

**DESIGN AND FABRICATION OF MOTORIZED SCREW JACK**



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**A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF  
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**FACULTY OF ENGINEERING**

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**BENIN CITY**

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**APRIL, 2024**

## **DECLARATION**

I **AKPORTOBORE ETADAFE EREWA**, hereby declare that the project work entitled **DESIGN AND FABRICATION OF MOTORIZED SCREW JACK** is a record of an original work done by me, as a result of my research effort carried out in the Faculty of Engineering, University of Benin under the supervision of

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Student's Signature & Date

## **CERTIFICATION**

This is to certify that this study was carried out by **AKPORTOBORE ETADAFE EREWA** with matriculation number **ENG1805629** in the Department of PRODUCTION ENGINEERING Faculty of Engineering, University of Benin, under my supervision.

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## **DEDICATION**

This work is dedicated to God Almighty for His grace and strength granted us from the beginning to the completion of this project.

And to my family for their unwavering support throughout my academic career.

## **ACKNOWLEDGEMENT**

I wish to acknowledge God almighty for keeping us in health and being our strength throughout this work. I also specially appreciate our supervisor, Prof. R.O. Edokpia for his patience, support and steadfast guidance throughout the work.

I also wish to specially thank my families for their encouragement and financial support throughout the work.

I am grateful for support and encouragement from every other person who in one way or the other contributed to the actualization of this project.

## **ABSTRACT**

Advancements in technology have led to a steady decline in the effort required to produce work, with better designs offering an effective and economical means to achieve desired outcomes with reduced effort.

Power screws serve to transform rotary motion into translatory motion, as exemplified by the screw jack, where a minor horizontal force elevates or descends a substantial load. Operating akin to an inclined plane, the mechanical advantage of a screw jack is determined by the ratio of load to effort applied. Adjustment of the jack's height is facilitated by turning a lead screw, achievable either manually or through integration of an electric motor. The whole components is designed on a base plate of relatively good resistance to deformity and act as a support to weight balancing during the operation of the motor

This project analyzes the fabrication of a motorized screw jack by incorporating an electric motor in the screw in order to make load lifting easier. In this fabrication design, the power screw is rotated by connecting motor through universal joint and gear axle to power the screw jack plugged to the automobile 12 V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the power screw to be rotated with required speed reduction and increased torque to drive the power screw. The significance of this project to design a car jack in form of motor operating condition in order to make the operation easier, safer and more reliable in order to reduce health risks especially back ache problems associated with doing work in a bent or squatting position for a long period of time. The motorized screw jack is easy to use by women or whoever had problem with the vehicle tyres along the road. It will also save time and requires less human energy to operate. Based on results, the project provide a motorized jack able to effectively lift a load of 750kg to 1000kg and also provide a safe usage during maintenance of vehicle.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of study

A screw jack is a device used to fully or partially lift a vehicle or other object off the ground. These tools can be used to lift a car several feet into the air so that workers can reach the underside of the vehicle, or they can be used to raise a vehicle's corner. Machine shops, auto repair shops, and the automotive racing industry are common places to find screw jacks. Along with the spare tire kit, many cars also come with a screw jack, so owners can repair a flat tire more easily. Very large screw jack systems are even used to lift houses for foundation repair or replacement.

These devices are typically made of steel, lead or lightweight stainless steel. They are available in two basic varieties; scissor jacks and “worm gear” screw jacks. Another type of jack design, based on hydraulic principles, is primarily used in industrial and manufacturing facilities and does not operate like a screw jack. Scissor screw jacks, commonly employed for flat tyre repairs, feature a scissor-shaped structure operated through a sizable lead screw. Positioned with its base on the ground and the top fitting beneath a vehicle, the jack is elevated by turning a central screw to the right. This action raises the car for tire maintenance, and upon completion, turning the screw to the left lowers the vehicle back to the ground.

Screw type mechanical jacks were very common for "jeeps" and trucks of World War II vintage. For example, the World War II jeeps (Wally's 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. Before the invention of weight lifting device such as screw jack, hydraulic jack, crane, etc., the early man apply a crude way of lifting objects to great heights through the use of ropes and rollers, which was mostly applied in the construction area, where, it was used to raise mortar (cement, sand & water).

The benefits of employing a screw—basically, an inclined plane wound around a cylinder—as a machine were initially illustrated by Archimedes in 200 BC with his water-pump invention. 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 recognizable 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 three centuries, almost four centuries.

It is not until the late 1800s that we have evidence of the product being developed further. Screws were first used in machine tools during the industrial revolution in the late 18th and early 19th centuries, thanks to English inventors like John Wilkinson and Henry Causley. The most notable inventor in mechanical engineering from the early 1800s was undoubtedly the mechanical genius Joseph Whitworth, who recognized the need for precision had become as important in industry as the provision of power .A screw jack that has a built-in motor is now referred to as a linear actuator but is essentially still a screw jack.

With the advancements in motion control, screw jacks can now be connected mechanically or electronically and loads can be positioned down to 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. Car jacks usually use mechanical advantage to allow a human to lift a vehicle by manual force alone. The use of screws in the Ancient Roman world but it was the great Leonardo Vinci, in the late 1400s, who first demonstrated the use of a screw jack for lifting loads. A lifting screw was driven by the rotation of a worm shaft in Leonardo's design, which employed a threaded worm gear supported on bearings to move the load. This design instantly became known as the modern principle.

Jacks are of mainly two types mechanical and hydraulic. They vary in size depending on the load that they are used to lift.

The common varieties of jacks and their mechanisms are listed below:

### **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 several types of mechanical jacks: scissor jack, floor jack, scaffolds, bottle jack etc.

#### **i. Screw Jacks**

Screw jacks are also mechanical and have been in use at least since the 1930s. A screw 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.



Figure 1.1: Screw jack

ii. House jack

A house jack, also called a screw jack, is a mechanical device primarily used to lift buildings from their foundations for repairs or relocation. A series of jacks is used and then wood cribbing temporarily supports the structure. This process is repeated until the desired height is reached. The house jack can be used for jacking carrying beams that have settled or for installing new structural beams.

iii. Bottle (cylindrical) jack

A bottle jack or whiskey jack is a jack which resembles a bottle in shape, having a cylindrical body and a neck. Within is a vertical lifting ram with a support pad of some kind fixed to the top. The jack may be hydraulic or work by screw action. In the hydraulic version the hydraulic ram emerges from the body vertically by hydraulic pressure provided by a pump either on the base plate or at a remote location via a pressure hose.



