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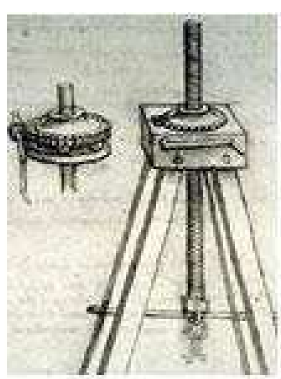
Android Based Motorized Screw Jack for a Four Wheeler

Vishnu Aadithyan .M[1], Sabaresan K. S[2], Sanjith Karthi .R[3], Dr. D. Shanmugam[4], Mr. Mahendran[5]
[1, 2, 3]*Automobile Engineering, Dr. Mahalingam College of Engineering and Technology*
[4]*M.E., Ph.D., HEAD OF THE DEPARTMENT, Automobile Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi – 642003*
[5]*Assistant Professor, Automobile Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi – 642003*

Abstract: With the increasing levels of technology, the efforts being put to produce any kind of work 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 translatory motion. A screw 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. The principle on which it works is similar to that of an inclined plane. The mechanical advantage of a screw jack is the ratio of the load applied to the effort applied. The screw jack is operated by turning a lead screw. The height of the jack is adjusted by turning a lead screw and this adjustment can be done either manually or by integrating an electric motor.
In this project, an electric motor will be integrated with the screw jack and the electricity needed for the operation will be taken from the battery of the vehicle and thereby the mechanical advantage will be increased.

I. LITERATURE SURVEY

Screw type mechanical jacks were very common for jeeps and trucks of World War II vintage.
For example, the World War II jeeps (Willys MB and Ford GPW) were issued the "Jack, Automobile, Screw type, Capacity 1 1/2 ton", Ordnance part number 41-J-66. This jacks, and similar jacks for trucks, were activated by using the lug wrench as a handle for the jack's ratchet action to of the jack. The 41-J-66 jack was carried in the jeep's tool compartment. Screw type jack's continued in use for small capacity requirements due to low cost of production raise or lower it. A control tab is marked up/down and its position determines the direction of movement and almost no maintenance.
The virtues of using a screw as a machine, 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, that rotated by the turning of a worm shaft to drive a lifting screw to move the load - instantly recognisable as the principle we use today.



We can‟t be 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 we have evidence of the product being developed further.

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 recognised the need for precision had become as important in industry as the provision of power.

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 had become internationally famous for their precision and quality and dominated the market from the 18η0s. Inspired young engineers began to put Whitworth‟s machine tools to new uses. During the early 1880s in Coaticook, a small town near Quebec, a 24year-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.

Local Coati cook industrialist, Arthur Osmore Norton, spotted the potential for Sleeper‟s design and in 188θ hired the young man and purchased the patent. The „Norton‟ jack was born. Over the coming years the famous „Norton‟ jacks were manufactured at plants in Boston, Coaticook 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 local 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.

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.

Air Motor Power Jack

There was clearly 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”.

Worm Gear Jack

Since then the product has evolved to push, pull, lift, lower and position loads of anything from a few kilos to hundreds of tonnes. One of the biggest single screw jacks made to date is a special Power Jacks E-Series unit that is rated for 350 tonnes –even in earthquake conditions for the nuclear industry. More recent developments have concentrated on improved efficiency and durability, resulting in changes in both lead screw and gearbox design options for screw jacks.

A screw jack that has a built-in motor is now referred to as a linear actuator but is essentially still a screw jack. Today, screw jacks can be linked mechanically or electronically and with the advances in motion-control, loads can be positioned to within microns. Improvements in gear technology together with the addition of precision ball screws and roller screws mean the applications for screw jacks today are endless and a real alternative to hydraulics in terms of duty cycles and speed at a time when industry demands cleaner, quieter and more reliable solutions.

II. POWER SCREWS

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.

A. Applications

The main applications of power screws are as follows:

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

There are three essential parts of a power screw, viz.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.

B. 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 15 kN can be raised by applying an effort as small as 400 N.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.

C. 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.

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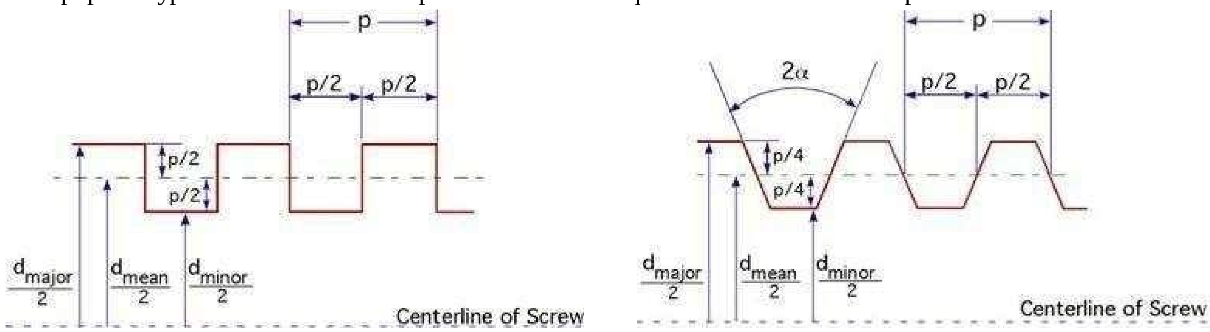
D. Forms of Threads

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



1) Advantages of Square Threads

The advantages of square threads over trapezoidal threads are as follows:

a) The efficiency of square threads is more than that of trapezoidal threads.

b) There is no radial pressure on the nut. Since there is no side thrust, the motion of the nut is uniform. The life of the nut is also increased.

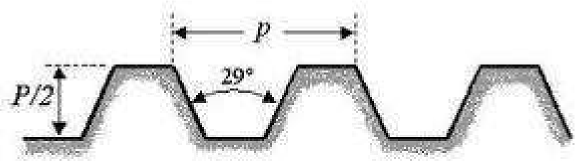
2) Advantages of Trapezoidal Threads

The advantages of trapezoidal threads over square threads are as follows:

a) Trapezoidal threads are manufactured on thread milling machine. It employs multi-point cutting tool. Machining with multi-point cutting tool is an economic operation compared to machining with single point-cutting tool. Therefore, trapezoidal threads are economical to manufacture.

b) Trapezoidal thread has more thickness at core diameter than that of square thread.Therfore; a screw with trapezoidal threads is stronger than equivalent screw with square threads. Such a screw has large load carrying capacity.

c) The axial wear on the surface of the trapezoidal threads can be compensated by means of a split-type of nut. The nut is cut into two parts along the diameter. As wear progresses, the looseness is prevented by tightening the two halves of the nut together, the split-type nut can be used only for trapezoidal threads. It is used in lead-screw of lathe to compensate wear at periodic intervals by tightening the two halves.



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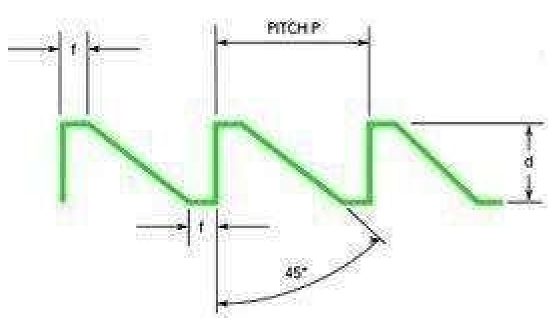
3) Advantages of Buttress Threads

The advantages of buttress threads are as follows:

a) It has higher efficiency compared to trapezoidal threads.

b) It can be economically manufactured on thread milling machine.



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c) The axial wear at the thread surface can be compared by means of spit-type nut.
d) A screw with buttress threads is stronger than equivalent screw with either square threads or trapezoidal threads. This is because of greater thickness at the base of the thread.

The buttress threads have one disadvantage. It can transmit power and motion only in one direction. On the other hand, square and trapezoidal threads can transmit force and motion in both directions.

E. 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

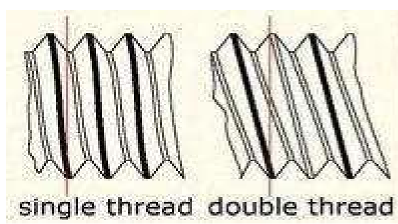
It indicates single-start square threads with 30mm nominal diameter and 6mm pitch.
Similarly single-start I.S.O metric trapezoidal threads are designated by letters „Tr‟ followed by the nominal diameter and the pitch expressed in millimeters and separated by the sign „x‟.For example,

Tr 40x7

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

1) Multiple Threaded Power Screws

Multiple threaded power screws are used in certain applications where higher travelling speed is required. 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 millimetres. For example,

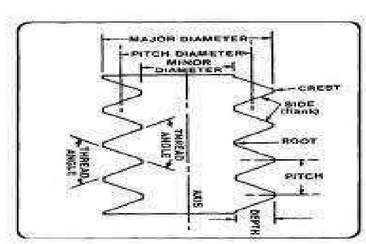
Tr 40 x 14 (P7)

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

F. Terminology of Power Screw

The terminology of the screw thread is as follows:



1) *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**‟. (ii) **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 singlethreaded screw, the lead is same as the pitch, for a double-threaded screw, the lead is twice that of the pitch, and so on.
2) *Nominal Diameter:* It is the largest diameter of the screw. It is also called major diameter. It is denoted by the letter„**d**‟.
3) *Core Diameter:* It is the smallest diameter of the screw thread. It is also called minor diameter. It is denoted by the letters „$\mathbf{d_c}$‟.
4) *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 α.

From the figure,

$$d_c = d- [p/2+p/2]$$

or

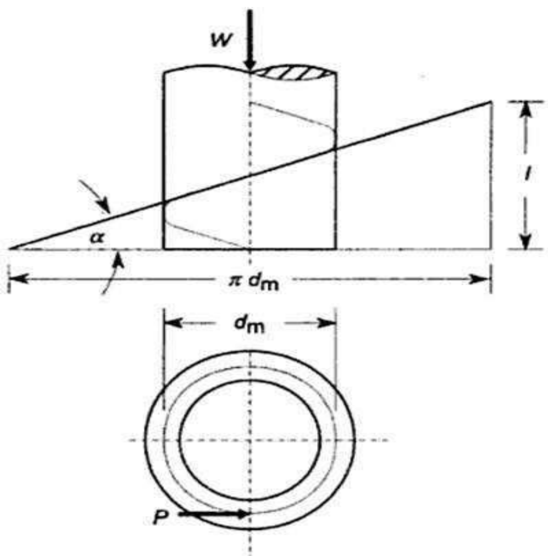
$$d_c= (d-p)$$

The mean diameter of the screw is denoted by d_m and it is given by,

$$d_m=1/2[d+d]$$

$$=1/2 [d + (d-p)]$$

Or, $d_m= (d-0.5p)$



Imagine that one thread of the screw is unwound and developed for one complete turn. The thread will become the hypotenuse of a right-angled triangle, whose base is ($\pi d_{m)}$ and whose height is the lead (l).Considering this right-angle triangle, the relationship between helix angle, mean diameter and lead can be expressed in the following form,

$$\text{Tan } \alpha = l/3.14d_m$$

where α is the helix angle of the thread.

The following conclusions can be drawn on the basis of the development of thread:
1) The screw can be considered as an inclined plane with α as inclination.
2) The load W always acts in vertically downward direction. When the load W is raised, it moves up the inclined plane. When the load W is lowered, it moves down the inclined plane.
3) The load W is raised or lowered by means of an imaginary force P acting at the mean radius of the screw. The force P multiplied by the mean radius ($d_m/2$) gives the torque required to raise or lower the load. Force P is perpendicular to load W.

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G. Torque Requirement- Lifting Load

The screw is considered as an inclined plane with inclination α.When the load is being raised, following forces act at a point on this inclined plane:

1) Load W: It always acts in vertically downward direction.
2) Normal reaction N: It acts perpendicular (normal) to the inclined plane.
3) *Frictional force μN*: Frictional force acts opposite to the motion. Since the load is moving up the inclined plane, frictional force acts along the inclined plane in downward direction.

