Automatic Scissor Jack Using Car Battery

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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. An automotive jack is a device used to raise all or part of a vehicle into the air in order to facilitate repairs. Most people are familiar with the basic car jack (manually operated) that is still included as standard equipment with most new cars. These days, a car jack is an important tool to have in our vehicle due to unknown upcoming events such as flat tire in our journey. Even so, people who like to rotate their tires themselves or who may install snow tires before the winter and remove them in the spring need to use a jack to perform the job. Changing a flat tire is not a very pleasant experience. Women have a much lighter skeleton that means, among other things, woman can’t pull more forces as well as men and are at greater risk of skeletal injuries. Usually the car purposely tries to get a flat tire at the least opportune moments. On average, 160 injuries are associated with car jacks each year. Injuries have ranged from amputation to fractures and crush injuries. The correct use of jacks can prevent death or injury. Improvement in automotive car jack is really needed to make the tool more efficient, user friendly, practical to use, changes in industry direction and most importantly high safety features. Further research on car jack is very important. Operating the manual car jack is quite difficult job for pregnant women and old men. The purpose of this project is to encounter these problems. An automatic car jack which has a frame type of design by using electricity from the car will be developed. Operator only needs to press the button from the controller without working in a bent or squatting position for a long period of time to change the tire. In order to fulfill the needs of present car jack, some improvement must be made.

1. Introduction:
Jack

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

Problem Statement
Available jacks present difficulties for the elderly people and women and are especially disadvantageous under adverse weather conditions. Presently available jacks further require the operator to remain in prolonged bent or squatting position to operate the jack which is not ergonomic to human body. It will give physical problems in course of time. Moreover, the safety features are also not enough for the operator to operate the present jack. Furthermore, available jacks are typically large, heavy and also difficult to store, transport. Carry or move into the proper position under an automobile. The purpose of this project is to overcome the problems.

An automatic car jack which has a frame type of design by using electricity from the car will be developed. Operator only need to press the button from the controller without working in a bent or squatting position for a long period of time to change the tire.

Objectives
1. To design a power scissor jack which is safe and reliable to raise and lower the load easily.
2. To develop a car jack that is powered by internal car power and fully automated with a button system.
Various Developments in Lifting Devices

1. Levers
2. Screw threads
3. Gears
4. Wheels and axles
5. Hydraulics

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

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

Gears
The jack will lift a load in contact with the load platform when the power screw is rotated through its connecting gear with the pinion gear when connected to the motor, plugged to the automobile 12V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the pinion gear meshing with the bigger gear connected to the power screw to be rotated with required speed reduction and increased torque to drive the power screw. The power screw rotates within the threaded hole of its connecting members in the clockwise direction that will cause the connecting members to be drawn along the threaded portion towards each other during a typical load-raising process.

During the typical load-raising process, the jack will first be positioned beneath the load to be lifted such that at least a small clearance space will exist between the load platform and the object to be raised.

Next, power screw will be turned so that the load platform makes contact with the object and the clearance space is eliminated. As contact is made, load from the object will be increasingly shifted to the load platform and cause forces to be developed in and transmitted through lifting members and connecting members. The force transmitted through the connecting members will be transferred at the threaded bore to the lead Acme threads therewithin. A switch button connected to the motor is used to regulate the lifting and lowering process.

Necessity of Jack
In the repair and maintenance of automobiles (car, it is often necessary to raise an automobile to change a tire or access the underside of the automobile. Accordingly, a variety of car jacks have been developed for lifting an automobile from a ground surface. Available car jacks, however, are typically manually operated and therefore require substantial laborious physical effort on the part of the user. Such jacks present difficulties for the elderly and handicapped and are especially disadvantageous under adverse weather conditions. Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move the proper position under an automobile. In addition, to the difficulties in assembling and setting up jacks. Such jacks are generally not adapted to be readily disassembled and stored after automobile repairs have been completed. Car jacks must be easy to use for women or whoever had problem with the tire in the middle of nowhere.

In light of such inherent disadvantages, commercial automobile repair and service stations are commonly equipped with large and hi-tech car lift, wherein such lifts are raised and lowered via electrically-powered systems. However, due to their size and high costs of purchasing and maintaining electrically-powered car lifts, such lifts are not available to the average car owner. Engineering is about making things simpler or improving and effective.

Such electrical-powered portable jacks not only remove the arduous task of lifting an automobile via manually-operated jacks, but further decrease the time needed to repair the automobile. Such a feature can be especially
advantageous when it is necessary to repair an automobile on the side of a roadway or under other hazardous conditions. There also reportson car jacks which lead to a serious number of accidents.

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

Types of Jack Used Today

1. Scissor Jack

Scissor jacks are mechanical devices and have been in use since 1930s. A scissor jack is a device constructed with a cross-hatch mechanism, much like a scissor to lift up a vehicle for repair. It typically works in a vertical manner. The jack opens and folds closed, applying pressure to the bottom supports along the cross pattern to move the lift. When closed, they have a diamond shape. Scissor jacks are simple mechanisms used to handle large loads over short distances. The power screw design of a common scissor jack reduces the amount of force required by the user to drive the mechanism. Most scissor jacks are similar in design. Consisting of four main members driven by a power screw 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 coming this screw thread, the scissor jack can lift a vehicle that is several thousand pounds. A scissor jack has four main pieces of metal and two base ends. The four metal pieces are all connected at the corners with a bolt that allows the corners to swivel. A screw thread runs across this assembly and through the corners. When opened, the four metal arms contract together, coming together at the middle, raising the jack.