Figure 1.2: Bottle jack

### **Hydraulic Jacks**

Hydraulic jacks are typically used for shop work, rather than as an emergency jack to be carried with the vehicle. Use of jacks not designed for a specific vehicle requires more than the usual care in selecting ground conditions, the jacking point on a vehicle, and to ensure stability when the jack is extended. Hydraulic jacks are often used to lift elevators in low and medium rise buildings



Figure 1.3: Hydraulic jack

### **1.1.1 Overview Of The Car Screw Jack**

A screw jack is a type of jack that is operated by turning a lead screw. In the form of a screw jack it is commonly used to lift moderately heavy weights, such as vehicles. More commonly it is used as an adjustable support for heavy loads, such as the foundations of houses, or large vehicles. These can support a heavy load, but not lift it. The power screws (also known as translation screws) are used to convert rotary motion into translator 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.

Automobile screw jacks or jack screw is a device that is used to lift an automobile in order to carry out repairs or maintenance. Screw jacks are designed with materials having the capabilities and properties to lift heavy loads and prevent buckling, wear etc. which can result to unforeseen accidents. Screw jacks have been used for more than 50 decades with new developments and redesigns [Khurmi et al., 2005]. The conventional screw jack (which is the scissors jack) is still commonly used due to its many advantages such as long life span, strength, packaging, mobility, cost etc., with the greatest to be its self-locking attribute, which means when the rotational force on the screw is removed, it will remain motionless where it was left and will not rotate backwards, regardless of how much load it is supporting. This makes them inherently

safer than hydraulic jacks, for example, which will move backwards under load if the force on the hydraulic actuator is accidentally released. Mechanical advantage is important in car jacks because it enable human lift a vehicle by manual force single-handedly. More powerful jacks use hydraulic power to provide more lift over greater distances. Mechanical jacks are usually rated for maximum lifting capacity. This is peculiar in developing nations where traditional screw jacks are often in use.[Rout et al., 2014] designed and fabricated a motorized automated object lifting jack using electric motor for lifting and lowering of heavy loads.

There are different kinds of jacks available; a good example is the bumper jacks obtainable in older cars and scissor jacks, quite common in newer cars. The tension force applied by the jack lead screw gives rise to a compressive force. An Acme thread is a very tough and strong thread often used and is capable of resisting the large loads imposed on most jack screws. Car jacks usually use mechanical advantage to enable vehicle lifting. There are two types of automotive car jacks: Hydraulic and Screw type. The screw type is common. The screw-type devices has a very great advantage which has to do with the tapered sides of the screw wear, the mating nut automatically comes into closer meeting, instead of allowing backlash to develop [Rajput, 2010].

There also categories of screw and hydraulic jacks. Hydraulic jacks by operating the handle, lift a lever (a simple machine), fluid is compressed and routed to an actuating cylinder which results in lift. Other examples of hydraulic type of screw are hydraulic jack, bottle jack, floor jack, friction jack, and racking jack. Parker and Pickup[Parker F.,2004] revealed the accurate and precise prognostication of a screw thread, the tedious nature and time taken to achieve the lifting process. Different design of threads are shown conventionally on engineering drawings. It is also very

important to note the need to lubricate screw jacks with grease on regular basis. Another type of screw is the ball screw which is quite unconventional and uses re-circulation ball nut to minimize friction and prolong the life of the screw threads. The major disadvantage of this kind of ball screw is its inability to self- lock [Gere ., 2010]

### **1.1.2 Application**

The main applications of screw jack are as follows:

- i. To raise load, screw-jack,
- ii. To obtain accurate motion in machining operations, e.g. lead-screw of lathe,
- iii. To clamp a work piece, e.g. vice, and
- iv. To load a specimen, e.g. universal testing machine.

### **1.1.3 Overview Of The Motorized Screw Jack**

The motorized screw jack is 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 is 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 motorized jacks can also be used for pull, push, creating tension etc.

In the mechanisms of the motorized jack, the D.C motor is attached with the screw jack by some coupling techniques of gear systems which convert horizontal and vertical motion. A D.C motor utilize the D.C current to convert electric power into mechanical power. Its work on the principle that “when a current-carrying conductor is positioned in a magnetic field, it experiences a magnetic force whose direction is given with the aid of using Fleming’s left-hand rule”.

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. The efficiency of the motorized screw jack is maximized with the use of lubrication.

#### **1.1.4 Part of Motorized Screw Jack**

To fabricate and design a motorized screw jack, the following are component parts to be assembled;

- i. D.C Motor( permanent magnet)
- ii. Switch
- iii. Screw Jack
- iv. Battery
- v. Electrical wires
- vi. Housing/frame(u-channel )
- vii. Universal joint

##### **1.1.4.1 Advantage**

The motorized screw jack easily lift or raise the moderate heavy weights against gravity and uses very small handle force which is applied bits motor mechanism.

Below are the advantages:

- i. They are self-locking.
- ii. They are simple to Operate.
- iii. They have large load carrying capacity.
- iv. The manufacturing of motorized screw jack is easy without requiring specialized machinery.
- v. The motorized screw gives smooth and safe service cared to an ordinary screw jack.

vi. There are only a few parts in the fabrication of motorized screw jack which reduces cost and increases reliability.

vii. They can lift moderately loads like cars with very less force.

#### **1.1.4.2 Disadvantage**

The major disadvantage of the motorized screw jack is that without proper source it will not function, other disadvantages include chances of dropping, tipping or slipping of the load, stiffness of screw, and they cannot be used to lift or support very heavy loads and can cause serious accidents hence the device is termed as not safe fail.



Figure 1.4: Typical example of a motorized jack.

## **1.2 Statement problem**

The motorized screw Jack is constructed to lift the weight of approximately 750kg part of a vehicle with relative ease and use of minimal force. The motorized screw jack will easily lift and lower the car, with a minimum ground clearance of 110 mm for tyre replacement. The maximum load of the jack is 1000 Kg, and the maximum input torque of the motor is 220Nm. The vehicle should be lifted for certain type of works.

To make the work easier other than using a screw jack a new concept of screw jack which is the motorized screw jack is introduced, this concept should facilitate

operation of the screw jack without human effort. Vehicle can easily be lifted up and down by using the ON/OFF switch mechanism.

