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Design of an Automated Car Jack

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ABSTRACT

The main aim of this research work is to produce a motorized jack that will save time, be faster and easier to operate, requires less human energy and additional work to operate and also safe, reliable and able to raise and lower the level. Most of the people are familiar with the basic car jack (manually operated) that is still included as standard equipment with most new cars. Operating the manual car jack is quite difficult job for mainly women's and old men cannot be used on the uneven surface. The purpose of this project is to encounter these problems. The automatic car jack basically works on the conservation of the motion that converts the rotary motion into the translatory motion. The automatic car jack is operated by turning the leadscrew with the motor which is controlled by using wiper DC motor attached to the screw jack, and connected to the cigarette receptacle. The motor is driven by the 12V battery which is generally the battery of car itself. Tire pressure monitoring system will ensure that all tires are inflated properly and the system uses a sensor that is mounted in the wheel to measure air pressure in each tire. This will result into increasing the lifetime of tire and reducing fuel consumption.

Keywords: Motorized Jack, Translatory Motion, Automatic Car Jack, Leadscrew, Reducing Fuel Consumption

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INTRODUCTION: THE NEW FRONTIER

It is observed that in several automobile garages, revealed the facts that mostly some difficult methods are being adopted in lifting the vehicles for reconditioning, repair and maintenance.

This fabricated model has mainly concentrated on this difficulty, and hence a suitable device can be designed, such that the vehicle and heavy objects can be lifted from floor land without the application of 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 its essential tools on automobile garages. The object lifting jack has been developed to cater to the needs of small and medium automobile garages, which are normally man powered with minimum skilled labour. 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 automated motorized object lifting 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 lead screw by gear arrangement; the lead screw rotation depends upon the rotation of d.c motor. 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.

A screw jack is a mechanical device used as a lifting device to lift heavy loads or apply great forces while lifting objects. It could however be classified in the form of levers where a small force lifts a big load, which makes use of screw thread or threads to carry heavy load. It can carry load which can never be imagined considering the effort applied in lifting the load. This is as a screw mechanical jack employs the mechanism of a screw treaded system in the lifting of heavy equipment or loads [5]. The most common form is a car jack, floor jack or garage jack which

lifts vehicles or trucks so that maintenance can be performed. Screw jacks are usually rated based on its maximum lifting capacity which could include: 1.5-ton, 3-ton, 20 ton or ton [6].

An electrical remote-controlled screw jack is a type of jack designed to incorporate a DC motor control and link mechanisms having an infrared transmitter and receiver circuits which processes and downward movement of the screw jack [1,2]. This works in such a way that it can be used to lift heavy loads designed for it very smoothly without any impact force and also a simple operation so that even unskilled laborer can operate it perfectly with little or no instruction. This is an era of automation where it is broadly defined as the replacement of manual effort with mechanical power in all degrees. The mechanical automation remains to be an essential part of the system, although it comes with some physical changes on the jack; the degree of mechanization is greatly increased.

The origin of screw jack can be dated several years ago when Richard Dudgeon, the owner and inventor of screw jack, started a machine shop. In the year 1851, he was granted a patent for his screw jack. In the year 1855, he literally amazed onlookers in New York when he drove from his abode to his place of work in a steam carriage. It produced a very weird noise that disturbed the horses and so its usage was limited to a single street. Richard made a claim that his invention had the power to carry about 10 people on a single barrel of anthracite coal at a speed of 14 m.p.h .Dudgeon deserves a special credit for his innumerable inventions including the roller boiler tube expanders, hole punches and various kinds of lifting jacks [1].

A screw jack is a type of jack that is operated by turning a lead screw. It is commonly used to lift moderately heavy weights, such as vehicle; to raise and lower heavy equipment; and as adjustable supports for heavy loads such as the foundations of a house.

A screw jack consists of a heavy-duty vertical screw with a load table mounted on its top, which screw into a threaded hole in a stationary support frame with a wide base resting on the ground. A rotating collar on the head of the screw has hole into which the handle, of a metal bar, fits. When the handle is turned clockwise, the screw move further out of the base, lifting the load resting on the load table. In order to support large load forces, the screw usually have either square threads or buttress threads.

Car jacks varies based on the model or brand of car. However, the following are some jacks: Scissor car jack: Scissor car jacks usually use mechanical advantage to allow a human to lift a vehicle by manual force alone using long, self-locking jack screws to raise the vehicle.

Bottle car jack: This type consists of a power screw that converts the rotary motion to a linear motion.

