Ijeas Ideal Journal of Engineering and Applied Sciences 2(2) 96-102 Ijeas

http://ijeas.truescholar.org

DEVELOPMENT OF AN AUTOMATED HYDRAULIC CAR JACK POWERED BY 12 VOLT DC BATTERY

Ogbeide, S.O (Ph.D)
Ambrose Alli University,
Faculty of Engineering and Engineering Technology,
Department of Mechanical Engineering,
Ekpoma, Edo State, Nigeria

ABSTRACT

This study introduces the development of an automated hydraulic car jack powdered by12 volt DC Battery. Car jacks usually use mechanical advantage to allow a human to lift a vehicle by manual force. More powerful jacks are using hydraulic power to provide more lift over greater distances. Most people are familiar with the usual car screw 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 oncoming event such as flat type in journey. Changing a flat tyre is not a very pleasant experience. Women have a much lighter forces as much as men and are at greater risk of skeletal injuries. On average, 160 injuries are associated with car jacks each year. Injuries have ranged from amputation to fractures and crush injuries. The purpose of this project is to arrest these problems and design a hydraulic car jack that works on current supplied from that car battery itself, making it easy to operate. Operators only need to press the button from the control switch without working in a bent or squatting position for a long period of time to change the vehicle's tyre. The total cost of production was ₦35,480 with an efficiency of 61%.

KEYWORDS: Automated, Hydraulic, Car Jack, Tyre, 12 Volt Dc Battery

INTRODUCTION

An automotive jack is a device used to raise all or part of a vehicle into the air in order to facilitate repair (Howe 2007). Most people are familiar with the normal car screw 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 forthcoming event like deflated tyre in a journey. More so, people who like to replace their tyres themselves or who may want to install snow tyres before the winter and remove them in the spring need the use of a jack to perform this job. Changing a flat tyre is not a very pleasant experience. Charles (1995) shows that only 12% of women can accomplish the two-person stretcher carrier, a requirement critical to ship security. Women may be able to drive a five-ton truck, but need a man's help if they must change a tyre. Women have a much lighter skeleton than men amongst other things she can't pull more force as much as men and are at greater risk of skeletal injuries.

Usually the car is prone to having a flat tyre at the most available moment. Working near a vehicle that is supported by a car jack can be fatal. In Australia, over the last four years at least 19 people have been crushed and killed by a vehicle while they were working. All the deaths were men and involved the vehicle being lifted or supported in the wrong way. Home mechanics are most at risk of this type of death or injury. In some case, the operator is killed when the vehicle was not secured by chocks and the vehicle rolled on top of them, or the structures used to support the vehicle failed. 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. With the spare installed, you should be able to reach your house or the nearest service station. Furthermore, an organization called the American Lift Institute (ALI) was established to promote improvements in automotive lift technology, especially in the area of safety (Young 2013). As recently as the late 1990s, car lift or jack manufactures were allowed to declare that their products were safe even though they did not meet any set standard. Thanks to ALI's cooperative venture with the American National Standard Institute, all jacks and lifts must meet a set number of performance standards in order to be ALI/ANSI certified. 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. (Edward M, 1992).

In the repair and maintenance of automobiles (car), it is a usual tradition to raise an automobile to change a tyre or access the underside of the automobile. Accordingly, a variety of car jacks have been developed for suspending an automobile above the ground surface (Kevin A. 2005). Available car jacks, however, are typically manually operated and therefore require substantial laborious physical effort on the part of the user. Such jacks present difficulty for the elderly and handicapped and are especially disadvantageous under adverse weather conditions. Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. In addition, to the difficulties in assembling and setting up jacks, such jacks are generally not adapted to be readily disassembled and stored after automobile repairs have been completed (Brain, 2006). Supposed car jacks must be easy to be used by pregnant women or whoever has problem with the tyre in the middle of nowhere.

In light of such inherent disadvantage, 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 sheer size and high costs of purchasing and maintaining electrically-powered car lift, such lifts are not available to the average car owner. Engineering is about making things simpler or improving the effectiveness. Such electrical-powered portable 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. This is because safety features that are in conventional car jacks are not enough. 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 till 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 specified to hold. Tests have proven that such jacks has the propensity to buckle well under the weight it is promoted to withstand, and is doesn't meet the labeling or performance requirements of the Australian Standard for vehicle jacks (Mario, 2001).