### **1.3 Aim**

The main aim of this design is to develop a mechanism of a motorized screw jack that is more efficient, stress free, saves time and a reliable way to achieve lifting of the load making it quick and effortless in order to reduce physical fatigue caused by former versions of screw jack. The motorized screw jack is also aimed at low cost automation in manufacturing industries.

### **1.4 Objectives**

The specific Objectives of this design are as follows;

- i. To design a motorized system for a screw jack.
- ii. To achieve an efficient and controlled weight lifting (in this case; a vehicle).
- iii. To save time and reduce labour by automating lifting.
- iv. To enhance safety by minimizing manual lifting effort thereby reducing risk of injury caused by mechanical Operations.

### **1.5 Step**

To attain the above objectives of development of the motorized screw jack, the following are steps to be taken:

- i. Define Requirements: The load capacity, desired lift height, power source (electric, hydraulic, pneumatic), and other specifications are determined.
- ii. Conceptual Design: Create a rough sketch or 3D model of the scissor jack layout, considering factors such as the arrangement of scissor arms, motor placement, and control mechanism.
- iii. Detailed Design: Develop detailed engineering drawings specifying materials, dimensions, tolerances, and assembly instructions. This includes designing the scissor

mechanism, motor mount, gearbox, control system, and safety features mainly using AUTOCAD.

iv. Material Selection: Appropriate materials are chosen for each component based on factors like strength, weight, and cost. Common materials include steel for the scissor arms, aluminum for lightweight components, and various plastics for non-load-bearing parts.

v. Fabrication: The components are fabricated according to the engineering drawings. This may involve cutting, welding, machining, and assembly processes. Precise fabrication, functionality and safety is maintained

vi. Motor and Control Integration: Motor, gearbox, and control system are installed according to the design specifications. The motor is tested to ensure proper functionality and compatibility with the scissor jack mechanism.

vii. Safety Testing: This is a procedure taken to ensure that the modified jack could safely lift the intended load. This also include the test for durability and safety standards.

viii. Assembly: All components are assembled, this include scissor mechanism, motor control system and safety features.

### **1.6 Justification of the Project**

While there are car jacks made to raise cars, changing a flat tire can be an unpleasant task. Additionally, the majority of car jacks are manual, meaning that users must exert significant physical effort to use them. This becomes challenging for the elderly and handicapped, especially in unfavorable weather conditions. To this end the motorized screw jack is designed to alternatively provide an apt solution as it reduces labour imposed on the user, its efficiency and reliability.

The amount of time needed to change tires is greatly reduced due to the introduction of controlled mechanical operation of the motorized jack, this is important and serves as an added advantage especially to vehicle repair experts.

### **1.7 Scope**

This project focuses on designing and fabricating a prototype motorized screw jack, specifically utilizing a motor mechanism for its reliability and ease of operation. The goal is to present a novel idea in car jack design, focusing on optimizing the jack to have a maximum lifting capacity of 750kg to 1000kg . The project scope also includes optimizing human power by incorporating a motor and gear axle for the operation involved in utilizing screw jack for lifting load.

The analysis results will guide the selection of the most user-friendly concept for the motorized jack.

### **1.8 Limitation**

In the design of screw car jack we have faced so many limitations including:

- i. Due to the initiation of the motor mechanism, the jack would be less portable compared to the normal screw jack.
- ii. The maximum lifting capacity of the jack does not exceed 800kg
- iii. Lack of resource i.e. computer access, money, powered motor of high quality.

## CHAPTER TWO

### 2.1 LITERATURE REVIEW

#### 2.1.1 Principle of The Motorized Screw Jack

The ideal situation is for the jack to be placed beneath the car body with some leeway between the top plate and the skeleton. A battery is used to drive the D.C motor. The D.C motor shaft is connected to the screw through coupling. If the power is driven to the D.C motor, it will run so that the screw also runs and converts rotary to translator motion. The arms of the 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 the power from the battery. The screw receives power from the battery once the switch is pressed.

When tapping the switch to the positive pole, positive voltage is supplied to the D.C. motor in clockwise direction and the lead screw moves in downward direction. Similarly, when tapping the switch to the negative pole, negative voltage is supplied to the D.C. motor which moves in anticlockwise direction and the lead screw moves in upward direction. In this way the directions can be controlled which in turn regulates the lift load direction either upward or downward.

Considering the movement of the screw thread in a jack, it is shown that one complete turn of the screw, will form an inclined plane as shown in the figure below;

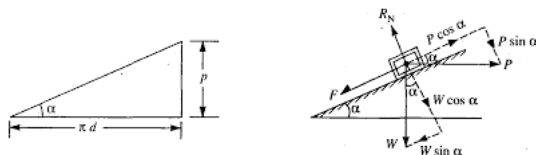


Figure 2.1: An inclined plane

Where.

$P$  = Effort applied at the circumference of the screw to lift the load,  $W$  = Load to be lifted, and  $\mu$  = Coefficient of friction, between the screw and nut  $\tan \alpha$ , where  $\alpha$  is the friction angle.

From the geometry of the Figure 2.1 we find that

$$\tan \alpha = p/n d$$

since the principle, on which a screw jack works is similar to that of an inclined plane, therefore the force applied on the circumference of a screw jack is considered to be horizontal. Since the load is being lifted, therefore the force of friction ( $F = \mu.R$ ) will act downwards. All the forces acting on the body are shown as resolving the force along the plane,

$$p \cos \alpha = w \sin \alpha + F = W \sin \alpha + \mu. K \dots \dots \dots (i)$$

and resolving the forces perpendicular to the plane,

$$R_{\{N\}} = P \sin \alpha + W \cos \alpha$$

Substituting this value of  $R_N$  in equation (i), we have =

$$W \sin \alpha + \mu(P \sin \alpha + W \cos \alpha) \dots \dots \dots (ii)$$

## **2.2 Introduction To Literature Review About The Design and Fabrication of Motorized Screw Jack**

In this project section, an exploration of relevant project papers is conducted. Emphasis is placed on published papers, incorporating information gathered from reference books, magazines, journals, technical papers, and websites. The primary goal of this literature review is to extract insights for the project. The discussion in this chapter is based on a comprehensive analysis of various sources. A few articles on pressure vessel supports serve as a foundation for developing the structural analysis methodology for the motorized screw jack.