Hydraulic bottle car jack: This type of automotive jack uses hydraulics to provide enough pressure to lift a vehicle weighing up to several tons.

Trolley carjack: Is any type of wheeled hydraulic floor jack that can be moved easily.

Pneumatic car jack: This is a hydraulic jack that is actuated by compressed air - for example, air from a compressor - instead of human work.

Electrical Car jack: Is a device that plugs into the 12V lighter or power socket on your car. Which is the subject of interest.

MATERIALS AND METHODS

Electrical control remote screw jack which has a base with two frame placed opposite to each other for rising and lowering of vehicles is made to enhance safety and save human effort. In this, there is a powered screw used to perform the rotation of clockwise and anti-clockwise.

Design Consideration

The properties that need to be considered by designers when specifying steel construction products are:

i. Strength
ii. Weldability
iii. Durability:
iv. Wear resistance
v. Lubrication
vi. Stiffness or rigidity
vii. Operational safety

Materials and Equipment

i. Motor
ii. knob remote control
iii. Power screw
iv. Cigarette lighter receptacle

Motor

An electric motor is an electric machine that converts electrical energy into mechanical energy. In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy. Electric motors can be powered by direct current (DC) sources, such as

from batteries, motor vehicles or rectifiers, or by alternating current (AC) sources, such as from the power grid, inverters or generators [3].

Knob Remote Control

A control knob is a rotary device used to provide manual input adjustments to a mechanical/electrical system when grasped and turned by a human operator, so that differing extent of knob rotation corresponds to different desired input. Control knobs are a simpler type of input hardware and one of the most common components in control systems. A control knob works by turning a shaft which connects to the component which produces the actual input. Common control components used include potentiometers, variable capacitors, and rotary switches [7].

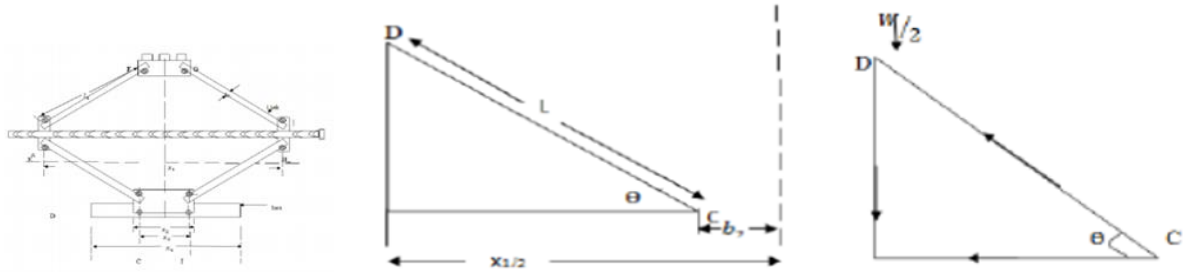
Cigarette Lighter Receptacle

The cigarette lighter receptacle in an automobile, was initially designed to power an electrically heated cigarette lighter, but became a DC connector to supply electrical power for portable accessories used in or near an automobile. While the cigarette lighter receptacle is a common feature of automobiles and trucks. As a DC power connector, it has the disadvantages of bulkiness, relatively low current rating, and poor contact reliability. Examples of devices that can be operated from a cigarette lighter receptacle include lights, fans, beverage heating devices, and small motorized tools such as air compressors for inflating tires. Many portable electronic devices such as music players or mobile telephones use a cigarette lighter receptacle to recharge their internal batteries or to directly operate from the vehicle electrical system. Adapters for electronic devices may change voltage to be compatible with the supplied device. Devices that require alternating-current mains electricity can be operated with a plug-in inverter. Currently, automobiles provide such device through the cigarette receptacle [4].

Power Screw

The power screws are used to convert rotary motion into linear motion. For example, in the case of the lead screw of lathe, the rotary motion is available but the tool has to be advanced in the direction of the cut against the cutting resistance of the material. In case of screw jack, a small force applied in the horizontal plane is used to raise or lower a large load. Power screws are also used in vices, testing machines, presses, etc. In most of the power screws, the nut has axial motion against the resisting axial force while the screw rotates in its bearings. In some screws, the screw rotates and moves axially against the resisting force while the nut is stationary and in others the nut rotates while the screw moves axially with no rotation [4].

Design Analysis



The jack can be seen to have 8-links and 10- joints. Hence its mobility can be found to be M (degree of freedom) = 3(n – 1) – 2J [8].

M = 3(n – 1) – 2J

Where n = number of links, J = number of joints.