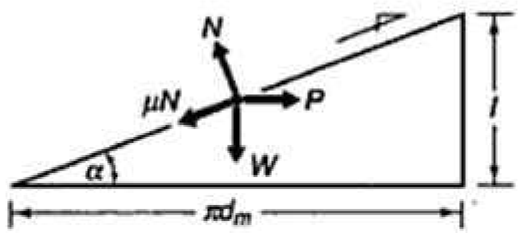

Fig.

4) Effort P: The effort P acts in a direction perpendicular to the load W.It may act towards right to overcome the friction and raise the load.

For an equilibrium of horizontal forces,

$$P = \mu N \cos\alpha + N \sin\alpha \quad \text{(a)}$$

For an equilibrium of vertical forces,

$$W = N \cos\alpha - \mu N \sin\alpha \quad \text{(b)}$$

Dividing expression (a) by (b),

$$P = W(\mu \cos\alpha + \sin\alpha) / (\cos\alpha - \mu \sin\alpha)$$

Dividing the numerator and denominator of the right hand side by cos α,

$$P = W(\mu + \tan\alpha)/(1 - \mu\tan\alpha) \quad \text{(c)}$$

The coefficient of friction μ is expressed as,

$$\mu = \tan \quad \text{(d)}$$ where is the friction angle.

Substituting μ = tan in θq. (c),
θ

$$P = \frac{W(\tan\theta + \tan\alpha)}{(1 - \tan\theta \tan\alpha)}$$

or $$P = W \tan(+ \alpha) \quad \theta \quad \text{(e)}$$

The torque „T" required to raise the load is given by,

$$T = \frac{P d_m}{2}$$

$$T = \text{tar}\, \frac{W d_m}{2} \quad \theta \quad \text{(f)}$$

H. Torque Requirement- Lowering Load

When the load is being lowered, the following forces act at a point on the inclined plane:

1) Load W: It always acts in vertically downward direction.
2) Normal reaction N: It acts perpendicular (normal) to the inclined plane.
3) *Frictional force μN*: Frictional force acts opposite to the motion. Since the load is moving down the inclined plane, frictional force acts along the inclined plane in upward direction.

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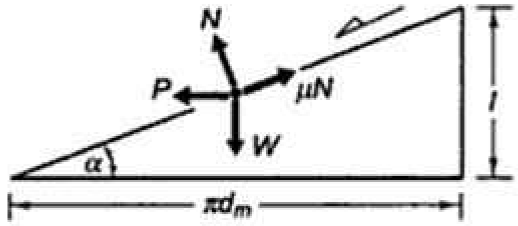

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4) Effort P: The effort P acts in a direction perpendicular to the load W.It should act towards left to overcome the friction and lower the load.

For an equilibrium of horizontal forces,

$$P = \mu N \cos \alpha - N \sin \alpha \qquad \text{(a)}$$

For an equilibrium of vertical forces,

$$W = N \cos \alpha + \mu N \sin \alpha \qquad \text{(b)}$$

Dividing expression (a) by (b),

$$P = \frac{W\,(\mu \cos \alpha - \sin \alpha)}{(\cos \alpha + \mu \sin \alpha)}$$

Dividing the numerator and denominator of the right hand side by cos α,

$$P = \frac{W(\mu - \tan \alpha)}{(1 + \mu \tan \alpha)} \qquad \text{(c)}$$

The coefficient of friction μ is expressed as,

$\mu = \tan \theta$ (d) where is the friction angle.

Substituting μ = tan θ in Eq. (c),

$$P = \frac{W(\tan \theta - \tan \alpha)}{(1 + \tan \theta \tan \alpha)}$$

or $P = W \tan(\theta - \alpha)$ (e)

The torque „T" required to raise the load is given by,

$$T = \frac{P d_m}{2}$$

$$T = \tan \frac{W d_m}{2} \theta$$

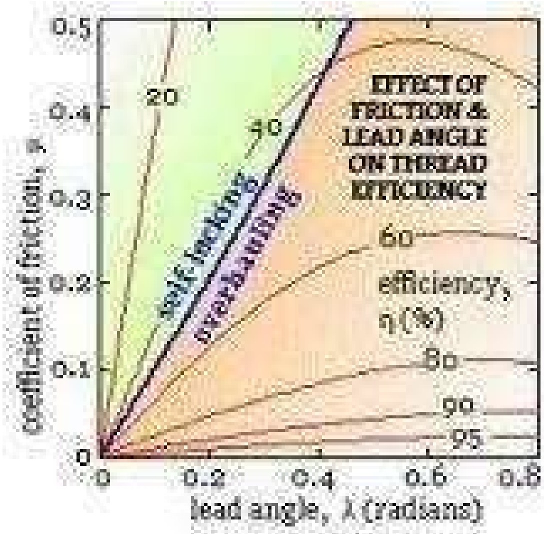
I. Self-Locking Screw

The torque required to lower the load can be given by,

$$T = \frac{W d_m}{2} - \alpha) \; \theta$$

It can be seen that when,

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,

θ

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 ids equal to or greater than the tangent of the helix angle.

For self locking screw,

θ > α tan > tan α

Therefore, the following conclusions can be made:

(i) θ Self-locking of screw is not possible when the coefficient of friction (μ) 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.

(ii) 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 screw from selflocking considerations.

J. Stresses in Screw and Nut

The body of a screw is subjected to an axial force W and torsional moment (T).The direct compressive stress F_c is given by,

$$F_c = \frac{W}{(\frac{\pi}{4}d_c^2)}$$

The torsional shear stress

$$F_t = \frac{16T}{\pi d_c^3}$$

The principal shear stress is given by,

$$F_s = \sqrt{F_c^2 + 4F_t^2}$$

The threads of the screw which are engaged with the nut are subjected to transverse shear stresses. The screw will tend to shear off the threads at the core diameter under the action of load W.The shear area of one thread is $\pi d_c t$. The transverse shear stress in the screw is given by,

$$T_s = \frac{W}{\pi d_c\, t\, n}$$

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Where,
T_s = transverse shear stress at the root of the screw (N/mm²) t = thread thickness at the core diameter (mm) n = number of threads in engagement with the nut.
The transverse shear stresses in the nut are determined in a similar way. Under the action of load W, the thread of the nut will tend to shear off at the nominal diameter. The shear area of one thread is πdt.Therefore,

$$T_n = \frac{W}{\pi d t n}$$

where,
T_n = transverse shear stress at the root of the nut (N/mm²)
t = thread thickness at the root of the nut (mm).
The bearing pressure between the contacting surfaces of the screw and the nut is an important consideration in design. The bearing area between the screw and the nut for one thread is

[$\frac{\pi}{4}(d^2 - d_c^2)$ refore,

$$P_b = \frac{W}{[\frac{\pi}{4}(d^2 - d_c^2)n]}$$

where P_b = unit bearing pressure(N/mm²)
The permissible bearing pressure depends upon the materials of the screw and the nut and the rubbing velocity.

K. Buckling of Columns

When a short member is subjected to axial compressive force, it shortens according to the Hooke‟s law. As the load is gradually increased, the compression of the member increases.
When the compressive stress reaches the elastic limit of the material, the failure occurs in the form of bulging.However, when the length of the component is large compared to the crosssectional dimensions, the component may fail by lateral buckling. Buckling indicates elastic instability. The load at which the buckling starts is called critical load, which is denoted by $P_{cr.}$ When the axial load on the column reaches P_{cr}, there is sudden buckling and a relatively large lateral deflection occurs. An important parameter affecting the critical load is the slenderness ratio. It is defined as,
Slenderness ratio = l/k

where,
l = length of column (mm)
k = least radius of gyration of the cross-section about its axis (mm) The radius of gyration is given by,

$$k = \sqrt{\frac{I}{A}}$$

where,
I = least moment of inertia of the cross-section (mm^4)
A = area of the cross-section (mm^2)
When the slenderness ratio is less than 30, there is no effect of buckling and such components are designed on the basis of compressive stresses. Columns, with slenderness ratio greater than 30 are designed on the basis of critical load. There are two methods to calculate the critical load- Euler‟s equation and Johnson‟s equation.
According to the Euler‟s equation,

$$P_{cr} = \frac{n\pi^2 EA}{(\frac{l}{k})^2}$$

where,
P_{cr} = critical load (N).
n = end fixity coefficient
E = modulus of elasticity (N/mm^2)
A = area of cross-section (mm^2)

The load carrying capacity of the column depends upon the condition of restraints at the two ends of the column. It is accounted by means of a dimensionless quantity called end fixity coefficient (n).
According to Johnson"s equation,

$$P_{cr} = S_{yt} A \left[1 - \frac{S_{yt}}{4n\pi^2 E} x \left(\frac{l}{k}\right)^2\right.$$

where S_{yt} is the yield strength of the material.

III. MECHANICAL JACKS

A mechanical jack is a device which lifts heavy equipment. The most common form is a car jack, floor jack or garage jack which lifts vehicles so that maintenance can be performed. Car jacks usually use mechanical advantage to allow a human to lift a vehicle by manual force alone. More powerful jacks use hydraulic power to provide more lift over greater distances. Mechanical jacks are usually rated for maximum lifting capacity. There are two types of mechanical jacks:

A. Scissor Jacks

- Scissors jacks are also mechanical and have been in use at least since the 1930s.
- A scissor jack is a device constructed with a cross-hatch mechanism, much like a scissor, to lift up a vehicle for repair or storage. It typically works in just 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 drive large loads 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.
- 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.

B. 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.

C. Design and Lift

A scissor jack uses a simple theory of gears 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 you were to put pressure directly on the crank, or lean your weight against the crank, the person would not be able to turn it, even though your weight is a small percentage of the cars.

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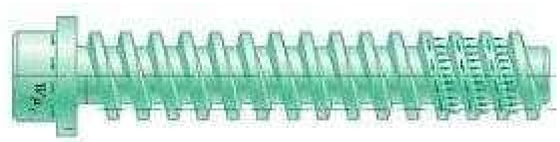
1) Step I Problem Specification

It is required to design a screw jack for supporting the machine parts during their repair and maintenance. It should be a general purpose jack with a load carrying capacity of 50KN and a maximum lifting height of 0.3m. The jack is to be operated by means of a D.C motor.

2) Step II Selection of Materials

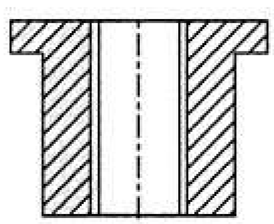
(i) The frame of the screw jack has complex shape. It is subjected to compressive stress. Grey cast iron is selected as the material for the frame. Cast iron is cheap and it can be given any complex shape without involving costly machining operations. Cast iron has higher compressive strength compared with steel. Therefore, it is technically and economically advantageous to use cast iron for the frame.

(ii) The screw is subjected to torsional moment, compressive force and bending moment.
From strength consideration, EN8 is selected as material for screw.



Screw

(iii) There is a relative motion between the screw and the nut, which results in friction. The friction causes wear at the contacting surfaces. When the same material is used for these two components, the surfaces of both components get worn out, requiring replacement. This is undesirable. The size and shape of the screw make it costly compared with the nut. The material used for the nut is stainless steel.



Nut

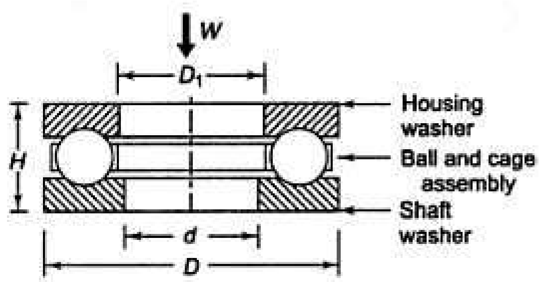
3) Step III Design of Screw

The screw jack is an intermittently used device and wear of threads is not an important consideration. Therefore, instead of trapezoidal threads, the screw is provided with square threads. Square threads have higher efficiency and provision can be made for self-locking arrangement. When the condition of self-locking is fulfilled, the load itself will not turn the screw and descend down, unless an effort in the reverse direction is applied.