### **2.3 Illustration of Literature Review About Design And Fabrication of Motorized Screw Jack**

Experimental Investigation of the Performance of a motorized Screw Jack and concluded and has been established that the relationship between the load and efficiency, and between the load and effort applied is linear and was also discovered that decrease in load means decrease in effort and decrease in load causes increase in efficiency. [ISOR journal of mechanical and civil engineering., 2010]

In this paper a lifting device is a system that allows small force (effort) to overcome a large force or load. There are practically hundreds of uses for lift tables in manufacturing, warehousing and distribution facilities. The addition of this device (lift table) makes job faster, safer and easier. Some typical applications include; machine feeding and off-loading, product assembly, inspection quality control repair, feeding and offloading conveyor levels. The commonest method for operating a scissors lift is the use of a power screw [Ferreira., 2004]

This research journal shows that automatically operated screw jack lift is a device that makes use of a horizontally placed power screw to overcome large load through less effort applied on the power screw transmitted from the rotating shaft of a motor (D.C). One of the most important factors of lift platform is its stability. Knowing that stability is a source of concern for a lift platform, its positioning should be on a flat surface and the load should be place or concentrated at the center of gravity of the table. Other constraint to be considered is the deflection of the unit. Deflection in the lift can be defined as the resulting change in elevation of all parts of a motorized screw jack lift assembly, typically measured from the floor to the top of the platform deck, whenever load is applied to or removed from the lift.

The electricity for operating the motorized screw jack was sourced from a 12V direct current (DC) battery, leveraging increased mechanical advantage. Okonkwo et al. developed a hand water pump utilizing a quick return crank mechanism. Chaudhary et al. designed a screw jack using Solid Works in 2010, then constructed it using available machine tools such as lathe, grinding, threading, and milling machines. The efficacy of the developed jack was tested and found to effectively address ergonomics issues.[ Okonkwo et al., 2010]

In this journal, there was a designed and constructed screw jack where worm and spur gear arrangement were considered. The component parts of the system included the worm gear, spur gear, ball bearings, and circular shafts. They utilized soft engineering materials, including aluminum and bronze alloys, in the development of the worm gear. For the lifting screw, they selected a tough and heat-treated hard material and performed failure analysis to determine the appropriate screw shaft. [Kumar et al., 2010]

This journal shows that in existence, there are a range of car jacks that are designed to lift a vehicle from the ground. Most of these are however manually operated which implies that they require extra physical effort from the operator. For operation of these jacks, operators are required to be in prolonged. squatting position for some duration which can lead to the problem of backache. During road- side emergency like tire punch, a jack is required to lift the vehicle.

Hence, there is need to design and fabrication of a motorized screw jack that is used for lifting, using the power from a DC motor. This, does not only reduce human efforts but also save time needed to effect repairs and that is easy and safe to use. This study focuses on design of a motorized car jack that utilizes the 12-volt vehicle battery which supplies power to the motorized jack through the cigarette lighter

receptacle point on the dashboard of the car. The fabrication has been considered with utmost simplicity and economy, such that this can be accommodated as one of the essential tools on automobiles garages [Noor et al., 2010].

Our research in this regard reveals the facts that mostly some difficult methods were adopted in lifting the vehicles for reconditioning. This paper attempts to solve this issue, and an appropriate tool must be created so that the car can be raised off the ground without using any impact force. Even though there are more mechanical components to the system due to shifting requirements for physical input, the operation is still vital to it. [Anand et al., 2017]

This journal show that by utilizing a 12V DC motor to rotate the jack screw, the effort needed to do so can be reduced, making tire replacement simpler. Advantage of this system is that it draws the energy from the vehicle's battery. Two spur gears are used to multiply the torque that the motor produces. A small gear is mounted on motor shaft and a large spur gear on power screw of jack. Additionally, by adjusting the helix angle, which can reduce the amount of energy the motor draws, we hope to improve the efficiency of the motorized screw jack. [Prashant et al., 2013]

In this research journal, the attention of researchers has been drawn to the failure of screw in manufacturing and production companies. The major causes of screw failure is attributed to poor design, lack of grease and poor engineering practices. In order to avoid stiffness and this kind of failure, the design calls for the screw to be well lubricated.[Rajput,2010]

In this journal, the project shows modification of current mechanical manual jack with the use of an electric DC motor in the screw in order to make load lifting easier as we know reduction in mileage is due to drop of few pressure units in vehicle, tire life, safety and performance. This system can be placed in every in automobile under any

operating condition, this will not only maintain the correct tire pressure but also increase tire life, mileage and safety. So, to inflate and deflate the tire automatically by using control unit the system was fabricated [ Parmeshwar et al., 2019]

In this Paper, 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. An Android device is used to Control the DC Motor by using a Printed Circuit Board. [Radhakrishna et al.,2019]

In this journal, studies have shown that in order to mitigate the problems associated with the use of a single jack and other lifting devices to raise cars completely off the ground to effect repairs, analyzes the modification of the existing motor screw jack by incorporating an electric motor in the screw in order to make load lifting easier. Modification of design, power screw is rotated by connected in prime mover through universal coupling, plugged to the automobile 12 V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the power screw to be rotated with required speed reduction and increased torque to drive the power screw [Musa Nicholas et.al., 2016]

This research journal conferred that whenever any vehicles undergo a tyre failure, it becomes a really cumbersome task for the person to raise the vehicle from the foundation level and lot of manual effort is required even though a jack is used [Dr. Ramachandra, CG et.al., 2013]

In this journal, studies shows that automobile hydraulic jack often simply be operated by a one push button provided on the dash board. The jack will be installed on either sides of chassis according to the weight distributions of the car. The system operates on hydraulic drive which consists of three main parts: hydraulic pump, driven by an electric motor, hydraulic cylinder to raise the vehicle. The car gets lifted and load gets

distributed on three point i.e.. plunger or ram of hydraulic cylinder and two tires opposite to side which is lifted [N.K. Mandavgade., 2012]

In this journal researches have concludes on the basis principle of hydraulic power and 12 Volt DC current supplied, to solves the all major dilemma on maintenance of all automobiles specially the heavy vehicles like truck and bus [Blaise Pascal., 2013]

In this research journal, It shows that jacks are devices that uses force to carry significant load. The primary mechanism with that force is applied varies, depending on the specific type of jack, but is typically a screw thread or a hydraulic cylinder. Categorization of jack is based on the type of force they employ: mechanical or hydraulic. Mechanical jacks, for example car jacks and house jacks, lift weighty equipment and are rated based on lifting capacity (for instance, the number of tons they can lift) [Mohammed et.al., 2014]

From the above reviews there is need for a D.C. motor, battery, gear arrangement and a screw jack arrangement such that will accommodate deflection when the jack is in use, materials to be used must be able to accommodate certain level of deflection.