PROBLEM STATEMENT

Available jacks offer difficulties for the elderly women and expected mothers and are especially disadvantageous under adverse weather conditions and loose/rugged terrain. These presently available jacks further require the operator to remain in prolonged bent or squatting position to operate then jack.

Doing work in a bent or squatting position for a period of time is not ergonomic to human body. It will give spine problem in due time. Moreover, the safety features are also not enough for operators to operate the present jack. Present car jack do not have a lock or extra beam to withstand the massive load of the car. This is for the safety precaution in case if the screw break. Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. Supposed car jacks must be easy to be used by pregnant women or whoever have problem with the tyre in the middle of nowhere.

The purpose of this project is to arrest these problems. An electric car jack which has a frame type of design by using electric from the car lighter 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 tyre.

In order to fulfill the needs of present car jack, some improvement must be made base on the problems statement:

- To design a car jack that is safe, reliable and able to raise and lower the height level.
- To develop a car jack that is powered by internal car power and fully automated with a button/switch system.
- To evaluate the automated car jack

HYDRUALIC JACK

Hydraulic jacks are devices used to lift load. Hydraulic jacks are used in workshops, in lifting vehicles, lifting houses from their foundation. Hydraulic jacks are often used to lift elevators in low and medium size buildings.

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

Hydraulic jack is a device used for lifting in automobile/heavy machine. Thus, a hydraulic jack is a mechanical system that uses the power of fluids (hydraulic-study of mechanical property of fluid) to lift really heavy objects, hence the jack has a mean of power transmissions.

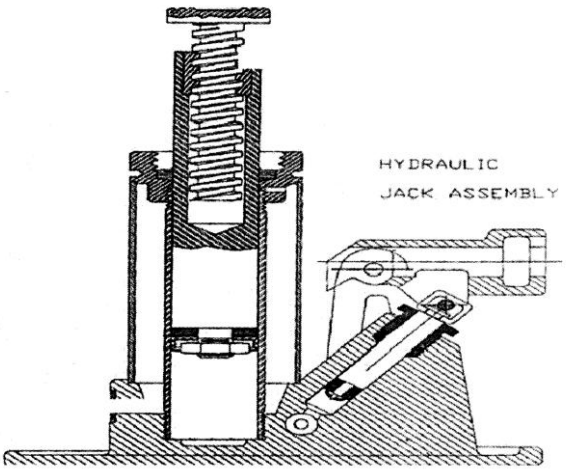

Fig 1: Hydraulic Jack

TYPES OF HYDRAULIC JACK

Air Hydrualic Jack

Basically jack climb up on the jack rod (part of lifting trestle) with the desired pressure, to lift up the load. Its action is same as monkey that climbs a trunk tree; i.e. first it holds up on the trunk with its legs and lunges upwards, then it holds on to the trunk with its hands and lifts it legs up. At any time, either its hands or legs have a grip on the trunk, which prevents it from falling down. In the same manner, air hydraulic jack, air hydraulic bottle jack and jack is provided with two pairs of jaws and an upper pair of jaw for an excellent grip. During lifting, both the pairs are "locked". In this position the jack can only move upward. At the time of lifting, the lower pair of jaw grips the trestle rod while the jack lifts up. After completing the full stroke, the upper pair of jaws grips the trestle rod, however, the base of the jack moves upwards. During the process of lowering, any one of the pairs is always locked (Farhad, 2007)

Lightweight and build for heavy-duty use: The quick-lift mechanism allows a substantially shortened ram lifting time without load. A flow control valve prevents sudden fall of ram. It featured a special processed air pump for low noise. The built-in safety valve prevents use beyond the rated capacity or lifting limit.