D. Thrust Bearings

Thrust ball bearings are used to replace the sliding force with rolling friction. The friction torque is so small, that it can be neglected. Thrust ball bearing is suitable for a purely axial load. It is a single-direction thrust ball bearing, because it can support axial load in one direction only, i.e., vertically downward. This ball bearing should not be subjected to radial load.

Single-direction thrust ball bearings are separable and the mounting is simple as the components can be mounted individually. There are three separable parts of this bearing known as shaft washer, a housing washer and the ball and cage assembly. The mounting of thrust bearing I shown in the figure below



Thrust Bearing

The inner diameter of the shaft washer is press fitted in the screw body. The outer diameter of the housing washer is press fitted in the cup. These two components are separately mounted before final assembly. The life of thrust bearing is assumed to be 3000 hours.

E. Operational Considerations of a screw jack

1) 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.
2) Maintain low surface speed: Increasing the screw head will reduce the surface speed for the same linear speed.
3) 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.
4) 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.
5) 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.

IV. MOTORIZED SCREW JACK

Our survey in the regard in several automobile garages, revealed the facts that mostly some difficult methods were adopted in lifting the vehicles for reconditioning.

Now the project has mainly concentrated on this difficulty, and hence a suitable device has been designed, such that the vehicle can be lifted from the floor land without application of any impact force.

The fabrication part of it has been considered with almost case for its simplicity and economy, such that this can be accommodated as one of the essential tools on automobile garages.

A. Introduction

The motorized screw jack has been developed to cater to the needs of small and medium automobile garages, which are normally man powered with minimum skilled labor. In most of the garages the vehicles are lifted by using screw jack. This needs high man power and skilled labour.

In order to avoid all such disadvantages, the motorized jack has been designed in such a way that it can be used to lift the vehicle very smoothly without any impact force. The operation is made simple so that even unskilled labour can use it with ease.

The d.c motor is coupled with the screw jack by gear arrangement. The screw jack shaft‟s rotation depends upon the rotation of D.C motor. This is a simple type of automation project.

This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains to be an essential part of the system although with changing demands on physical input, the degree of mechanization is increased.

Degrees of automation are of two types, viz.

- Full automation.
- Semi automation.

In semi automation a combination of manual effort and mechanical power is required whereas in full automation human participation is very negligible.

B. Need for Automation

Automation can be achieved through computers, hydraulics, pneumatics, robotics, etc. Automation plays an important role in mass production.

For mass production of the product, the machining operations decide the sequence of machining. The machines designed for producing a particular product are called transfer machines. The components must be moved automatically from the bins to various machines sequentially and the final component can be placed separately for packaging. Materials can also be repeatedly transferred from the moving conveyors to the work place and vice versa.

Nowadays, almost all the manufacturing processes are being atomized in order to deliver the products at a faster rate. The manufacturing operation is being atomized for the following reasons:

1) To achieve mass production
2) To reduce man power
3) To increase the efficiency of the plant
4) To reduce the work load
5) To reduce the production cost
6) To reduce the production time
7) To reduce the material handling
8) To reduce the fatigue of workers
9) To achieve good product quality
10) Less Maintenance

C. Parts of Motorized Screw Jack

The main parts of the motorized screw jack are as follows:

1) D.c. motor (permanent magnet)

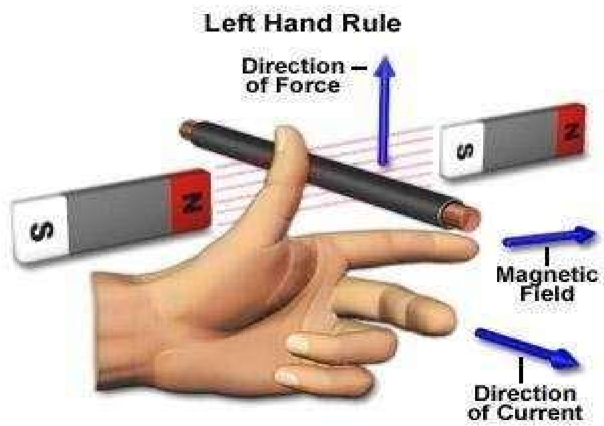
a) Description of dc motor

An electric motor is a machine which converts electrical energy to mechanical energy. Its action is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a magnetic force whose direction is given by Fleming‟s left hand rule.

When a motor is in operation, it develops torque. This torque can produce mechanical rotation. DC motors are also like generators classified into shunt wound or series wound or compound wound motors.

b) Fleming's Left Hand Rule

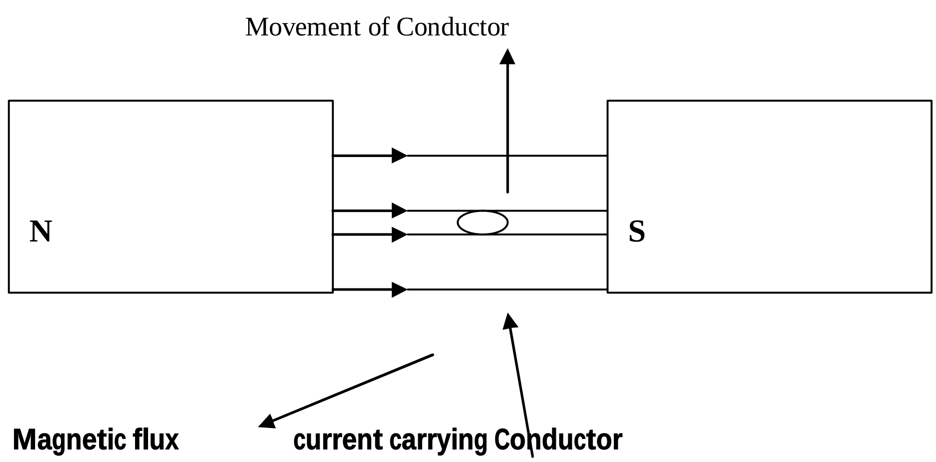
Keep the force finger, middle finger and thumb of the left hand mutually perpendicular to one another. If the fore finger indicates the direction of magnetic field and middle finger indicates direction of current in the conductor, then the thumb indicates the direction of the motion of conductor.



c) Principle of Operation of Dc Motor

A uniform magnetic field in which a straight conductor carrying no current is placed. The conductor is perpendicular to the direction of the magnetic field.

The conductor is shown as carrying a current away from the viewer, but the field due to the N and S poles has been removed. There is no movement of the conductor during the above two conditions. When the current carrying conductor is placed in the magnetic field, the field due to the current in the conductor supports the main field above the conductor, but opposes the main field below the conductor.

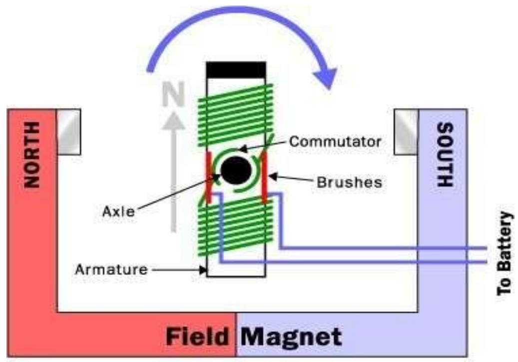


The result is to increase the flux density in to the region directly above the conductor and to reduce the flux density in the region directly below the conductor. It is found that a force acts on the conductor, trying to push the conductor downwards as shown by the arrow. If the current in the conductor is reversed, the strengthening of flux lines occurs below the conductor, and the conductor will be pushed upwards.

Now consider a single turn coil carrying a current. In view of the reasons given above, thone side of the coil will be forced to move downwards, whereas the other side will be forced to move upwards. The forces acting on both the coil sides will be of same magnitude. But their direction is opposite to one another. As the coil is wound on the armature core which is supported by the bearings, the armature will now rotate. The commutator periodically reverses the direction of current flow through the armature. Therefore the armature will have a continuous rotation.

A simplified model of such a motor is shown in figure VI. The conductors are wound over a soft iron core. DC supply is given to the field poles for producing flux. The conductors are connected to the DC supply through brushes

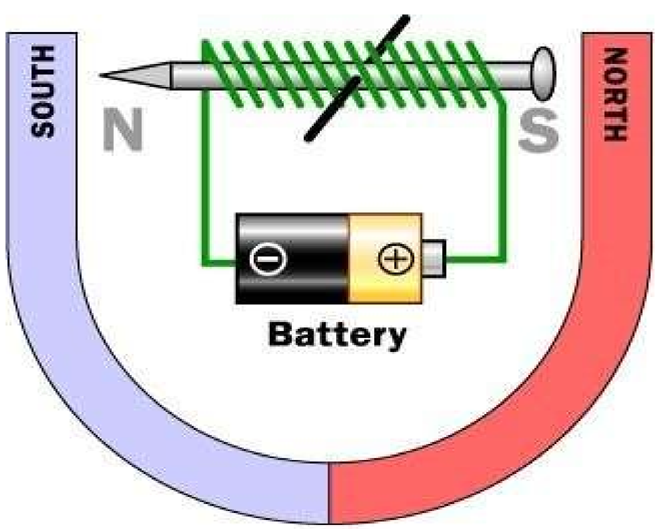
A simple 2-pole DC electric motor has 6 parts, as shown in the diagram below.
- An armature or rotor
- A commutator
- Brushes
- An axle
- A field magnet
- A DC power supply of some sort



An electric motor is all about magnets and magnetism: a motor uses magnets to create motion. Opposites attract and likes repel. So if there are 2 bar magnets with their ends marked north and south, then the North end of one magnet will attract the South end of the other. On the other hand, the North end of one magnet will repel the North end of the other (and similarly south will repel south). Inside an electric motor these attracting and repelling forces create rotational motion.
In the diagram above, you can see two magnets in the motor, the armature (or rotor) is an electromagnet, while the field magnet is a permanent magnet (the field magnet could be an electromagnet as well, but in most small motors it is not to save power).

d) Electromagnets and Motors

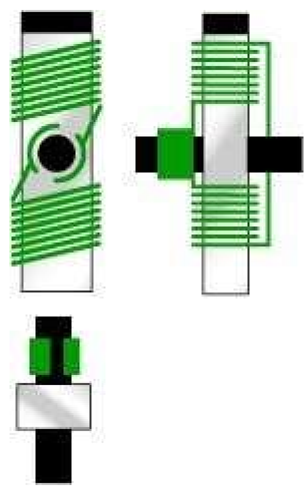
An electromagnet is the basis of an electric motor. You can understand how things work in the motor by imagining the following scenario. Say that you created a simple electromagnet by wrapping 100 loops of wire around a nail and connecting it to a battery. The nail would become a magnet and have a North and South pole while the battery is connected.
Now say that you take your nail electromagnet, run an axle through the middle of it, and you suspended it in the middle of a horseshoe magnet as shown in the figure below. If you were to attach a battery to the electromagnet so that the North end of the nail appeared as shown, the basic law of magnetism tells you what would happen: The North end of the electromagnet would be repelled from the north end of the horseshoe magnet and attracted to the south end of the horseshoe magnet.



The South end of the electromagnet would be repelled in a similar way. The nail would move about half a turn and then stop in the position shown. You can see that this half-turn of motion is simple and obvious because of the way magnets naturally attract and repel one another. The key to an electric motor is to then go one step further so that, at the moment that this half-turn of motion completes, the field of the electromagnet flips. The flip causes the electromagnet to complete another half-turn of motion. You flip the magnetic field simply by changing the direction of the electrons flowing in the wire (you do that by flipping the battery over). If the field of the electromagnet flipped at just the right moment at the end of each half-turn of motion, the electric motor would spin freely.

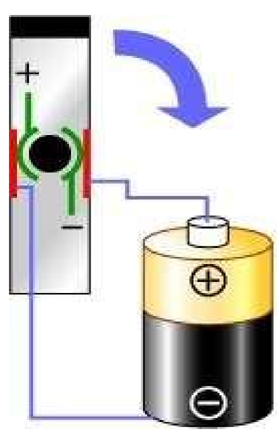
e) *The Armature*

The armature takes the place of the nail in an electric motor. The armature is an electromagnet made by coiling thin wire around two or more poles of a metal core. The armature has an axle, and the commutator is attached to the axle. In the diagram above you can see three different views of the same armature: front, side and end-on. In the end-on view the winding is eliminated to make the commutator more obvious. The commutator is simply a pair of plates attached to the axle. These plates provide the two connections for the coil of the electromagnet.