While fabricating the motorized screw jack power source should be considered, hence instead of making use of the accessory outlet to draw power which may be an hindrance to full power output of the battery we can jus draw power directly from the car battery.

In the process of coupling the D.C motor to the jack , a universal joint will be introduced to support easy movement and transmission of torque, a gear axle which make use of speed reduction system will also be introduced to support the load.

## CHAPTER THREE

### DESIGN METHODOLOGY AND ANALYSIS

#### 3.1 Methodology

Our approach to the design and fabrication of the motorized screw jack will include:

Research and analysis: Research on previous designs, reviewing related literature of previous studies to get a better understanding of current designs and their limitations.

Analyze the requirement and constraint of improving or modifying the current design to meet with expected result.

##### 3.1.1 Design Consideration

i. Problem specification: It is required to design a motorized screw jack able to support lifting of a vehicle during repair or maintenance. It should be a general purpose jack with a load carrying capacity of 900 tonnes and maximum height lifting of 0.3 m. the jack is to be operated by means of D.C motor.

ii. Design: Develop an initial design considering factors such as load, load resistance, efficiency of effort applied, output power of the motor, ease of use and ease of maintenance. Create schematics, including specifications for components, materials, and manufacturing processes.

iii. Material selection: The selection of materials to be used for this project will depend on several factors such as intensity, type of stress to which the components are subjected to, whether the component is rigid or flexible, if it is to experience high resistance or deformation.

iv. Prototype Development: fabricate a prototype based on the design. Test and refine the prototype to ensure optimal functionality and performance.

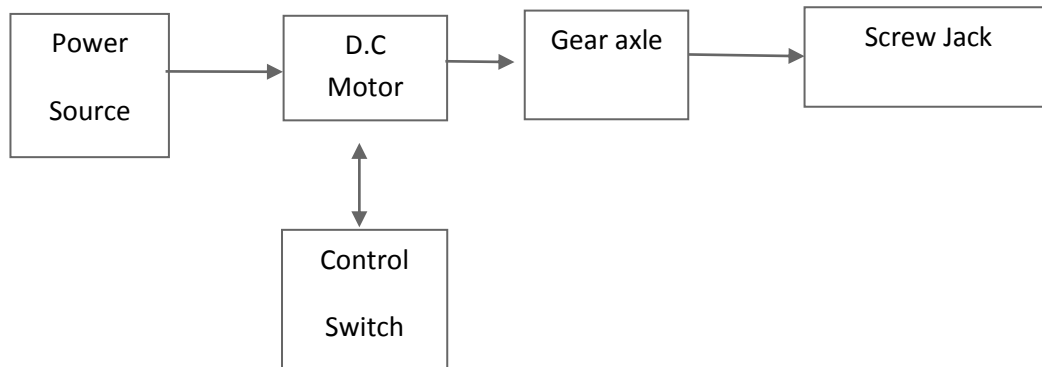


Figure 3.1: Flowchart diagram of a motorized screw jack

### 3.1.2 Design Requirement

- i. The motorized screw jack should be able to lift load within the specified range. The jack should have high torque also need or means of controlling the motor speed or torque).
- ii. It should be safe to operate. (should include a secure locking mechanism to prevent operation),
- iii. It should be easy to maintain(clean) for proper hygiene. Ensuring motor do not pose a risk when cleaning.
- iv. The screw jack should be portable. It should easily fit in a car booth without occupying excessive space and should be easy to carry.

Other requirements include;

- i. Power source: Typically due to motor operation, the power source as regard the motorized screw jack should be electric.

ii. Speed: In alignment to calculations, the speed of the motor to support the specified load is determined

iii. Control system: For simplicity of the prototype the control system will only include a toggle switch.

iv. Safety Features: in the project cold works, and for the purpose of safety when the motorized screw jack is in use, there is need to introduce an overload protection or emergency switch button.

### **3.2 Material selection**

Screw jacks are usually made of materials that are very strong and are suitable for withstanding heavier loads on it. Steel is selected as material for scissor screw jack because of its durability. Mild steel is a type of carbon steel that contains a low level of carbon. Otherwise known as low carbon steel, mild steel contains roughly between 0.05% and 0.25% of carbon by weight. This is opposed to high carbon steel, which can be composed of up to 2.5% carbon by weight. Mild steel is ductile, machinable, affordable, and weldable.



Figure 3.2: Mild steel

The major factors to be considered during selection of materials are

- i. Strength: High-strength materials might be chosen for components subjected to heavy loads or stress to ensure durability and performance. For example steel or aluminum alloys for structural elements in machines.
- ii. Weight: Lightweight materials may be preferred for applications where weight is critical, such as aerospace or portable devices. For example Aluminum or carbon-fiber composites for lightweight structures.
- iii. Part of the machine to be fabricated: Different parts may require different materials based on their function and operating conditions. Some parts of the machine may be subjected to high temperature or corrosive action, this should be taken into account when selecting materials.
- iv. Work-ability of the material: Ease of fabrication, machining, and forming can influence choice based on manufacturing processes. For instance aluminum is often chosen for its easy machining and forming capabilities.
- v. Cost of production: This is an important factor to consider as it determines the total cost of production which in turn affects the price of the product or retail cost and consumer choice. If overall production costs are high, the eventual price of the finished product will likely be high, a higher product price may prompt consumers to explore alternative options
- vi. Corrosion Resistance: The screw jack will be mostly used outdoors, as such materials to be used should be able to resist rust and corrosion.

Designing and fabricating a motorized scissors screw jack involves several materials and equipment. Here's a basic description of equipment used:

SN	Materials used	Selection Criteria
1	Mild steel for screw jack and base plate	Workability, relatively cheap, toughness and high resistance to deformation.
2	Bolts and Nuts	To couple or fasten parts together.
3	Screws	To couple parts together.
4	Electric Motor	For producing rotational power or torque.
5	Electrodes	For welding metal parts together.
6	Paint	To coat metal parts of the project work.
7	Universal joint (alloy steel)	To aid movement of parts in different angles.

