-500	20	18	0.5	1	270-290	10	24	0.5	1	290-300	10	44	0.5	1

Mean diameter of screw(d)= +p/2

=23+5/2

=25.5mm

Torque Acting On The Screw Rod:-

The screw in the right nut is subjected to twice the screw frivtion torque in the left nut

Maximum torque=W×d/2tan(Ø+α)×2

Ø=85 (friction angle)

α=

α=3.57

Load angle of the screw=3.57

M=co-efficent friction between screw and nut

Maximum torque(T)=2×15398.6×25.5/2×

=83964.9

Torque acting on screw rod.

MAXIMUM PRINCIPAL STRESS:-

Torsional shear stress= $(\tau)=\underline{\quad\quad}$

$=\overline{\quad\quad\quad\quad}$

$=35.16N/mm^2$

Direct tensile stress $(\sigma)= = \underline{\quad\quad}$

$=\overline{\quad\quad\quad\quad}$

$=37.08N/mm^2$

$\sigma_{1=}\sigma/2+\sqrt{(\ )}$

$=\underline{\quad\quad}\ \sqrt{\quad\quad\quad\quad}$

$=58.28N/mm^2$ $[\sigma]=90N/mm^2$

The screw dimension 23 and pitch=5 are satisfactory.

Design of Nut:-

Number of thread in nut=________

$=4\ 15398.6$

$=n$

Then it is satisfactory.

Length of nut=n×p

=5×8

=40

Length of nuts=60mm (as required)

Width of the nut=1.5×d0=1.5×28=42mm

Length of the screwed portion of the screw

=218+t+2×thickness of rigs

=218+50+2×9

=286mm

Since the Toggle Jack is operated by spanner so total length at the screw

=286+16×2

=318mm

Design of Spanner:-

Assuming that a force of 165N is applied by each person at each end of the rod, then the length of the spanner required.

=

=254.45mm

300mm

DESIGN OF PINS:-

Load on the pin=

=

F =7699.32N

Let , d= diameter of the pin.

P =2 (d1)²×τ

7699.32= 2

Or (d1)² =

Or d1= 11mm

Dia of pin,d1=11mm

Therefore dia of pin head $=1.5\times d1$

1.5×11

$=16.5mm$

Length of the pin =60mm (assume)

Design of Link:-

Here the links are buckle in two planes right angle to each other.

The load on the link=F/2

$=7699.32/2$

$=3849.66N$

Load of Link

Assuming factor of safety=5

$W_L=3850\times 5$

$=19250N$

Let

$t1$=thickness of link

$b1$=width of the link

assuming the width of link is three times of link thickness

i.e $b1=3t1$

cross-sectional area of the link=A

$A=t1\times 3t1$

$=3t1^2$

Moment of inertia at cross sectional at the link

$$I=1/12\times t1\times(3t1^2)$$

$$=2.25$$

Radius of gyration=K=$\sqrt{}$

=$\sqrt{}$

=0.866t1

Since for bucking of the link is the vertical plane, the ends are consider as hinged, therefore equivalent on the link.

Link l=112mm

Rankine's constant a=1/7500

According to Rankine's formula

$W_L =$

=

Or 71.29 =

Or $71.29(t1^2+2.23) = (t1^2)^2$

$(t1)^2 = \sqrt{}$

Taking (t)=

$t1^2 = 73.5$

$t1 = \sqrt{}$

t1 = 9mm

Width, b1 = 3×t1

= 3×9

= 27mm

MATERIAL SELECTED:-

Selection of material is done on the basis of the strength of the material i.e. their ultimate. For the reference of the material strength the PSG Data Book is referred and the following materials were found to be most optimal for the use in the manufacturing of the plates and columns for the low load carrying capacity as in our case.

PART OF THE MACHINES — MATERIALS

PART OF THE MACHINES	MATERIALS
One Screw	C40
Eight Links	C40
Four Pins	C40
Two Nuts	C40
One Top plate	C40
One Base plate	C40
One Spanner	C49

BASIC MACHINING OPERATION WHICH IS DONE ON LATHE MACHINE.

Drilling

Drilling is used to remove material from the inside of a work piece. This process utilizes standard drill bits held stationary in the tail stock or tool turret of the lathe.

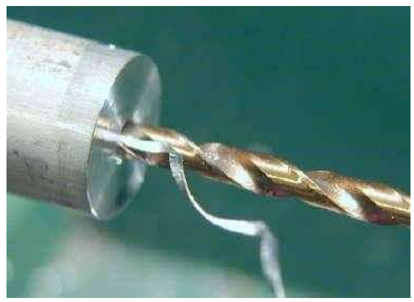


Fig. of Drilling operation

Threading

In threading both standard and non-standard screw threads can be turned on a lathe using an appropriate cutting tool (Usually having a 60 or 55° nose angle).Either externally or within a bore which is generally referred to as single-point threading. Threading operations include a)all types of external and internal thread forms using a single point tool also taper threads, double start threads, multi start threads and worms as used in worm wheel reduction boxes, lead screw with single or multistate threads. b) By the use of threading boxes fitted with 4 form tools, up to 2" diameter threads but it is possible to find larger boxes than this.