Design of Square Threaded Screw

Let p = pitch of the screw,

d= means diameter of the screw,

α=Helix angle

P = Effort applied at the circumference of the screw to lift the load.

W = Load to be lifted

μ=cofficient of friction,between the screw and nut = tanφ is the friction angle

Width of the link, b1 = 36mm,

Length of the link = 185mm,

Length of the powered screw shaft, X1= 350mm,

X2 = 50mm,

X3 = 35mm

According to [9], a mechanical toggle jack was considered in the following design calculation for component and other parameters as follows:

Letθbe the angle of inclination of the link CD with the horizontal. From the geometry of the we find that;

cos 〖θ=(x1/2〗 -b2)/ll

〖=> θ〗 〖=cos-1(x1/2〗 -b2)/ll

Each nut in the jack carries half the total load on the jack, as a result of this, the link CD is subjected to tension while the threaded screw is under pull. Thus the magnitude of the pull on the square thread screw is given by;

$F=w/(2\tan\theta)$

Since a similar pull acts on the other nut, therefore total tensile pull on the square threaded rod is;

$w_1=2F$

But load on the screw was estimated using [8]

$w_1=\pi/4\ [(d)\_c)]^2\ \sigma_t$

where dc= core diameter of the screw

$d_c=\sqrt{(4w_1)/(\pi\sigma_t)}$

Since the screw is subjected to torsional shear stress, therefore to account for this; we have adopt the nearest value in the standard table of reference.

Therefore outer diameter of screw (d0) was obtained using;

$d= dc + p$

Also mean diameter of screw is;

$d=d_0-p/2$

Where p = pitch

For us to check for principal stresses, we know that;

where α is the helix angle

The effort required to rotate the screw is given by;

$p= w_1\ \tan(\alpha+\theta)=(w_1(\tan\alpha+\tan\theta))/(1-\tan\alpha.\tan\theta)$

where θ=frictional angel

Torque required in rotating the screw is given by,

$T=P\times d/2$

In the new design of this jack, the D.C servo-motor must be able to provide a torque that is above the calculated value of T above.

Shear stress in the screw due to torque is given by;

$\tau=16T/(\pi(d_c)^3)$

Therefore, the direct tensile stress in the screw can be calculated as;

$\delta t= w_1/(\pi/4(d_c)^2)=(4w_1)/(\pi d^2)$

Maximum principal (tensile) stress is thus calculated as;

$\sigma_{(t(max))}=\sigma_t/2+1/2\ \sqrt{([(\sigma_t)^2+4\tau^2])}$

$\tau_{(t(max))}=1/2\ \sqrt{([(\sigma_t)^2+4\tau^2])}$

According to basic dimensions for square threads in mm for fine series (IS 4694, 1968 (Reaffirmed 1996)), the maximum stresses are within safe limits, then the design of the square threaded screw is satisfactory. Efficiency of a screw jack is therefore given by;

$\eta=\tan\theta/(\tan(\alpha+\theta))$

Design for Motor Selection

P=F×V(Rajput, 2007)

Where:

P = power

F = Force

V = Velocity

N = 75 Rpm

V= 2πN/60(Rajput, 2007)

V= (2×3.142×75)/60

V= 7.855m/s

Maximum load 2 ton

2 ton = 19613.3N

Factor of safety = 2

19613.3×2=39226.6N

∴F=39226N

p=39226.6 ×7.855

p=308124.943W

p=308.124943Kw

=0.416HP

But for the design 1 HP motor is used.

S/N	Names of Parts	Materials Used	Reasons
1.	Wiper motor	Carbon steel	Strength Ductility

			Toughness
2.	5mm base plate	Mild steel	High tensile strength High impact strength Good malleability
4.	Power screw	Mild steel	High tensile strength High impact strength Good malleability
5.	Knob control button	Reinforced plastic	Finishing surface Corrosion resistance Strength
6.	Jack	Mild steel	High tensile strength High impact strength Good malleability
7.	Wire	Copper wire	Good conductor Malleable Ductile

Table 1: *Material Selection*

S/N	Operation	Tools Used
1.	Cut-out a piece of mild steel	Saw. Tape and scribers
2.	Weld the acquired screw car jack to the base	Welding torch, gauge and combination set.
3.	Align and weld the motor to the power screw	Welding torch, gauge, and combination set.
4.	Connect the cable to the control box and the power plug	wires, sockets, tester

Table 2: *Fabrication Techniques*

Testing

When carrying out the test, the jack was placed under the car and when plugged into the power source, the motor rotates at the rate of 75 rpm which in turn rotate the screw, it takes 5 sec to raise the jack to a height of 80mm. It is done repeated for 0.5tones to 2tones at different time interval which displaces the jack to different height.