Table 3.1 Material selection

### 3.3 Machine components

To construct a motorized screw jack the following are major components to be utilized

#### Screw jack

A jack serves as a simple tool for lifting various loads, utilizing different mechanisms like mechanical screw threads or hydraulic power. Commonly encountered types include automobile jacks, which are pivotal for lifting vehicles or heavy loads for maintenance or relocation purposes. Jacks come with a designated maximum safe lifting capacity, ensuring operational safety and efficiency. Industrial-grade jacks can handle substantial loads, often rated for hundreds of tons. Scissor jacks, for instance, leverage mechanical advantage, allowing users to lift vehicles with manual force. Early garage jacks featured a platform for raising a car's body or axle, while modern electric scissor jacks streamline the process with 12-volt power drawn from the

vehicle's cigarette lighter socket. Electric variants significantly reduce the effort required compared to manual counterparts.

### **Switch**

A toggle switch is employed to initiate or halt the operation of a lifting jack. It falls under the category of electrical switches activated manually by a lever, handle, or rocking mechanism. Toggle switches are engineered to facilitate simultaneous activation of multiple electrical contacts or the management of substantial electrical currents or mains voltages.

### **Electrical wires**

An automobile's wiring has to distribute electricity from the battery to gadgets positioned everywhere in the automobile. It additionally has to transmit statistics on a statistics bus, in addition to a whole lot of virtual and analog signals from switches and sensors. There are many distinct types of wires used in automobile industry. Some wires that transmit signals from switches or sensors convey nearly no current, & also those that offer electricity to huge electric powered motors carry lots of current.

### **Battery**

A car battery, also known as an automobile battery, is a rechargeable lead-acid battery utilized to initiate the ignition of a motor vehicle. Its main function is to supply electrical power to the starter motor, which in turn activates the chemically-powered internal combustion engine responsible for driving the vehicle forward. For the case of our project the car battery serves as a provision for source of power for the motor.

### **D.C Motor**

A D.C motor utilize the D.C current to convert electric power into mechanical power. Its work on the principle that "when a current-carrying conductor is positioned in a magnetic field, it experiences a magnetic force whose direction is given with the aid

of using Fleming's left-hand rule" ("Keep the fore finger, center finger and thumb of the left hand mutually perpendicular to one another. If the fore finger suggests the direction of magnetic field and middle finger suggests course of current within the conductor, then the thumb suggests the direction of the movement of conductor.").

A DC motor's speed can be controlled with the usage of both a variable deliver voltage or with the aid of using changing the strength of current in its field winding.

When a motor is in operation, it develops torque, which is used to rotate the shaft of the mechanism through belts, chains or shaft coupling.

### **Gear**

In this project external spur gears are used, the outer teeth are cut on the outside diameter while the internal diameter is kept smooth. Gears are used to transmit rotary movement among parallel shafts and the shafts that rotate in opposite directions. They have a tendency to be noisy at excessive speeds as the equipment surfaces come into touch at once.

Design considerations for a gear drive in the design of a gear drive, the subsequent information is typically given:

- i. The power to be transmitted,
- ii. The speed of the driving gear,
- iii. The velocity ratio, and
- iv. The center distance.

The following necessities should be met for a gear drive:

- i. The teeth of the gear should have sufficient strength so that it can withstand the static or dynamic load applied during working.
- ii. The gear teeth need to have wear characteristics in order that their lifecycle is satisfactory.

iii. The use of space and material need to be economical.

Alignment & shaft deflection should be taken into consideration as they impact the performance and life of gears.

### **3.4 Construction Technique of The Motorized Screw Jack**

The following operation sequences were undertaken in the fabrication of the multipurpose pounding machine: measurement and marking out, cutting of material, welding, grinding, and drilling operation. And the following tools were used: Hack saw, Scriber, Try-square, Measuring tape, welding machine, Grinding Machine and Drilling Machine.

#### **3.4.1 Operation Sequence**

These Include;

Measurement and Marking Out: The measurements were used according to the design specification and the marking out was done accordingly.

Cutting of Materials: Sheet metal (stainless plate) of 3mm thickness, sheet metal (mild steel) 5mm thickness were marked out according to the dimension. The cutting operation was carried out manually using shearing machine to cut angle bar and shaft while hand cutting machine is used to cut sheet metal manually.

Welding Operation: Welding machine is used for joining metal components, especially for welding the frame and scissors mechanism. MIG or TIG welding is commonly used for this purpose. Welding plays a crucial role in the manufacture of a scissors screw jack by allowing for the fabrication of a strong and reliable structure that can withstand the forces involved in lifting heavy loads. Welding is used to attach brackets for mounting the motor, screw, and other components to the frame of the jack. The scissors mechanism of the screw jack is typically made of metal bars that

are linked together. Welding is used to join these bars at the pivot points, allowing them to expand and contract as the jack is raised and lowered.

All materials being cut out were joined by the use of arc weld machine.



Figure 3.3: Welding Machine

Grinding operation: Contours on the welded joints of the work piece smoothed by use of grinding machine. It is the operation in which all welded area and rough surfaces are slightly ground for smooth and aesthetes surface finishing.

Painting Operation: After all joining processes of the motorized screw jack the whole body apart from the motor was painted as such to coat the metal and prevent from rust.

### 3.4.2 Fasteners

Fasteners forms a non-permanent joint, joints that can be removed or dismantled without damaging the joining components. Grade 8.8 or higher bolts are often used for their strength. Bolts, nuts, and washers made of steel to assemble the components securely. Fasteners can reliably hold together objects that can experience a great degree of stress. Some examples of fasteners are bolts, screws, nuts, grommets, rivets, and studs.



Figure 3.4 : Fasteners

### 3.4.3 Lubricant

Grease or oil to lubricate moving parts and reduce wear. It's important to use the right type of lubricant for each application. Lubricant is a substance which is used to control (more often to reduce) friction and wear of the surfaces in a contact of the bodies in relative motion. Depending on its nature, lubricants are also used to eliminate heat and wear debris, supply additives into the contact, transmit power, protect, seal.