Milling

Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, workpiece, fixture, and cutter. The workpiece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to a platform inside the milling machine. The cutter is a cutting tool with sharp teeth that is also secured in the milling machine and rotates at high speeds. By feeding the workpiece into the rotating cutter, material is cut away from this workpiece in the form of small chips to create the desired shape

COST ESTIMATION:-

Table 1

MATERIAL COST:-

Sl. No.	Name of the component	Material	Quantity	Cost in rupees
01	Power Screw	C40	01	800
02	Links	C40	08	600
03	Pins	C40	08	180
04	Top Plate	C40	01	200
05	Base Plate	C40	01	200
06	Spanner	C40	01	150
TOTAL COST IN RUPEES				**2130**

Table 2

MACHINING COST:-

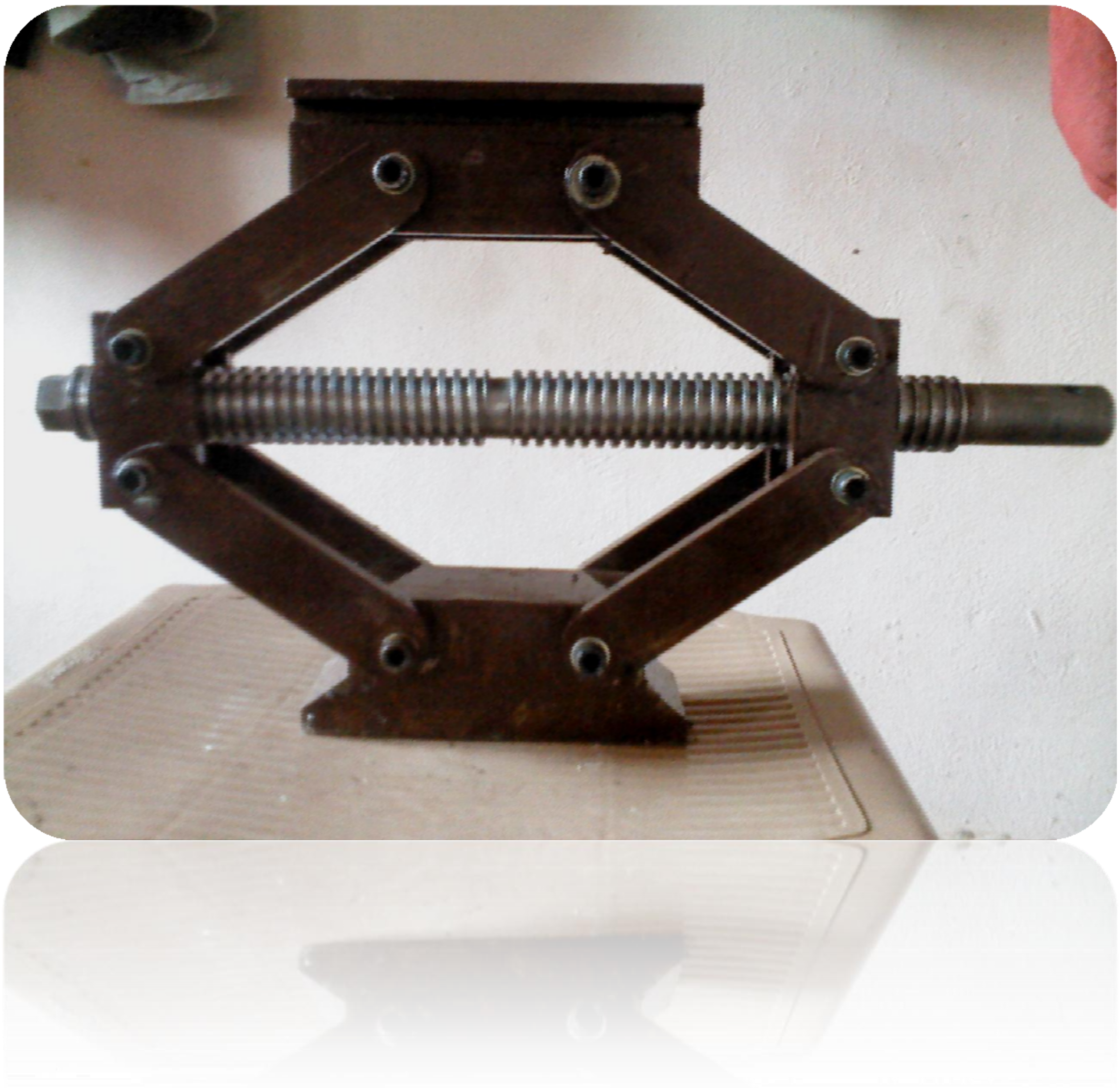
Sl. No.	Machine	Operation	Cost in rupees
1	Lathe (finishing)	Facing, turning, taper turning	1500
2	Fabrication and assembly 01. Lathe 02 Milling machine 03 Grinding machine	 Facing, turning, threading Drilling Surface finishing	 1200 500 500
TOTAL COST IN RUPEES			**3700**

Table 3

- **TOTAL COST OF DESIGN AND FABRICATION OF TOGGLE JACK**

Sl. No.	Particular	Cost in rupees
01	Material cost	2130
02	Machining cost	3700
03	Transportation and allowances	1000
04	Name plate	200
05	Colour	200
TOTAL COST IN RUPEES		**7230**

ASSEMBLY DIAGRAM:-



CONCLUSION:-

Our proposed design is similar to common Toggle designs in some aspects, but also advantageous in others. Similar to others, our proposed design can safely raise a load of 10000N to the required heights with relative ease on the user. Unique to our design, however, is the manufacturability of our design, which is much simpler. Since only Bar-shapes are utilized, bulk material can be more efficiently purchased and used. Also, less machining is required since there are no complex sleeves for the power screw. Only simple attachments which can be welded on are proposed. Therefore, when compared to similar Toggle jack designs that perform equally as well, our proposed design is recommended for its manufacturability and lower cost with high efficiency.

REFERENCES

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2. Machine Design ‘R. S. KHURMI’