Principle of Operation

The principle on which it works is similar to that of an inclined plane, in which a small force applied in a horizontal plane is used to raise or lower a large load.

I. Place the jack properly under the car

II. Plug in the Cigarette lighter receptacle in the power source on the dashboard

III. Turn the control knob to the clockwise direction to raise the load

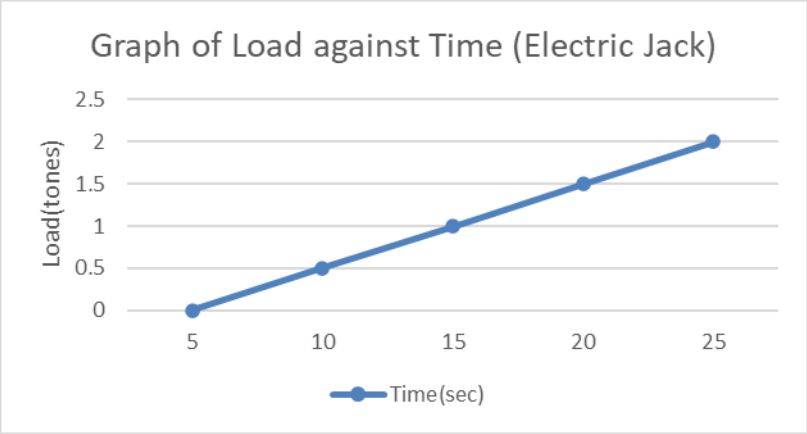
IV. After the repair is being carried out on the car, turn the control knob to lower the jack

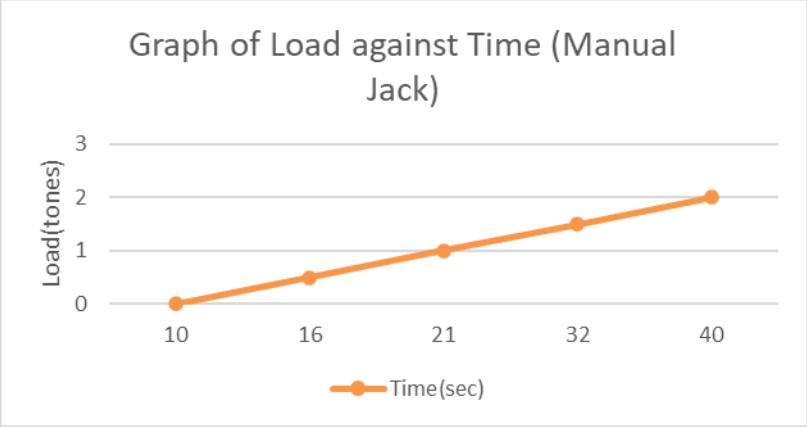
RESULTS AND DISCUSSIONS

Table 3 shows the results and comparison between the Electric jack and the manual jack.

S/N	Load (tones)	Lifting Time For Electric Jack (sec)	Lifting Time of Manual Jack (sec)	Displacement of Electric Jack (mm)	Displacement of Manual Jack (mm)
1	0	5	10	80	50
2	0.5	10	16	120	100
3	1.0	15	21	180	150
4	1.5	20	32	250	200
5	2	25	40	300	250

Table 3: *Test Result*





The results of the test that was carried out with varying loads showed that the jack was able to lift and lower loads of up to 2 tons. From the comparison of manual jack with electric jack, it was observed that the time of lifting for manual jack is greater than that of electric jack. Also as the load increases, the time also increases. The normal height of the jacks before lifting is 50mm and maximum displacement of 300mm. At no load condition, the speed of the electric jack is high with minimum time of performance. Furthermore, turning the ignition on also helps in increasing the speed as to keep jacking to a certain height. If the battery is low, it produces low current which cannot rotate the screw properly. From the two graphs shown, it is observed that electric jack moves in interval of 5sec to the next applied load. While in the manual jack, the time is not uniformly added due to the effort applied by human in turning the jack.