### 3.5 Design and Calculations Of The Motorized Screw Jack

Certain calculations were made on certain parameters so as to make correct choices in selecting each components of the motorized screw jack some of which are calculated based on load to be lifted and efforts to be applied.

#### a) Design of the Screw

To determine the force 'p' required to overcome a certain load 'W', it is necessary to observe the relationship of the load to the distance travelled. The total force on Pn given below

$$\sin\theta_n = \cos\theta_n \cos\alpha \tan\beta/2$$

$$\theta_n = \tan^{-1}(\cos\alpha \tan\beta/2)$$

Summing up vertical forces from figure 5,

$$P_n = \cos\theta_n \cos\alpha = \mu\psi \sin\alpha + w$$

$$P_n = w/(\cos\theta_n \cos\alpha - \mu \sin\alpha)$$

The torque required to raise the load is obtained by multiplying the horizontal force by the appropriate radii, thus

$$T_r = P_n(D_p/Z)(\cos\theta \sin\alpha + \mu \cos\alpha) + Y_c$$

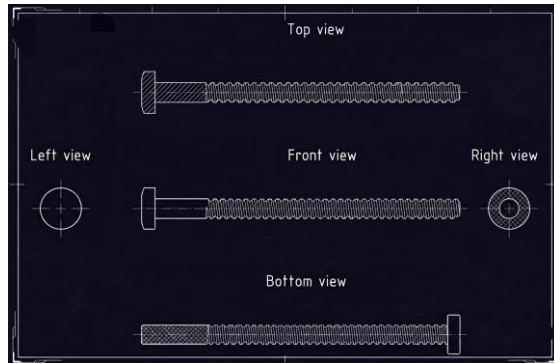


Figure 3.5: Power screw

Given pitch of screw = 4mm

Core diameter  $D_c = 10\text{mm}$

Major screw diameter  $d_o = 14\text{mm}$

Mean diameter,  $d = d_o - p/2$

$$D = 14 - (4/2)$$

$$= 12\text{mm}$$

$$\tan \alpha = p/\pi d$$

$$\tan \alpha = 4/(3.14 \times 12)$$

$$\tan \alpha = 0.106$$

Assuming coefficient of friction,  $\tan \theta = 0.1$

Maximum Load to be raised = 750Kg = 7500N

Taking gravity  $g = 10\text{m/s}^2$

$$W = 7500\text{N}$$

$N$  = Number of revolutions to reach one cycle

$P$ , Effort required to raise the load

$$P = W \times \tan(\alpha + \theta)$$

$$= W \times \tan(\alpha + \tan\theta)/(1 - \tan\alpha \times \tan\theta)$$

$$P = 7500 \times [(0.106 + 0.1)/(1 - (0.106 \times 0.1))]$$

$$P = 1561.55 \text{ N}$$

Torque required to raise the load,  $T = P \times d/2$

$$= 1561.55 \times 12/2$$

$$= 9369.27 \text{ Nmm}$$

$$T = 9.37 \text{ Nm}$$

Power required to drive the Screw jack;

$$P = T \times \omega,$$

$$W = (2\pi N)/60$$

$$P = 9.37 \times [(2 \times 3.14 \times 51)/60 ]$$

$$P = 50.02 \text{ watts}$$

$$\text{Shear stress, } \tau = 16T / \pi DC^3$$

$$= (16 \times 9369.27) / \pi \times 10^3$$

$$\tau = 4.77 \text{ N/mm}^2$$

#### b) Design of Pin

The pins are used to join a rotating link axis. They are used to hold parts together or limit traveling distance of moving part.

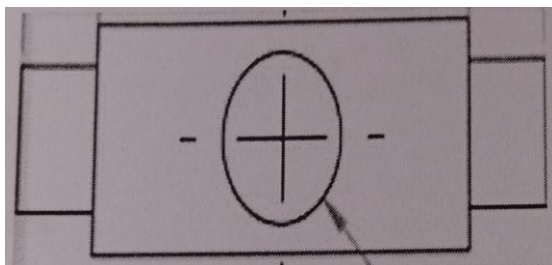


Figure 3.6: Pin

$$\text{Diameter of head } d_h = 1.5 \times d_{\text{pin}} = 1.5 \times 20 = 30\text{mm}$$

$$T = F_s/A = F_s/\pi d^2 = 1041.03 / (3.142 \times 20^2) = 1.26 \text{ MPa}$$

### c) Design of Base Plate

Here the base plate should withstand applied load plus the whole component load by itself, the force, we have to select the material during the design process in order to resist the load.

$$A_{\text{bending}} = t_{\text{bending}} \times d_{\text{hole}}$$

$$0.25 \times 0.10 = 0.025 \text{ mm}^2$$

Base thickness is 6mm designed from mild steel.

## 3.6 Manufacturing process

### a) Manufacturing of power screw

The power screw was fabricated from cast iron, so as to withstand pressure from load and also from deformation. The power screw was designed with the following parameters

Pitch of screw 4mm

Major screw diameter 14mm

Having length of

Friction coefficient 0.21

Safe pressure  $P_o = 17 \text{ MPa}$ ,

The power screw was threaded on a lathe machine, with an acme thread type.

Thread cutting of power screw on a lathe: -

Threads are cut using lathes by advancing the cutting tool quickly so that it cuts in a helical band. This helical band is actually a thread. The procedure calls for correct settings of the machine, and also that the helix be restarted at the same location each time.

The basic procedure is,

The tool point must be ground so that it has the same angle as the thread to be cut. Typical angles are  $60^\circ$  for V threads, and  $29^\circ$  for ACME threads. A thread gauge can be used to measure thread angles. (Also called Centre Gauge or Fish Tail Gauge).

The compound slide is set at half the thread angle. This is so that as multiple passes are made to cut the thread (most threads require a few passes to cut), the tool will be advanced in by the compound slide in such a way that only one face cuts. If both faces were used for cutting there would be a good chance of vibrations and chatter. For example, if a  $60^\circ$  thread is being cut, the compound rest is often set at  $29^\circ$ .

The cutting tool is set in the holder perpendicular to the work, and the fishtail gauge is used to check the angle of the point.

The In-feed is set to the surface of the part for the first pass (quite often the first pass just scratches the surface to allow visual checking of the settings). On each subsequent pass the in feed will be set closer.

The cross slide is set at the same location for each cutting pass. i.e., the dial setting is zero.