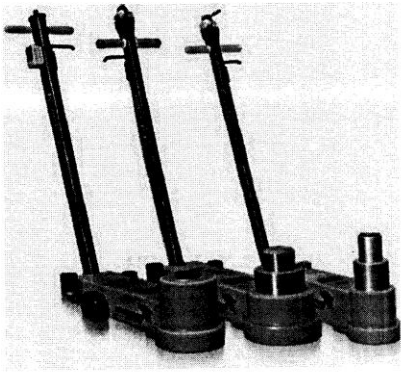

Fig 2: Air Hydraulic Jack

Bottle Hydraulic Jack

In a bottle jack the piston is vertical and directly supports a bearing pad that contains the object being lifted. With a single action piston the lift is somewhat less than twice the collapsed height of jack, making it suitable only for vehicle with a relatively high clearance. For lifting structure such as houses, the hydraulic interconnection of multiple vertical jacks through valves enabling the even distribution of force while enabling close control of the lift.

Fig 3: Bottle Hydraulic Jack (Exploded)

Hydraulic Floor Jack

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

Fig 4 Hydraulic Floor Jack

Pneumatic Jack

A Pneumatic Jack is a hydraulic jack is actuated by compressed air-for example, air from a compressor-instead of human work. This eliminates the need for the user to actuate the hydraulic mechanism, saving effort and potentially increasing speed of operation. Sometimes, such jacks are also able to be operated by the normal hydraulic actuation method, thereby retaining functionality, even if a source of compressed air is not available

Fig 5. Pneumatic Jack.

Component of the Hydraulic Jack System

The following are the various parts of this hydraulic jack system.

i. The hydraulic cylinder
ii. Reservoir
iii. Pump
iv. Valve (Check and Release)
v. Ram Piston
vi. The control unit

Working Principle of a Hydraulic Jack

When the switch is turn on, the motor starts running with the power which is readily available from the car's battery. The motor facilitate the flow of oil which is pressurized by the pump provided, this pressurized. As oil proceeds into the hydraulic cylinder exert a certain amount of pressure on the plunger or the ram inside the cylinder. This exerted pressure in the oil is converted in two linear motion of the plunger. As the plunger goes out the cylinder linearly, after a definite travel of the plunger in the downward direction and once it touches the ground it starts lifting the car.

Once the tyre is change the next thing is to release the pressure in the jack which is in form of pressurized oil. A release valve is provided for this purpose, once the release valve is open in the oil in the cylinder which then loses its pressure energy start returning to the control unit. Once the oil starts returning, the control unit sends the accumulated oil back to the oil pump or reservoir. In this way, the entire system cycle is completed. Oil is then directed to the control unit which in turn directs the flow.

METHODOLOGY OF AUTOMATED HYDRAULIC CAR JACK

The cylinder of the jack is placed accordingly in the lifting position of the vehicle. After that the terminal wires are connected according to polarity, positive terminal wire is connected to the positive terminal of the battery with the help of battery clip, while negative terminal is connected to the negative terminal of the battery or the vehicle body at any point near to the jack. Now after this connection, the jack is ready to lift the load or vehicle after placing it at the right spot of the chassis of the vehicle. When the starter switch is pushed, the motor receives electrical excitation and starts rotating the pump by means of a cam system. The pump pushes pressure fluid through the cylinder, it starts moving up (the pump sucks the oil from tank and delivers it to the cylinder). The jack starts lifting the load and stops at the maximum of complete lift of the piston or after the switch is released when lift is achieved. Now to lower down the load on the jack, the oil filled in the cylinder which tends to keep the vehicle lifted is released with the help of release valve. The oil filled in the cylinder is drained in the due to the force of the weight on it and the load comes down slowly. In this way, the oil circulates from cylinder to tank and tank to cylinder during operation.

DESIGN ANALYSIS

Jack Specification

1. Lift of piston + screw = 140 +60 = 200mm
2. Diameter of piston = 50mm
3. Mass of load to be lifted = 5000kg
4. Jack capacity = 10 ton

D.C Motor Specification

1. Watts ---------- 1.5kW
2. Volts---------- 12 V
3. RMP---------- 2500rpm
4. Horse power----- 3hp.

Design for Cam Profile

A cam with a minimum radius of 30mm rotates clockwise at a uniform speed is to be design to give a follower (Lever), at the end of the rod is described below.