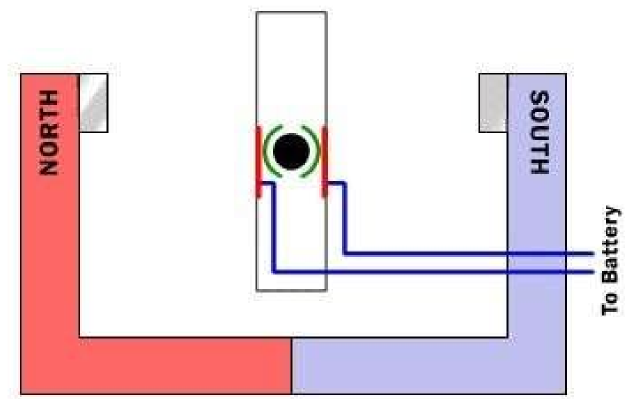
f) *The Commutator and Brushes*

The "flipping the electric field" part of an electric motor is accomplished by two parts: the commutator and the brushes. The diagram at the right shows how the commutator and brushes work together to let current flow to the electromagnet, and also to flip the direction that the electrons are flowing at just the right moment. The contacts of the commutator are attached to the axle of the electromagnet, so they spin with the magnet. The brushes are just two pieces of springy metal or carbon that make contact with the contacts of the commutator.



g) Putting It All Together

When you put all of these parts together, what you have is a complete electric motor:



In this figure, the armature winding has been left out so that it is easier to see the commutator in action. The key thing to notice is that as the armature passes through the horizontal position, the poles of the electromagnet flip. Because of the flip, the North pole of the electromagnet is always above the axle so it can repel the field magnet's North pole and attract the field magnet's South pole. If you ever take apart an electric motor you will find that it contains the same pieces described above: two small permanent magnets, a commutator, two brushes and an electromagnet made by winding wire around a piece of metal. Almost always, however, the rotor will have three poles rather than the two poles as shown in this article. There are two good reasons for a motor to have three poles:

- It causes the motor to have better dynamics. In a two-pole motor, if the electromagnet is at the balance point, perfectly horizontal between the two poles of the field magnet when the motor starts; you can imagine the armature getting "stuck" there. That never happens in a three-pole motor.
- Each time the commutator hits the point where it flips the field in a two-pole motor, the commutator shorts out the battery (directly connects the positive and negative terminals) for a moment. This shorting wastes energy and drains the battery needlessly. A three-pole motor solves this problem as well.
- It is possible to have any number of poles, depending on the size of the motor and the specific application it is being used in.

h) Design of D.C. motor

Torque in a motor

By the term torque, it is meant the turning or twisting moment of a force about an axis. It is measured by the product of the force and the radius at which this force acts.

For an armature of a motor, to rotate about its centre, a tangential force is necessary. This force is developed within the motor itself.

$$\text{Torque (T)} = \tfrac{1}{2}\,(Ia / A)\ BDC\ Z \text{ Newton meters}$$

Using the relation,

$$B = \varphi / a$$
$$= \varphi / (\Pi D / P)\,ł$$
$$= \varphi \times P / (\Pi Dł)$$

$$T = \tfrac{1}{2} \times (Ia / A) \times Z \times \varphi \times \{P/ (\Pi Dł)\} \times Dł$$
$$= \varphi\, Z\, P\, Ia / (2\Pi A) \text{ Newton meters}$$
$$= 0.1\eta 9 \times \varphi \times Z \times Ia \times (P/A) \text{ Newton meters}$$
$$= 0.1\theta 2 \times \varphi \times Z \times Ia \times (P/A) \text{ Kg-m}$$

The torque given by the above equation is the developed torque in the machine. But the output torque is less than the developed torque due to friction and windage losses.

2) Batteries

a) Introduction

In isolated systems away from the grid, batteries are used for storage of excess solar energy which can be converted into electrical energy. In fact for small units with output less than one kilowatt, batteries seem to be the only technically and economically available storage means. Since both the photo-voltaic system and batteries are high in capital costs, it is necessary that the overall system be optimized with respect to available energy and local demand pattern.

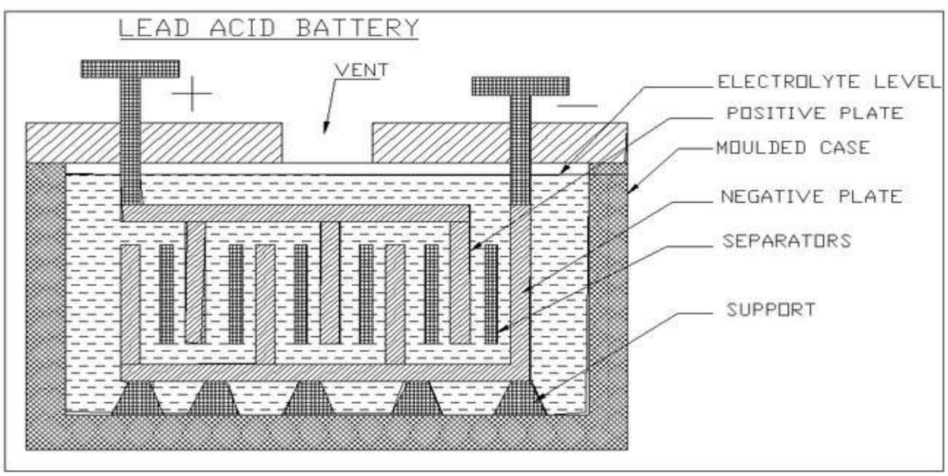
To be economically attractive the storage of solar electricity requires a battery with a particular combination of properties:

(1) Low cost
(2) Long life
(3) High reliability
(4) High overall efficiency
(5) Low discharge
(6) (Minimum maintenance
  (A) Ampere hour efficiency
  (B) Watt hour efficiency

b) Lead-acid Wet Cell

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A. One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery.

The lead acid cell type is a secondary cell or storage cell, which can be recharged. The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents shortens the useful life to about 3 to 5 years for an automobile battery. Of the different types of secondary cells, the lead-acid type has the highest output voltage, which allows fewer cells for a specified battery voltage.



c) Construction

Inside a lead-acid battery, the positive and negative electrodes consist of a group of plates welded to a connecting strap. The plates are immersed in the electrolyte, consisting of 8 parts of water to 3 parts of concentrated sulfuric acid. Each plate is a grid or framework, made of a leadantimony alloy. This construction enables the active material, which is lead oxide, to be pasted into the grid. In manufacture of the cell, a forming charge produces the positive and negative electrodes. In the forming process, the active material in the positive plate is changed to lead peroxide (pbo_2). The negative electrode is spongy lead (pb).

Automobile batteries are usually shipped dry from the manufacturer. The electrolyte is put in at the time of installation, and then the battery is charged.With maintenance-free batteries, little or no water is needed to be added in normal service. Some types are sealed, except for a pressure vent, without provision for adding water.

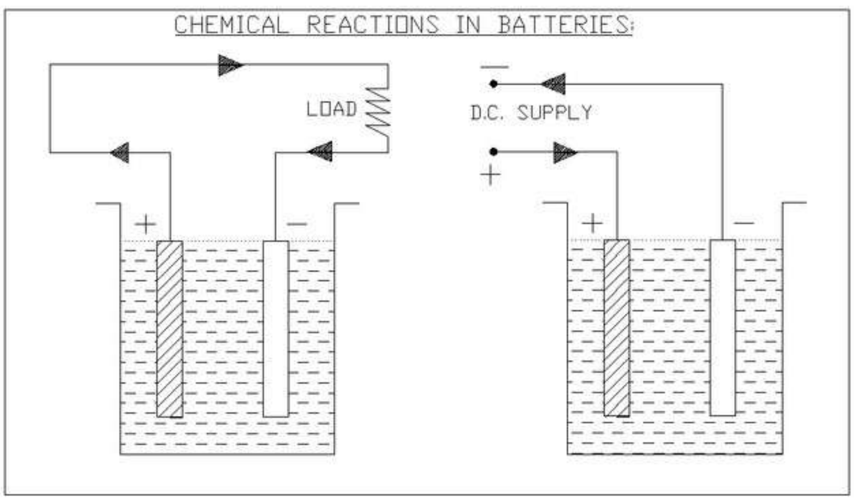
d) Chemical Action

Sulfuric acid is a combination of hydrogen and sulfate ions. When the cell discharges, lead peroxide from the positive electrode combines with hydrogen ions to form water and with sulfate ions to form lead sulfate. Combining lead on the negative plate with sulfate ions also produces sulfate. Therefore, the net result of discharge is to produce more water, which dilutes the electrolyte, and to form lead sulfate on the plates.

As the discharge continues, the sulfate fills the pores of the grids, retarding circulation of acid in the active material. Lead sulfate is the powder often seen on the outside terminals of old batteries. When the combination of weak electrolyte and sulfating on the plate lowers the output of the battery, charging is necessary.

On charge, the external D.C. source reverses the current in the battery. The reversed direction of flow of ions in the electrolyte results in a reversal of the chemical reactions. Now the lead sulfates on the positive plate reacts with the water and sulfate ions to produce lead peroxide and sulfuric acid. This action re-forms the positive plates and makes the electrolyte stronger by adding sulfuric acid.

At the same time, charging enables the lead sulfate on the negative plate to react with hydrogen ions; this also forms sulfuric acid while reforming lead on the negative plate to react with hydrogen ions. It also results in formation of current which can restore the cell to full output, with lead peroxide on the positive plates, spongy lead on the negative plate, and the required concentration of sulfuric acid in the electrolyte.



The chemical equation for the lead-acid cell is

$$Pb + pbO_2 + 2H_2SO_4 \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} 2pbSO_4 + 2H_2O$$

On discharge, the pb and pbo_2 combine with the SO_4 ions at the left side of the equation to formlead sulfate ($pbSO_4$) and water (H_2O) at the right side of the equation.

One battery consists of 6 cells, each having an output voltage of 2.1V, which are connected in series to get a voltage of 12V and the same 12V battery is connected in series, to get an 24 V battery. They are placed in the water proof iron casing box.

e) Current Ratings

Lead-acid batteries are generally rated in terms of how much discharge currents they can supply for a specified period of time; the output voltage must be maintained above a minimum level, which is 1.5 to 1.8V per cell. A common rating is ampere-hours (A.h.) based on a specific discharge time. Typical values for automobile batteries are 100 to 300 A.h.

As an example, a 200 A.h battery can supply a load current of 200/8 or 25A, used on 8h discharge. The battery can supply less current for a longer time or more current for a shorter time. Automobile batteries may be rated for “cold cranking power”, which is related to the job of starting the engine. A typical rating is 450A for 30s at a temperature of 0 degree F.

The ratings for lead-acid batteries are given for a temperature range of 77 to 80ºF. Higher temperature increases the chemical reaction, but operation above 110ºF shortens the battery life.

Low temperatures reduce the current capacity and voltage output. The ampere-hour capacity is reduced approximately 0.75% for each decreases of 1º F below normal temperature rating. At 0ºF the available output is only 60 % of the ampere-hour battery rating. In cold weather, therefore, it is very important to have an automobile battery unto full charge. In addition, the electrolyte freezes more easily when diluted by water in the discharged condition.

f) Specific Gravity

Measuring the specific gravity of the electrolyte generally checks the state of discharge for a lead-acid cell. For instance, concentrated sulfuric acid is 1.835 times as heavy as water for the same volume. Therefore, its specific gravity equals 1.835. The specific gravity of water is 1, since it is the reference. In a fully charged automotive cell, mixture of sulfuric acid and water results in a specific gravity of 1.280 at room temperatures of 70 to 80ºF. As the cell discharges, more water is formed, lowering the specific gravity. When it is down to about 1.150, the cell is completely discharged.

Specific-gravity readings are taken with a battery hydrometer.Note that the calibrated float with the specific gravity marks will rest higher in an electrolyte of higher specific gravity.