Principles of the Automated Car Jack

The car jack is designed such that it can be fitted to the car chassis and with the help of wiper motor, the jack will be lifted up. The motor works by the electric current supplied from the battery through the cigarette lighter receptacle. Wiper Motor is devices in the wiper system that functions on a power supply in order to move the wiper blades in a smooth motion. The wiper motor rotates continuously in one direction which is converted into a back and forth motion. The power source is the car battery, (12volts DC), current (minimum of 1.6 amps at 70 rpm; 1 amp at 41 rpm), and other battery supplies that does not exceed the limit of 12 volts otherwise the motor is bound to overheat. The wiper motor attached to the Jack An electric motor is an electrical machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of rotation of a shaft. A gear is a rotating machine part having cut teeth which mesh with another toothed part in order to transmit torque. By introduction of an electric motor in the power screw, connecting gear with the pinion, the electric switch connected to the motor and plugged to the 12V battery source to generate power for the motor. The power screw is rotated through its gear when electrical power flows through it. The lifting and uplifting are done by changing the battery supply to the motor

Safety Precautions and Maintenance Procedures

Precautional Measures to Ensure

Things to Always Do

• Store and handle jacks correctly.
• Inspect jacks before use and before placing into storage.
• Ensure the surface on which the jack is placed is level, even and capable of taking the imposed loads.
• Ensure the load is capable of withstanding the forces imposed by the jacking operation.

• Use packing capable of withstanding the imposed loads without crushing. Lift and lower in small stages using support packing to minimize load falls or the load coming onto a single jack.
• Ensure the jack is positioned so that the load is applied to the jack in the correct plane.
• Ensure that the power cable from the DC motor has no leakage

Things to Avoid

• Obliquely load jacks.
• Raise the load higher than necessary.
• Over extend the jack.
• Leave a load supported solely on jacks.
• Reach under a load supported by jacks.
• Work or climb on a load supported by jack

Maintenance of DC Motor Screw Jack

Jacks should be cleaned to remove any dirt or debris paying particular attention to racks, screws, the area around top ram seals etc. Hydraulic oil levels should be checked and the oil topped up or drained and replaced. Moving mechanical components should be lubricated etc. Care is necessary in the case of ratchet jacks as excessive grease can cause the holding pawl to stick or become retarded in operation allowing the rack to free fall thus dropping the load. Regularly inspect jacks and, in the event of the following defects, refer the jack to a Competent Person for thorough examination: jack fails to lift or lower; load slips or creeps down; damaged, cracked or distorted body; base cracked, distorted or does not sit solidly on the floor; operating lever/handle bent or cracked; toe or claw attachment cracked or distorted. In the case of hydraulic jacks: oil leaks; ram scored, nicked or distorted; release valve inoperative. In the case of mechanical jacks: rack teeth or screws chipped, worn or corroded; swivel head seized.

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 tons. 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 loads. Our proposed design has been constructed and tested. It can safely raise a load of 2 ton to the required height with relative ease on the user. The features of our design are, lifting the required load without human effort by using 12v DC supply from the car battery, remote control box and 12v wiper motor to raise and lower the specified weight of car. The salient features of the present fabrication are elimination of human effort to operate the jack, through a simple electrical device which can be operated by the power source from the car. Another feature of the unit is that it operates in clockwise and anti-clockwise direction. The elements which are useful are readily available commercially for easy replacement of failed components, if required. The modification of this car jack is to help elderly, handicapped, and women to operate the jack when the need arises. By using this jack, lifting and lowering of a car by disabled people becomes easier. Thus, it can also reduce the possibility of getting injuries such as backache. But the main part is about the safety. It is dangerous to operate with manual jack for maintenance to be done quickly to avoid unwanted event, like injury. This remote control screw Jack is safe to use after doing some testing and calculation under some specification. The torque of the jack is strong enough to be able to lift a vehicle with maximum load of 2-ton. This is more specifically for cars since the weight is around that point. It is also very economical which is the most fundamental concept of designing an equipment. In the process of designing this equipment, there were challenges on the rotation of the screw in clockwise and anti-clockwise due to improper connection in the control box, which was later rectified and corrected. Incorporated with the motor-actuator control circuit is a transistor-relay switch that transmits power to the DC motor to enable movement of the car jack.

RECOMMENDTION

A remote control screw Jack which is built to raise a car with a maximum weight of 2tons and render safety to the repairer in course of going under to rotate the jack for lifting is very reliable and eliminate hazard. Only simple attachments, which can be welded on are proposed. Therefore, when compared to similar scissor jack designs that perform equally as well, our proposed design is recommended for its easy handling, safety to human and reliable to be used. We are recommending that this design will be very useful at the time of tyre puncture and without any human effort. It can be easily operated by ladies and handicapped. If this project is developed to high load carrying capacity, a higher capacity motor with higher voltage should be used.

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