- To raise the valve through 40mm during 120^o rotation of the cam
- To keep the Ram fully raised through next 30^o
- To lower the Ram during the next 60^o
- To keep the Ram closed during test of the revolution i.e. 150^o

The profile of the cam is shown below

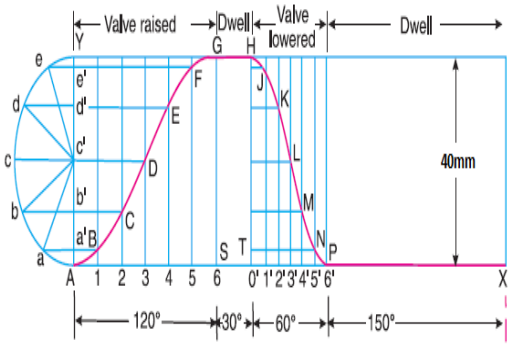

Fig 6: Displacement of CAM

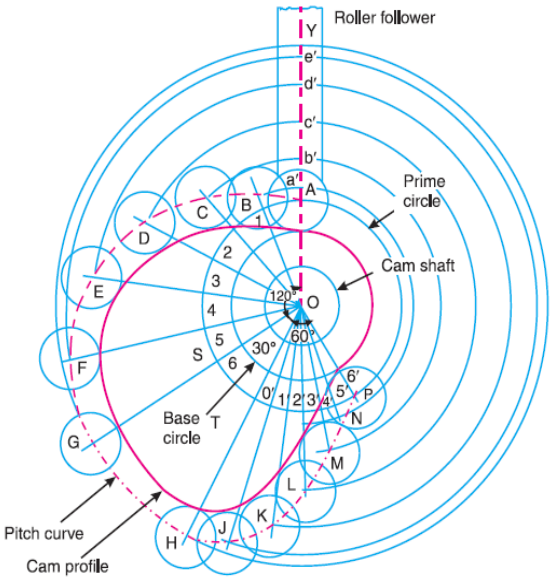

Fig 7: Can and Follower

Rotational speed of cam= Rotational speed of motor
S=2500rpm

Hence $w=\frac{2\pi N}{60}$ (1)

$=\frac{2*3.142*2500}{60}$

=262 rad/s

Maximum velocity of the rod to raise the ram

$V_o=\frac{\pi\omega S}{2}$ (2)

$\frac{\pi*262*0.04}{2*2.1}$

= 7.84m/s

Maximum velocity of the rod to lower the ram

$V_R=\frac{\pi\omega.S}{2\theta_R}$ (3)

$\frac{3.142*262*0.04}{2*1.047}$

= 15.7m/s

Therefore the maximum acceleration of the rod to raise the ram will be.

$a_R=\frac{\pi^2.\omega^2.S}{2(\theta_R)^2}$ (4)

$\frac{(3.142)^2*(262)^2*0.04}{2*(1.047)^2}$

$= 12361 m/s^2$

Base Plate

All the components are mounted on mild steal plate.
Base plate size = (l x b x t)
= 250mm x 180mm x 6mm

FABRICATION COST

The total fabrication cost of the Automated Hydraulic Jack is computed as the sum of the materials Cost (M_c), labor Cost (Lc) and Overhead Cost (O_c).
Thus = M_c+ L_c+ O_c

Material cost

From table 1, materials cost is calculated to be #21,980.

Table 1. Cost of Materials

S/No	Description	Unit Cost (#)	Quantity Required	Total Cost (#)
1	Dc motor	5,000	1	5,000
2	Hydraulic Jack	7,000	1	7,000
3	Terminal clip	200	2	400
4	Control switch	1,500	1	1,500
5	Paint	2,000	1	2,000
6	Thinner	1,000	1	1,000
7	Angle Bar	1,550		1,550
8	Bolt and nut	70	9	630
9	Electric cord	350yard	4 yards	1,400
10	Base Plate	1,500	(500*300)	1,500
11	Grand total			21,980

Labor Cost

The labor cost in the fabrication of an automatic hydraulic car jack is calculated accordingly with the process which includes cutting and welding machining, painting and transportation. The cost is given below.

Table 2: Labor Cost

S/No	Description	Cost (#)
1	Machining	4,000
2	Painting	1,500
3	Welding	2,000
4	Transportation	2,500
5	Total	10,000

The total cost is the sum of the materials cost and labor cost, that is
₦21, 980+₦10, 000 = ₦31,980

RESULT

After the development of the hydraulic jack, the system was effective in operation, It was tested to lift

load of 5-100kg, but was not able to lift certain vehicle due to power of the motor attach to the automated hydraulic jack and lost power supplied by the car battery.