The importance of the specific gravity can be seen from the fact that the open-circuit voltage of the lead-acid cell is approximately equal to

V = Specific gravity + 0.84

For the specific gravity of 1.280, the voltage is 1.280 = 0.84 = 2.12V, as an example. These values are for a fully charged battery.

g) Charging the Lead-Acid Battery

An external D.C. voltage source is necessary to produce current in one direction. Also, the charging voltage must be more than the battery e.m.f. Approximately 2.5 per cell are enough to produce current opposite to the direction of discharge current.

Note that the reversal of current is obtained just by connecting the battery VB and charging source VG with + to + and –to. The charging current is reversed because the battery effectively becomes a load resistance for VG when it higher than VB. In this example, the net voltage available to produce charging currents is 15-12=3V.

A commercial charger for automobile batteries is essentially a D.C. power supply, rectifying input from the AC power line to provide D.C. output for charging batteries. Float charging refers to a method in which the charger and the battery are always connected to each other for supplying current to the load. In figure the charger provides current for the load and the current necessary to keep the battery fully charged. The battery here is an auxiliary source for D.C. power. It may be of interest to note that an automobile battery is in a floating-charge circuit. The battery charger is an AC generator or alternator with rectifier diodes, driven by a belt from the engine.When you start the car, the battery supplies the cranking power. Once the engine is running, the alternator charges the battery. It is not necessary for the car to be moving. A voltage regulator is used in this system to maintain the output at approximately 13 to 15 V.It is a good idea to equalize charge when some cells show a variation of 0.05 specific gravity from each other. With proper care, lead-acid batteries will have a long service life and work very well in almost any power system.

D. Working Principle

The lead-acid battery is used to drive the d.c motor. The d.c motor shaft is connected to the spur gear. If power is given to the D.c motor, it will run so that the spur gear also runs to slow down the speed of the D.C motor. The screw jack moves the screw upward, so that the vehicle lifts from ground. The vehicle is lifted by using the lifting platform at the top of the screw jack. The motor draws power supply from the battery. The lifting and uplifting is done by changing the battery supply to the motor.

E. Advantages

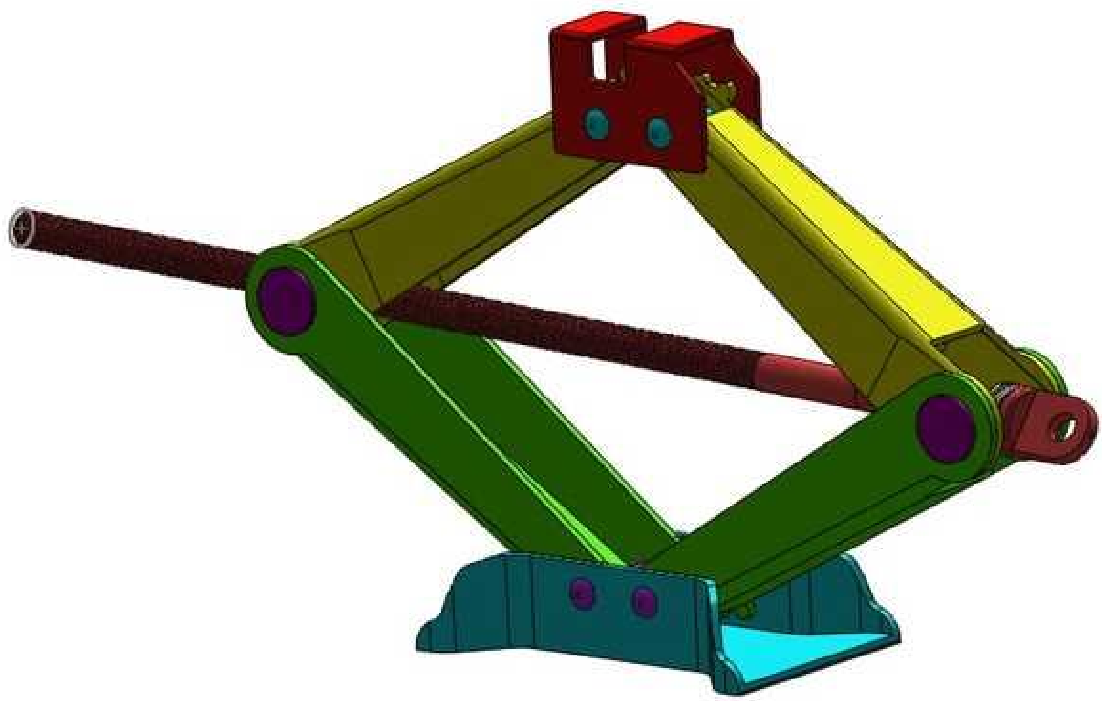
1) The loaded light vehicles can be easily lifted.
2) Checking and cleaning are easy, because the main parts are screwed.
3) Handling is easy
4) No Manual power required.
5) Easy to Repair.
6) Replacement of parts are easy

F. Disadvantages
1) Cost of the equipment is high when compared to ordinary hand jack.
2) Care must be taken for the handling the equipment such as proper wiring connection, battery charging checkup, etc.

G. Applications
1) It is useful in auto-garages.
2) This motorized screw jack is used for lifting the vehicles. Thus it can be useful for the following types of vehicles in future;
3) Maruti, Ambassador, Fiat, Mahindra

V. DESIGN CALCULATIONS

A. Scissor Jack Design



B. Background
The design approach for this project was to select a vehicle, select a material, design the arms, design the bracket, design the brace, design the power screw, and design the input crank.

C. Design Process
The Its mass and ground clearance have been given by Toyota. A maximum height for the jack was also predefined.
The material selected for this design was AISI 1020 Hot Rolled Steel. The jack is designed for use in emergency situations. Jacks for vehicles are not used daily. Therefore, stainless steel was not chosen. Instead, 1020 steel was chosen due to its availability. The tensile yield strength and the ultimate tensile strength can be obtained.

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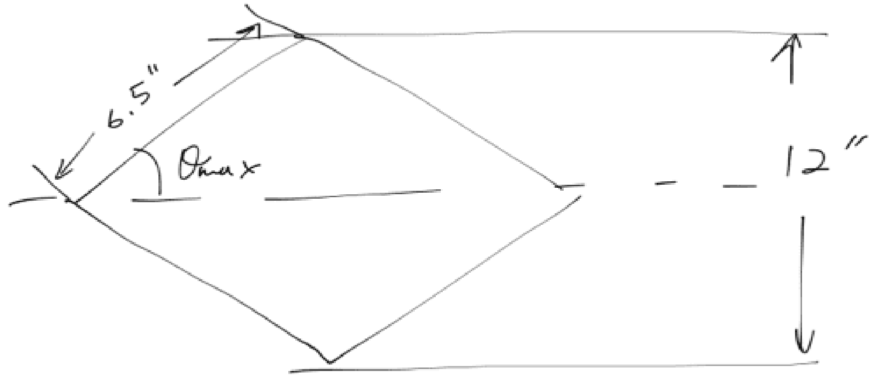
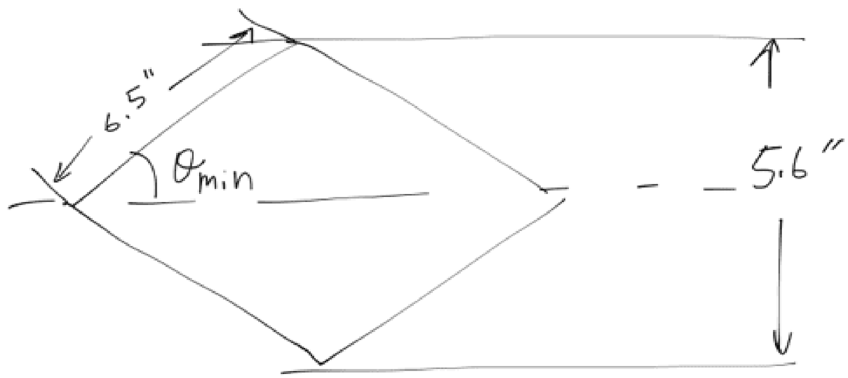
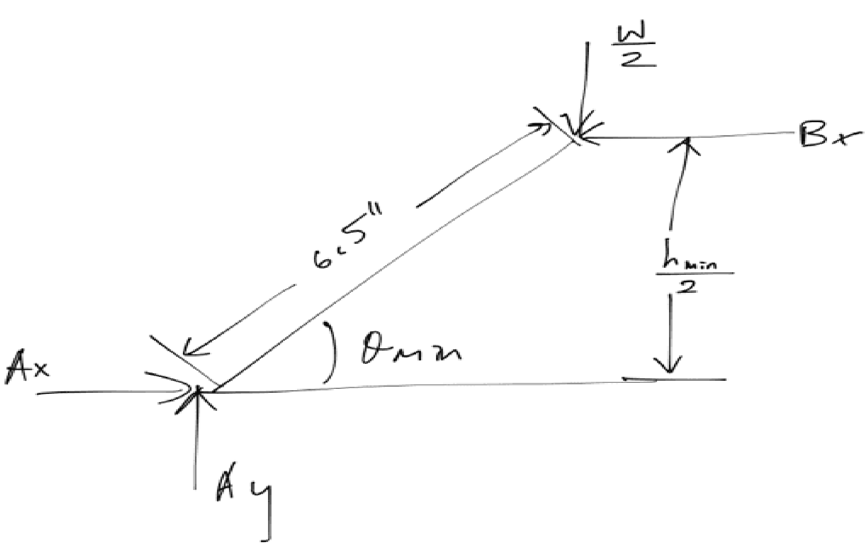
When designing the upper and lower arm/link, it is important to note that the maximum force occurs at the minimum angle and minimum height. The design approach for the arms of the scissor jack was to design the lower arm first. Because the upper arm would be slightly wider in width compared to the lower arm, it would be stronger than the lower arm. Thus, the larger dimensions have accounted for the forces it would withstand.



The length of the arm was set to 6.5 inches, where θmax and θmin represent the maximum and minimal angles. The maximum and minimal angles can be obtained.



The design must be focused on the minimum angle. If a force, F, were applied along each member of the link/arm, then the vertical load, L, would equal to $2Fsin\theta = L$. As θ decreases, the vertical load, L, increases.
The following figure studies one link and shows the free body diagram of the arm.



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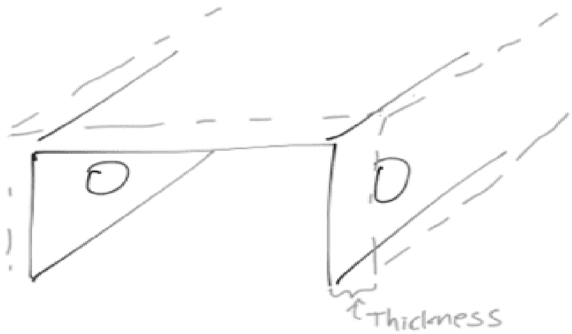
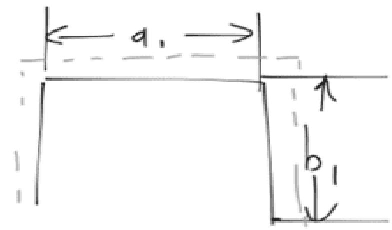
Volume 11 Issue V May 2023- Available at www.ijraset.com

Analyzing with static equilibrium, Ax, Ay, and Bx can be found.
Dimensions and sizing can be determined. The figure below shows the dimensions required to be solved. As stated earlier, thicknesses are placed on the outside for CAD purposes. Thickness is highlighted below with grey lines.