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

2. Construction & working:

Fig 1. Construction of automatic scissor jack using car battery

STEP 1: The car battery is used to drive the D.C motor. The D.C motor shaft is connected to the screw through coupling. If power is driven to the D.C motor, it will run so that the screw also runs and converts rotary to translatory motion. The arms of jack move upwards, so that the vehicle lifts from the ground. The vehicle is lifted by using the lifting platform at the top of the jack. The motor draws power supply from the battery. The lifting and uplifting is done by changing the battery supply to the motor.

STEP 2: After pressing the switch, power from battery is transferred to the motor that is connected to the screw. Now the screw starts moving. Now controlling the switch which is connected to the
motor at the base the set-up is adjusted below the body which is being lifted.

**STEP 3:** Now pressing the switch which is connected to the motor that is coupled to the lead screw, the circuit is completed and voltage from the battery is pass to the motor. When tapping the switch to the positive pole, positive voltage is supplied to the DC motor moves in clockwise direction and lead screw moves in downward direction.

**STEP 4:** When tapping the switch to the negative pole, negative voltage is supplied to the DC motor moves in anticlockwise direction and lead screw moves in upward direction. In this way the directions of motor can be controlled which in turns regulate the lift load direction either upward or downward as per the requirements.

3. **Result and discussion:**

![Fig 2. Design of automatic scissor jack using car battery](image)

**Fig 2. Design of automatic scissor jack using car battery**

**Fig 3. Design of automatic scissor jack using car battery**

**Design calculations:**

Length of each arm = L1 =L2 =L3 =L4 =160 mm

Length of the power screw = (w1+w2+w3) = 350 mm

w1 = w3 = 150 mm

w2 = 50 mm

Maximum lift of the jack = (h1+h2) = 300 mm

Ω is the angle made by link with horizontal when jack is at its lowest position.

\[
\cos (\Theta) = (150)/160 = 20.36^\circ
\]

\[
W = (\text{load } \times g) = (450 \times 10) = 4500 \text{ N} = 4.5 \text{ kN}
\]

The tension T acting on the power screw is shown in the Fig.

Tension, \( T = W/2\tan (\Theta) \)

Total tension = 2\( T = W/\tan (\Theta) \)

For a power screw under tension we can take \( \Theta t = 124 \text{ N/mm}^2 \) for mild steel

Let dcbe the core diameter of the screw. But load on the screw is

Load = \((\pi/4)\times dc = 2x\Theta t So,\)

2\( x\Theta t \)

2\( T = 4.5 \text{ kN}/(\tan (20.36^\circ)) = 12123.44 \text{ N} \)

\( dc^2 = (W/\tan (\Theta)) \times (4/ (\pi \times \alpha t)) \)

Hence, \( dc = 11.34 \text{ mm} \)

Since the screw is subjected to torsional shear stress we adopt, dc= 14 mm

Taking pitch, \( P = 2 \text{ mm} \)

Outer diameter, \( d_0 = dc + P = (14+2) = 16 \text{ mm} \)

Mean diameter, \( d = d_0 - P/2 = 16-2/2 = 15 \text{ mm} \)

**Check for self-locking**

\( \tan (\alpha) = \text{Lead}/\pi xd; \alpha = \text{helix angle} \)

Lead \( L = 2xP; \) since the screw has a double start square thread.

\( \tan (\alpha) = 2xP/\pi xd = 2x2/\pi 15 = 0.084 \)

Helix angle; \( \alpha = 4.85^\circ \)

Coefficient of friction; \( \mu = \tan (\alpha) = 0.20; \) friction angle; \( \Theta = 11.3^\circ \)

\( \Theta > \alpha \) Hence the screw is self-locking

Effort required to support the load = 2\( T \tan (\Theta + \alpha) \)

= 12123.44 \((\tan (\Theta) + \tan (\alpha))/ (1 - (\tan (\Theta) \times \tan (\alpha))) \)

= 3510.715 N

**Torque required to rotate the screw**

\( = \text{effort } \times d/2 = 3510.715 \times 15/2 \)

= 26330.36 N-mm

**Efficiency \( \eta \)**

\( = \text{Work output}/ \text{Work input} \)

\( = Wx L/(P \times \text{d}) \)

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

\( = \tan (\alpha)/\tan (\Theta + \alpha) \)

\( \eta = (4.85/tan (11.3+4.85)) = 0.28 \)

= 28%

So, finally we conclude our paper by calculating that an automatic screw jack with a torque capacity
of 26.33 KN/mm can lift a car wheel having 450 kg of weight.

4. Conclusion:
The existing design was modified by introduction of an electric motor in the power screw, connecting lead screw to the motor shaft, the electric switch connected to the motor and plugged to the automobile 12V battery source to generate power for the prime mover (motor), in order to make load lifting easier.

In this modified design, the power screw is rotated through the motor when electrical power flows through it. The main advantages of the modified design over the existing design are that the modified designed motorized jack will save time, be faster and easier to operate and requires less human energy and additional work to operate. There by effectively curb the problems associated with Ergonomics - which is a fundamental concept of design process.

Considering all available car jacks in the market, this prototype can be improved by a few modifications on the features and design. The objectives are to design a car jack that is safe, reliable and able to raise and lower the level, to develop a car jack that is powered by internal car power and automated with button system.

5. References:
9. Design and fabrication of motorized automated object lifting jack; IOSRJEN.ISSN(e):2250-3021.