	Load (kg)	Time, T(s)	Height Attain by the hydraulic jack (mm)	Additional screw length (mm)	Total height attained, H(mm)
	5	14	140	60	200
	10	17	140	60	200
	20	21	140	60	200
	40	28	140	60	200
	60	37	140	60	200
	80	48	140	60	200
	100	60	140	60	200
Average	44.43	32.14	140	60	200

$$P = \frac{M * H * G.}{T}$$

$$= \frac{43 * 200 * 9.8}{32.143} = 1367.73$$

P(out) =1367.73w

P(motor) = 3 horse power
3 * 746 = 2238N
P(motor)= 2238N

$$\text{Efficiency} = \frac{P(out)}{P(motor)} * 100$$

$$\frac{1367.73}{2238} * 100$$

Efficiency = 61%

DISCUSSION

The design was focused on all process of conception, invention visualization, calculation, refinement and specification of details that determines the form of the product. The automated hydraulic jack can be raised or lowered by the D.C motor which is connected to the jack by means of a shaft. A lead acid battery (12V) is used to drive the D.C motor. The D.C motor shaft is faster to a pulley and to the pulley of the pump by belt. The vehicle lifted using the screw head platform at the top of the hydraulic lack .The motor draws supply from the battery. The lifting and the down lifting are done by the switch that is connected to the D.C electric motor

CONCLUSION

After the experimental data was collected, the system was determined to operate within the stated requirements in terms of load. The Automated hydraulic jack load capacity varied between 0 to 100kg. The only problem with the system was inefficiency at loads above 100kg.

The development of a hydraulic car jack powered by 12 volts DC battery performed well and according to the design, it worked to the desire capacity of lifting load it was design for. The model is compatible, mobile, easy to operate and maintain. Components were machined and others that could not be fabricate, bought. To ensure proper function of this device, all requirements must be met and proper maintenance followed.

RECOMMENDATION

The DEVELOPMENT OF the automated hydraulic jack is far advantageous over conventional manual hydraulic or screw jack. This RESEARCH has its own limitation in the area of application. The basic limitation is the ability to work with insufficient power and maintenance. So, for efficiency we are recommending the following;

1. That the reservoir be filled with oil to the appropriate level.
2. That a fully charged 12volts battery is used for powering the D.C motor and when a 12volts car battery does not power the D.C motor effectively, also depending on the load, a 24volts battery can be used instead.
3. That the terminal heads be placed firmly on the battery terminals to avoid poor performance of the electric motor due to partial contact and thereby reducing pump power.
4. That the maximum load for the hydraulic jack should not be exceeded.

REFERENCE

Charles F Sweeney. (1995). “Pneumatic vehicle jack”
R.S. Khurmi, J.K Gupta “Theory of machine”
Howe Richard L. (2007) “Automobile jack Stand with light”
Young John D. (2013) “Autopower jack apparatus”
America life institute, ALI brochure. (2014). “automotive Lift-purchase considerations
Brain, Elliott S. (2006). “Air-Over-Hydraulic Jacks”, Compressed air operation manual, McGraw-Hill professional, Pp. 56-58

Hydraulic Deere and Company Service Publication (1997).Moline Hillinois.

Edward M.Lonon, East Orange,N.J,US .‘Motorized Jack’. United States Patent. Patent number: 5085407.Date of Patent: Feb 4, 1992.

Farhad Razzaghi, Douglasville, GA, US. ’Apparatus and Method for an Electric Jack’. United States Patent. Patent number: US2007/0256526 A1.Date of patent: Nov 8,2007

Jay Heizer and Barry Render, *Operations Management*, Sixth Edition: Pearson International Edition. 2006.

Kalpakjian S. and Schmid S.R *Manufacturing Engineering and Technology*. Fourth Edition: Prentice Hall International, 2001.

Pat L. Mangonon ,*The Principles of materials selection for engineering design*, Design, selection, and failure of materials, pg 432, 1999.

Yang–chou Liu, (1997). Taipei, Taiwan. 'Manually operated car jack' United States Patent. Patent number: 5603486.Date of Patent: Feb 18, 1997.