The holes for the pins located in this arm must be accounted for when designing for stress. This is a Box-Channel design with holes. The maximum stress will be accounted for with the appropriate stress-concentration factor. Knowing this information, iterations are performed to solve for the dimensions of the lower arm using this derived equation:

$$0 = \frac{S_y}{k_t FS_{arm}} - \frac{\sqrt{B_x^2 + \left(\frac{W}{2}\right)^2}}{2b_1 t_{arm} + a_1 t_{arm} + 2t_{arm}^2}$$

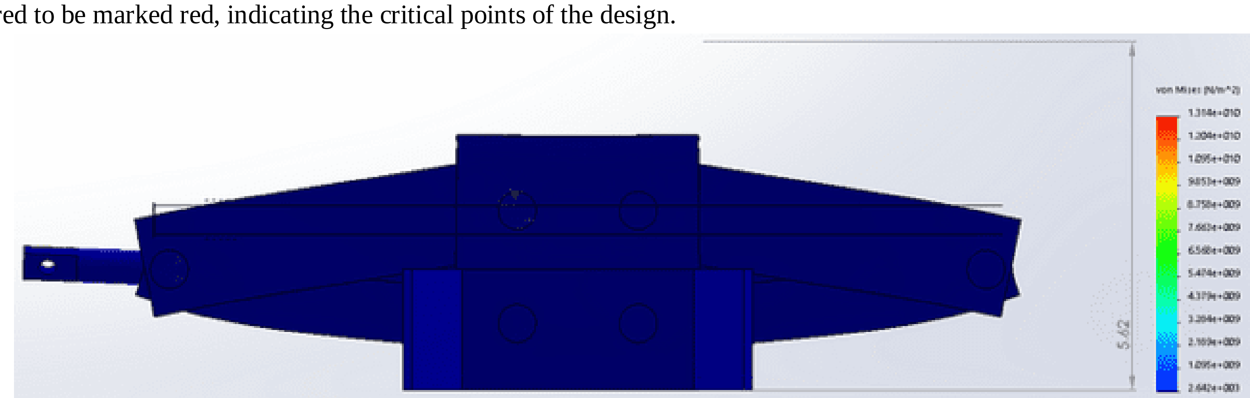
The dimensions of the upper arm are calculated similarly to the lower arm. The dimensions of the pins, top and bottom plate, power screw, locking nut, and input crank are obtained using the same logic.

D. Testing and Evaluation

Tests were performed at minimum height (5.6 inches) and maximum height (12 inches). Note that the input crank handle was excluded from the FEA analysis.

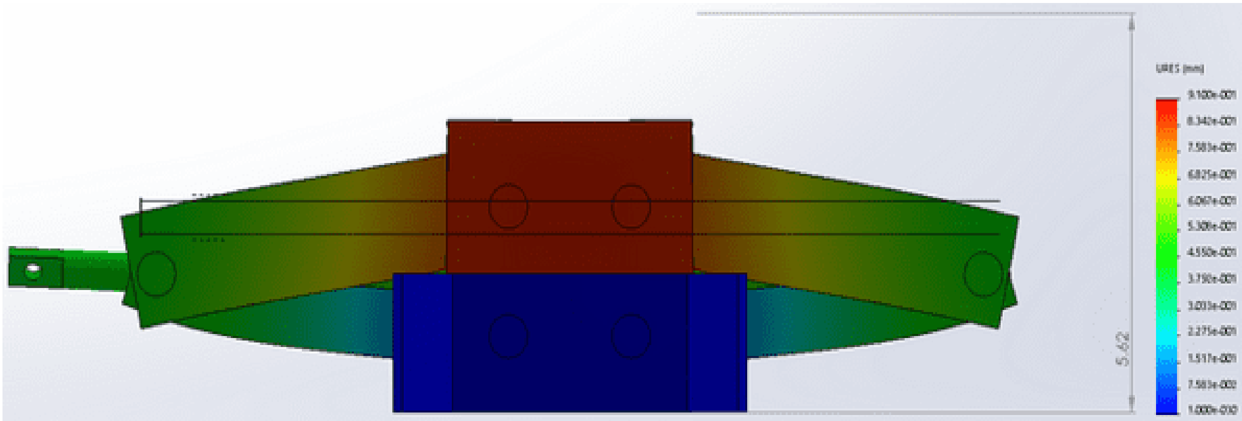
E. Compression

The figures below show the compression FEA tests. The value of the weight was the load. The load was placed on the top plate facing downward while the bottom plate was fixed. For the stress analysis, majority of the analysis was in the blue. The pins appeared to be marked red, indicating the critical points of the design.



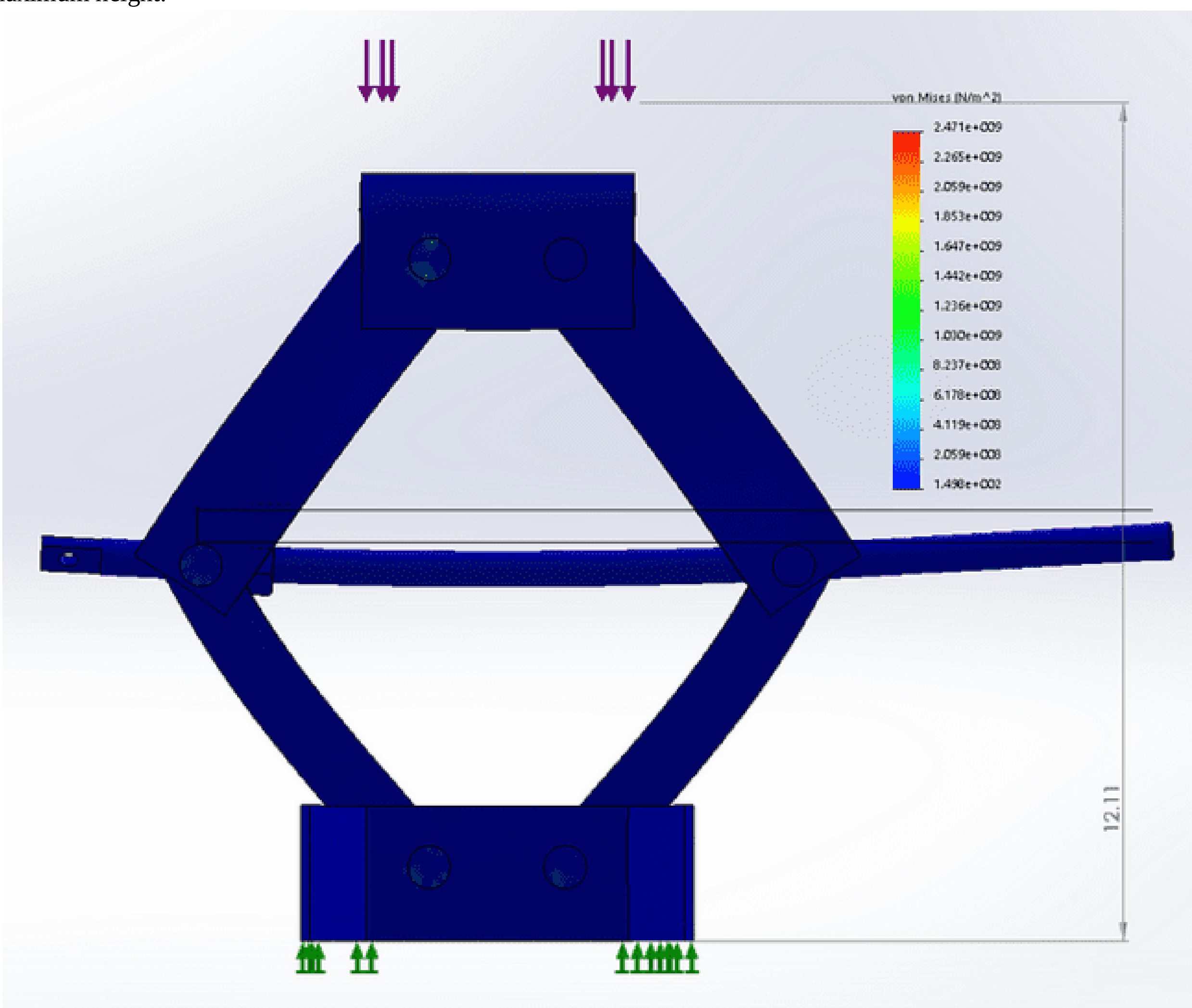
Compression FEA Stress Test

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com



Compression FEA Displacement Test

Even though the design focused around the minimum height and the minimum angle, the following figures showed FEA performed at the maximum height.



Compression FEA Stress Test at Maximum Height

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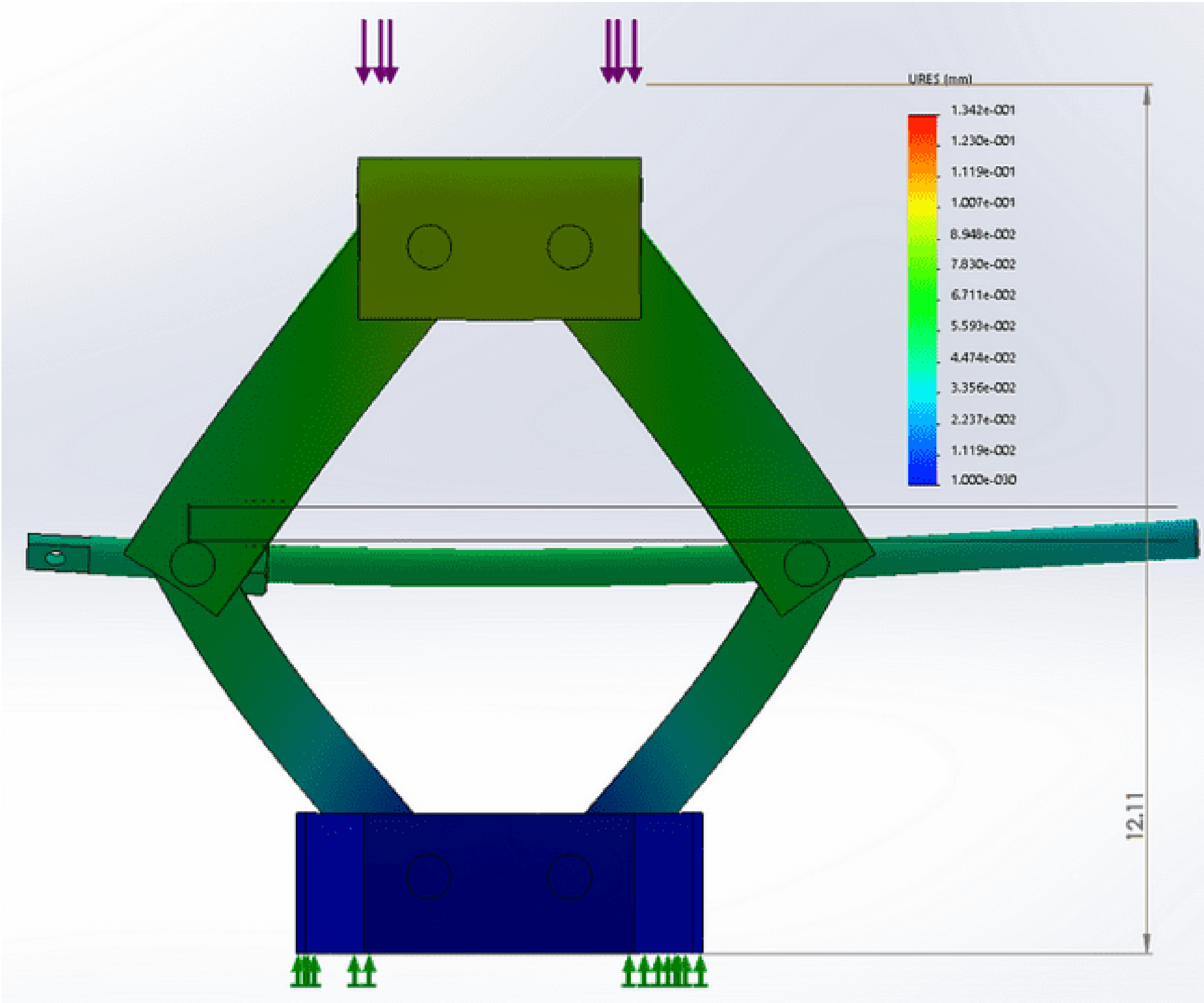
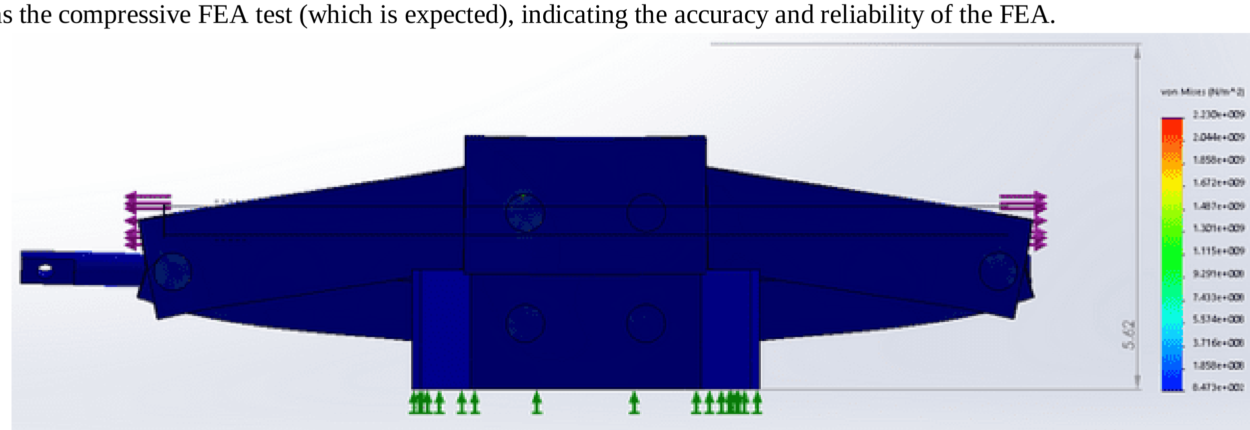
Volume 11 Issue V May 2023- Available at www.ijraset.com



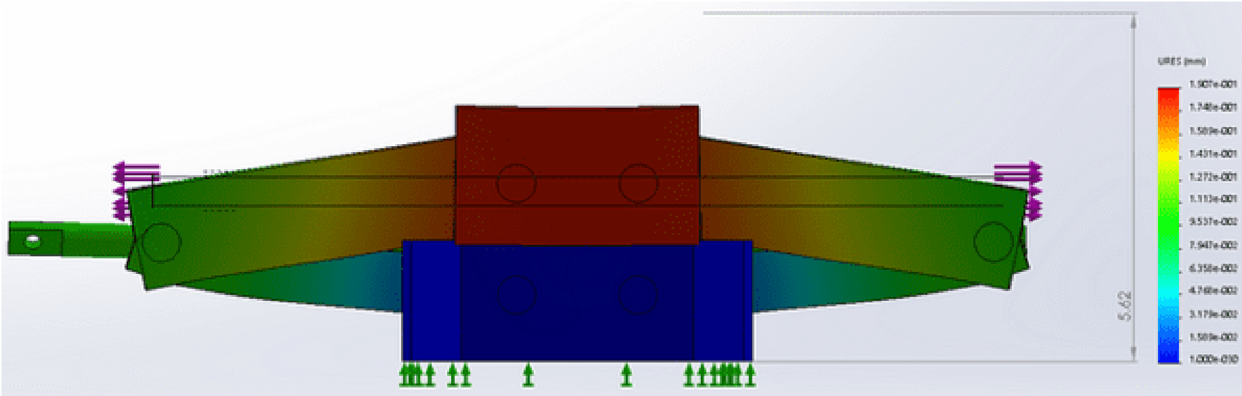
Compression FEA Displacement Test at Maximum Height

F. Tensile

A tensile FEA test was applied to the power screw. The horizontal force was applied to both ends of the screw. The results were the same as the compressive FEA test (which is expected), indicating the accuracy and reliability of the FEA.



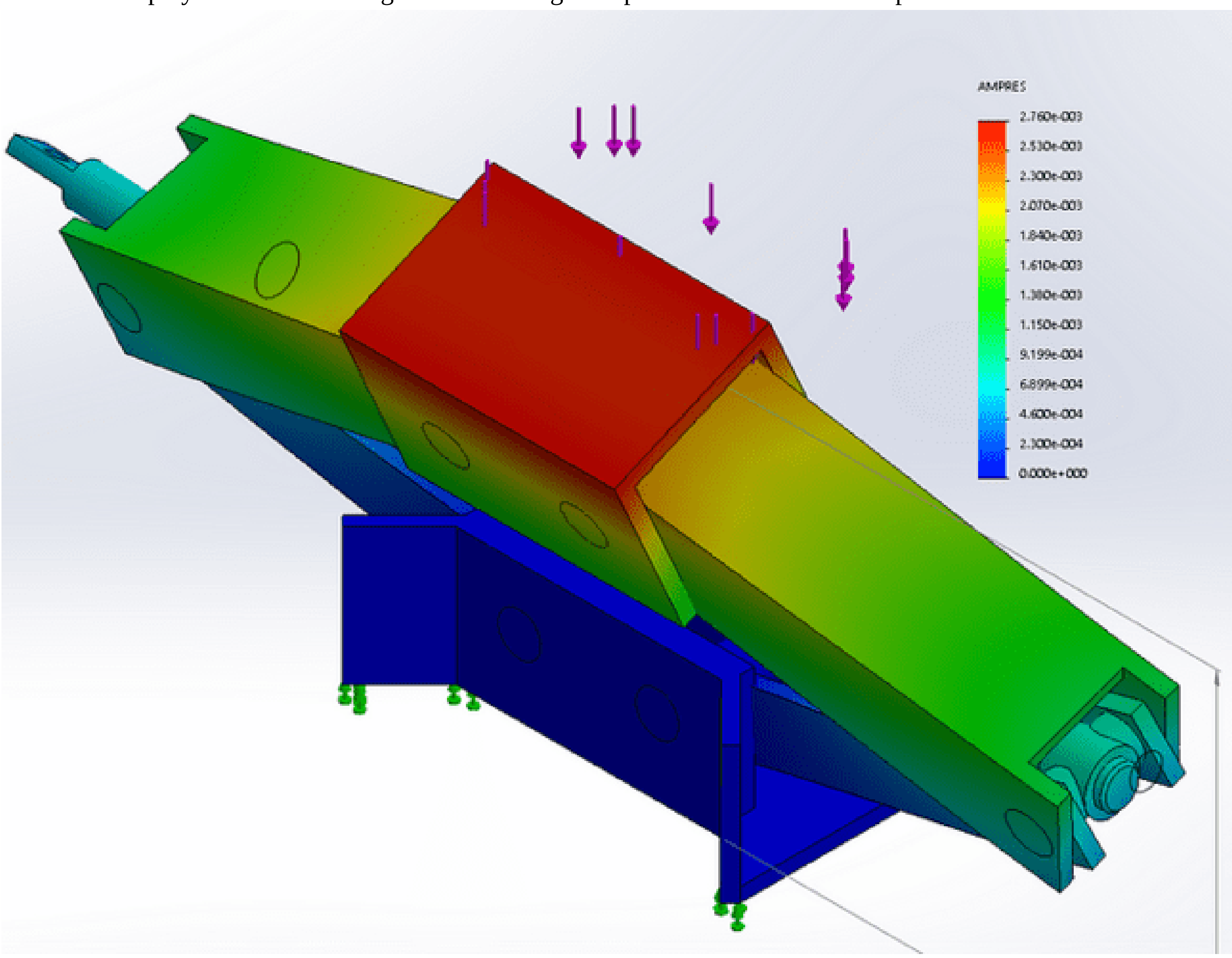
Tensile FEA Stress Test



Tensile FEA Displacement Test

G. Buckling

The figures below display the FEA Buckling Test. The design warps and rotates around the power screw.



Buckling FEA Test

H. Final Design

These dimensions differ from the calculations due to the fact that the calculations focused on what were the minimum dimensions in order for safe operation. Moreover, the calculation section overlooked the fitment of parts. Parts were expanded (instead of subtracting material) in order to ensure their necessary degrees of freedom were not obstructed by other pieces/parts. Therefore, with the different dimensions applied to the SolidWorks assembly, FEA gave different results compared to the calculations.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

1) Design calculations to check the safety of LEAD SCREW

Maximum Load to be lifted = 5 Ton
= 50×10^3 N
= 50KN

For a 5 Ton capacity screw jack, the suitable screw is the one whose nominal (major) diameter is 36mm.
Corresponding to the nominal diameter 36mm, the pitch (p) selected is 6mm.
The core diameter (d_c) = 30mm
The mean diameter (d_m) = 33mm
EN8 material is used for lead screw. The ultimate and yield stresses are 450N/mm^2 and 230N/mm^2 respectively.
The compressive stresses induced in lead screw due to load of 50KN is given by

$$F_c = \frac{W}{\frac{\pi}{4} d_c^{\,2}}$$

$$= (50 \times 10^3 \times 4) / (\pi \times 30^2)$$

$$= 70.73\,\text{N/mm}^2$$

Safety factor = 230/70.73= 3.25
Hence lead screw will bear 50KN easily

The helix angle of screw = $\tan\alpha = \dfrac{P}{\pi d_m}$

= 6/ (πx33)
= 0.057

Therefore, $\alpha = 3.31°$
Assuming coefficient of friction between screw and nut, μ = tan = 0.14

$\theta = \tan^{-1}(0.14) = 7.96°$

$\alpha < \theta$ hence it is a self locking screw.
The turning moment required to rotate screw under design load is given by

$T = W (d_m/2) \tan(\alpha + \theta)$
= (50×10^3) (33/2) tan (3.31°+7.96°)
=164.40KN.mm

The shear stress due to torque,
$F_t = 16T / (\pi d_c^3)$
= $(16 \times 164.40 \times 10^3)/\pi(30)^3$
= 31.01N/mm^2

Direct stress is given by
Fs = ½√ (Fc2 + 4Ft2)
= $\frac{1}{2}\sqrt{70.73^2 + 4(31.01)^2}$
= 47.03N/mm^2

The lead screw material has 115N/mm^2 shear strength.
Safety factor = 115/47.03
= 2.44

2) Design calculations to check the safety of nut

The material of the nut used is stainless steel. The yield stress in tension and compression are 216 N/mm^2 and 294N/mm^2 respectively.
Shear stress = 186N/mm^2

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
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Volume 11 Issue V May 2023- Available at www.ijraset.com

Bearing pressure between lead screw material and nut material is P_b =15N/mm^2 n = Number of threads in contact with the screwed spindle.

H = height of nut = n x p t =   thickness of screw = p/2 = 6/2 = 3mm

The number of internal thread (n) in nut for the load 50KN is given by

$$n = \frac{4W}{\pi(d^2-d_c^2)(P_b)}$$

= (4 x [illegible] 15))

≈ 11

H = n x p

= 11x6 = 66mm

The outer diameter of the nut, D_1 = 54mm

The inner diameter of the nut, D_0 =36mm

The tensile stresses induced in the nut is given by

$$Ft = \frac{4W}{\pi(D_1^2-D_0^2)}$$

= (4x5[illegible]

=39.29 N/mm² which is less than 216 N/mm²

Safety factor=216/39.29

= 5.49

3) Design calculations to check the buckling of screw

The maximum length of the screw above the nut when lifting the load is 100mm.

Radius of gyration (K) = ¼ dc = ¼ x 30 = 7.5mm

Area = d_c^2

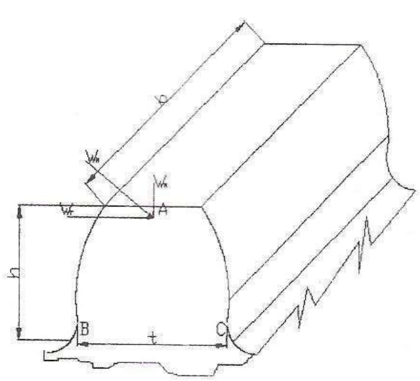
= $(30)^2$ =706.85mm^2

L/K=slenderness ratio=100/7.5=13.33

Slenderness ratio is less than 30, therefore there is no effect of buckling and such components are designed on the basis of compressive stresses.

4) Design considerations for a gear drive

Beam strength of gear teeth –Lewis Equation



Consider each tooth as a cantilever beam loaded by a normal load (W_N). It is resolved into two components i.e., tangential component (W_T) and radial component (W_R) acting perpendicular and parallel to the centre line of the tooth respectively.

The tangential component (W_T) induces a bending stress which tends to break the tooth.

The radial component (W_R) induces a compressive stress of relatively small magnitude; therefore its effect on the tooth may be neglected. Hence, the bending stress is used as the basis for design

The maximum value of the bending stress (or the permissible working stress), at the section BC is given by

$$F_w = M.y / I$$

where

M = Maximum bending moment at the critical section, BC = W_T x h, W_T = Tangential load acting at the tooth, h = Length of the tooth = 5mm y = Half of the thickness of the tooth (t) at critical section BC = t/2 = 4/2 = 2mm

I = moment of inertia about the centre line of the tooth = $b.t^2/12$ =33.33

b = width of gear face = 25mm

$$\text{Bearing strength of teeth } W_T = F_w \times b \times p_c \times y = F_w.b.\pi m.y$$

The quantity y is known as lewis form factor or tooth form factor and W_T is called the beam strength of the tooth. The value of y in terms of the number of teeth may be expressed as follows:

$$-\frac{0.192}{T}\ 54$$, for 20° full depth involute system.

5) Permissible working stresses for gear teeth in the Lewis equation

The permissible working stress (F_W) in the Lewis equation depends upon the material for which an allowable static stress (F_o) may be determined.

According to the Barth formula, the permissible working stress is given by,

$$FW = Fo \times Cv$$

where F_o = allowable static stress, for cast steel heat treated- 196N/mm^2

C_v = velocity factor.

The value of the velocity factor for very accurately cut and ground metallic gears operating at velocities upto 20m/s is given by,

$$Cv = -\frac{6}{6+v}$$

where v = pitch line velocity in m/s = $\frac{\pi DN}{100}$ (D= Pitch circle r = 150mm,Speed = 40)

v =188.495m/min = 3.141m/s

C_v = 0.656

F_W = 196 x 0.656 = 128.576 N/mm^2

W_T = 128.576 x 25 x 16/30

= 1714.266N = 174.806 kgf

6) Dynamic Tooth Load

Dynamic tooth load is given by

$$W_D = W_T + W_I$$

Where W_D = Total dynamic load,

W_T = Steady transmitted load in Newton, W_I = Incremental load due to dynamic action.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

For average conditions, the dynamic load is determined by using the following Buckingham equation, i.e.

$$W \frac{21v(b.C+W_T)}{21v+\sqrt{b.C+W_T}} +$$

Where W_D = Total dynamic load in Newton,

W_T = Steady transmitted load in Newton = V = Pitch line velocity in m/s = 3.141 m/s b = Face width of gears in mm = 25mm

C = A deformation or dynamic factor in N/mm.

A deformation factor (C) depends upon the error in action between teeth, the class of out of the gears, the tooth form and the material of the gears.

The value of C in N/mm may be determined by using the following relation:

$$C = \frac{K,e}{\frac{1}{E_P}+\frac{1}{E_G}}$$

Where K = A factor depending upon the form of the teeth.

= 0.111 for 20° full depth involute system.

E_P = Young"s modulus for the material of the pinion in N/mm^2 = 2 x 10^3 N/mm^2 E_G = Young"s modulus for the material of the gear in N/mm^2 = 2 x 10^3 N/mm^2

e = Tooth error action in mm = 0.0700 for 3.141m/s

The maximum allowable tooth error in action (e) depends upon the pitch line velocity (v) and the class of cut of the gears

$$C = \frac{0.111 \ x \ 0.0700}{\frac{1}{2 \ x \ 10^3}+\frac{1}{2 \ x \ 10^3}}$$

C = 7.77

$$W_D = 174.806+W_{I=}174.806 + \frac{21 \ x \ 3.141.(25 \ x \ 7.77+174.806)}{21 \ x \ 3.141+\sqrt{25 \ x \ 7.77+174.80}}$$

= 2862.456N = 291.889 kgf

7) Wear Tooth Load

The maximum load that gear teeth can carry,without premature wear,depends upon the radii of curvature of the tooth profiles and on the elasticity and surface fatigue limits of the materials. The maximum of the limiting load for satisfactory wear of gear teeth, is obtained by using the following Buckingham equation, i.e.

$$W_w = D_p.b.Q.K$$

Where Ww = Maximum or limiting load for wear in Newton,

$D_{p=}$ Pitch circle diameter of the pinion in mm = 48mm

b = Face width of the pinion in mm = 16mm Q = Ratio factor = 1.56

$$= \frac{2 \ x \ V.R}{V.R+1} = \frac{2T_G}{T_G+T_P}, \text{ for external gears.}$$

$$\text{V.R} = \text{Velocity ratio} = \frac{T_G}{T_P}$$

K = Load stress factor in N/mm^2.

The load stress factor depends upon the maximum fatigue limit of compressive stress, the pressure angle and the modulus of elasticity of the materials of the gears. According to Buckingham, the load stress factor is given by the following relation:

$$K = \frac{(f_{es})^2 \sin ø}{1.4} \left(\frac{1}{E_P}+\frac{1}{E_G}\right)$$

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Volume 11 Issue V May 2023- Available at www.ijraset.com

Where f_{es} = Surface endurance limit in N/mm² =630N/mm²

$\emptyset$ = Pressure angle= 20°

E_P = Young"s modulus for the material of the pinion in N/mm² = ²N/mm²

E_G = Young"s modulus for the material of the gear in N/mm² = N/mm²

$$K=\frac{(630)^2 \sin 20}{1.4}\left(\frac{1}{2\,x\,10^2}+\frac{1}{2\,x\,10^2}\right)$$

$$= 96.9627$$

Wear Tooth Load

$$W_w = D_p.b.Q.K$$
$$= 48 \text{ x } 16 \text{ x } 1.56 \text{ x } 96.9627$$
$$W_w = 116{,}169.907N$$
$$= 11846 \text{ kgf}$$

8) Static Tooth Load

The static tooth load is obtained by lewis formula by substituting flexural endurance limit or elastic limit stress (f_s) in place of permissible working stress (f_w). The static tooth load or beam strength of the tooth,

$$W_S = f_e.b.p_c.y$$
$$= f_e.b.\pi m.y$$
$$= 84 \text{ x } 10 \text{ x } \pi \text{ x } 1.92 \text{ x } (0.1\eta 2\text{-}0.192/25)$$
$$= 3854.9N$$
$$= 393.09 \text{ kgf}$$

For safety, against tooth breakage, the static tooth load (Ws) should be greater than the dynamic load (W_D).Buckingham suggests the following relationship between W_s and W_D.

For steady loads, $W_s \geq 1.2\eta W_D$

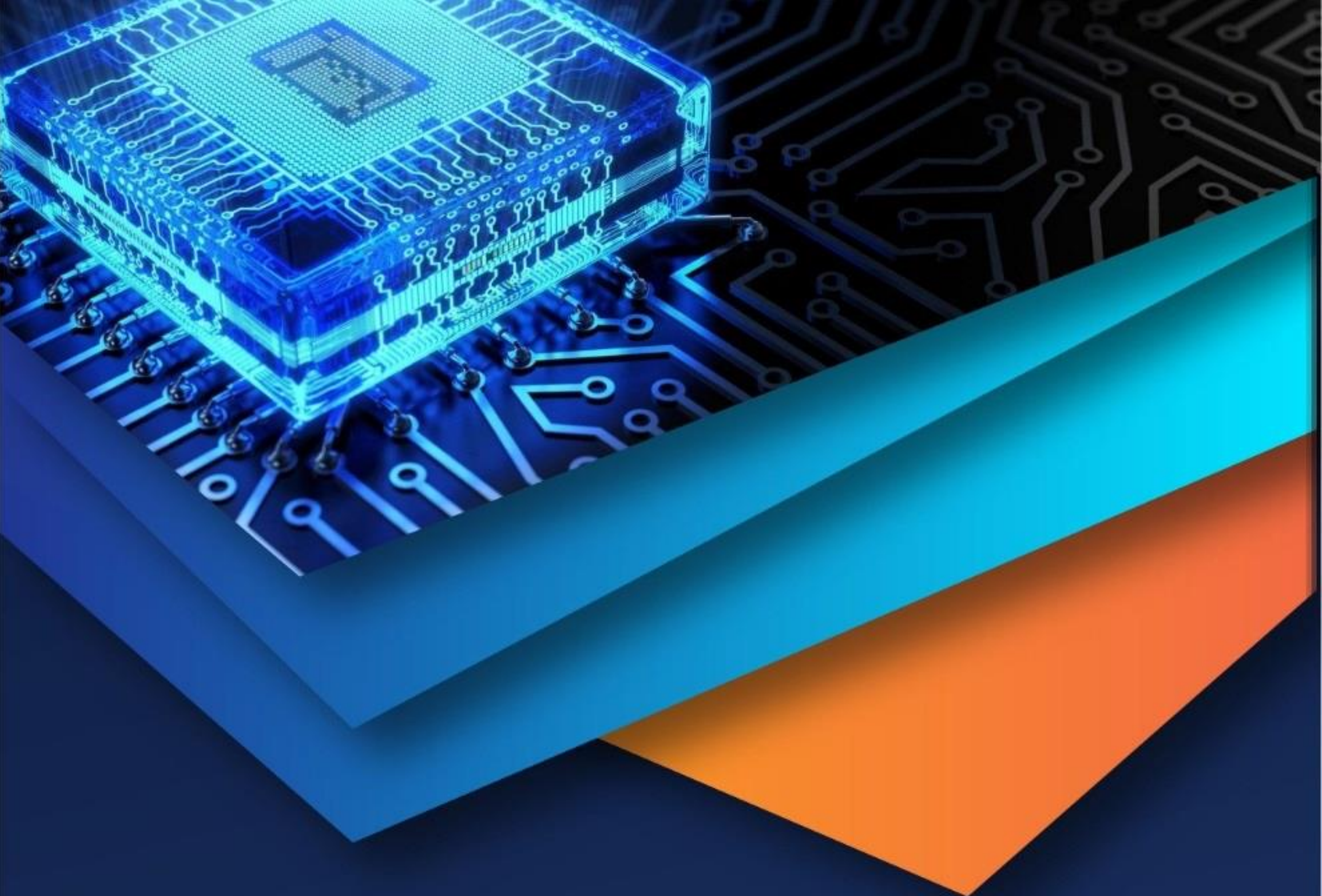
For shock loads, $W_s \geq 1.\eta W_D$

VI. CONCLUSION

Screw Jacks are the ideal product to push, pull, lift, lower and position loads of anything from a couple of kilograms to hundreds of tonnes.The need has long existed for an improved portable jack for automotive vehicles. It is highly desirable that a jack become available that can be operated alternatively from inside the vehicle or from a location of safety off the road on which the vehicle is located. Such a jack should desirably be light enough and be compact enough so that it can be stored in an automobile trunk, can be lifted up and carried by most adults to its position of use, and yet be capable of lifting a wheel of a 4,000-5,000 pound vehicle off the ground. Further, it should be stable and easily controllable by a switch so that jacking can be done from a position of safety. It should be easily movable either to a position underneath the axle of the vehicle or some other reinforced support surface designed to be engaged by a jack. Thus, the product has been developed considering all the above requirements. This particular design of the motorized screw jack will prove to be beneficial in lifting and lowering of load

BIBLIOGRAPHY

[1] Design of machine elements by V.B.Bhandari
[2] A text book of machine design by Rajendra Karwa
[3] Analysis and Design of Machine Elements by V K Jadon, Suresh Verma
[4] Tribology in Machine Design by T. A. Stolarski
[5] A text book of Machine Design by R.S.Khurmi,J.K.Gupta
[6] Design of Machine Elements by Farazdak Haideri
[7] Machine Design by S.G.Kulkarni
[8] Design of machine elements by K.Rao
[9] http://en.wikipedia.org/wiki/Jack_(device)
[10] http://hubpages.com/hub/Automobile-Jacks
[11] http://www.powerjacks-de.com/Screw-Jacks-FAQ.html
[12] http://www.radicon.com/screw-jacks.php
[13] http://www.powerjacks.com/PowerJacks-History-The-Screw-Jack-Story.php
[14] http://www.scribd.com/doc/38577261/Screw-Jack-Design



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