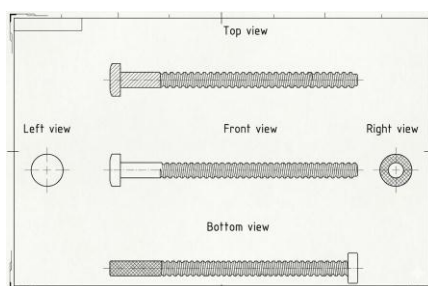


Figure 3.7: Power Screw

## b) Manufacturing of base plate

The base plate was fabricated from mild steel having thickness of 5mm,

The reason for using the mild steel was to withstand pressure and stress, when the jack is in operation the simple operation include

- i. Marking out: In accordance to the previous calculations the base plate was first measured and marking tools was used to mark out, on the mild steel, which was held by a vice an holding tool.
- ii. Cutting out: With the use of cutting tools, in this project we used cutting stone.
- iii. Machining: the cut out plate was machined to give desired shape,
- iv. Boring: This was done on the plate by use of drill,

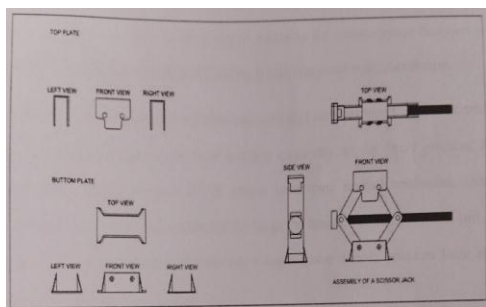


Figure 3.8: Cross sectional view of a screw jack

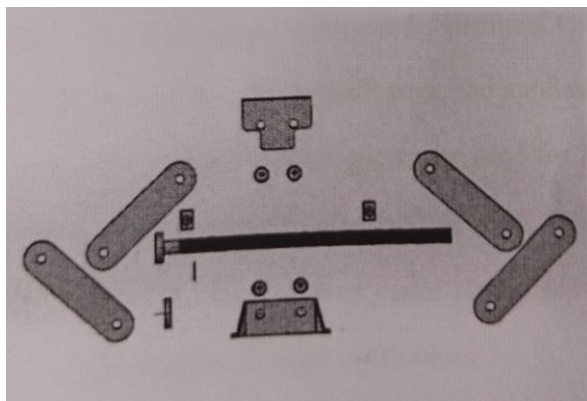


Figure 3.9: Expanded front view of screw jack

### **3.6.1 D.C Motor specifications**

Why choose D.C Motor ?

Many applications call for a high start-up torque. The D.C. motor, by its very nature, has a high torque vs. falling speed characteristic and this enables it to deal with high starting torques and to absorb sudden rises in load easily. The speed of the motor adjusts to the load. Furthermore, the D.C. motor is an ideal way of achieving the miniaturization designers are constantly seeking because the efficiency it gives is high compared with other designs.

A D.C motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of D.C motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

D.C motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A D.C motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field winding. Small D.C motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger D.C motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of D.C motors with A.C motors possible in many applications.

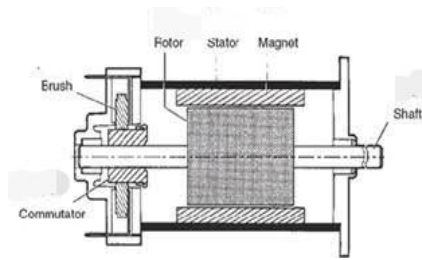


Figure 3.10: Composition of a DC motor

### Motor specifications

Voltage: D.C volt, 12- 14volts

Current: 3.5 amp

Power rating: 40 watts

Operating speed: 2600rpm

Torque: 220Nm

### 3.6.2 Spur gear axle

Spur gears are a cylindrical shaped toothed component used in industrial equipment to transfer mechanical motion as well as control speed, power, and torque. These simple gears are cost-effective, durable, reliable and provide a positive, constant speed drive to facilitate daily small scale and industrial operations.

The design and construction of a spur gear significantly influence its performance. To do their jobs effectively and efficiently, they need to be fabricated from high-quality materials and to precise dimensions. The dimensional measurements of each feature are integral to how a specific gear functions. As such, when an industry professional requires a new spur gear each gear part and their respective measurements to ensure clarity and accuracy in the production or purchase order.

Some commonly used spur gear terms include:

**Pitch Circle:** The circle derived from a number of teeth and a specified diametral pitch. The circle in which tooth spacing or profiles are established from which tooth proportions are constructed.

**Diametral Pitch:** Ratio of the number of teeth to the pitch diameter.

**Pitch Diameter:** Is the diameter of the pitch circle. This is where a spur gears angular velocity is measured. This is also a critical component for determining center distances between mating spur gears.

**Center Distance:** The distance between two gears, measured from the center shaft of one gear to the center shaft of the mating gear. This can be found roughly by taking the radius of each spur gears pitch circle and adding them together.

**Module:** The ratio of the reference diameter of the gear divided by the number of teeth. Module is the projects beyond the pitch circle.

**Dedendum:** The depth of a tooth space below the pitch circle. Generally greater than the addendum of the mating gear to provide clearance.

**Outside Diameter:** The diameter of the addendum circle, or the circle along the outermost points of a spur gear's teeth. This measurement is the largest diameter spur gears have.

**Root Diameter:** The diameter at the base of the tooth space, or the diameter of the tooth space.

**Pressure Angle:** The angle at a pitch point between the line of pressure which is normal to the tooth surface, and the plane tangent to the pitch surface.

**Whole Depth:** The total depth of tooth space, equal to the addendum plus the dedendum.

Spur gears are used to transfer motion and power from one shaft to another in a mechanical setup. This transference can alter machinery's operating speed, multiply

torque, and allow for the fine-tuned control of positioning systems. Their design makes them suitable for lower speed operations or operational environments with a higher noise tolerance.

We use spur gear in this project design specifically for the following reasons;

- i. **Simplicity:** Spur gears feature a simple, compact design that makes them easy to design and install, even in limited or restricted spaces.
- ii. **Constant Speed Drive:** These gears increase or decrease shaft speed with a high degree of precision at a constant velocity.
- iii. **Reliability:** Unlike other power and motion transmission components, spur gears are unlikely to slip during operation. Additionally, their durability decreases their risk of premature failure.
- iv. **Cost-Effectiveness:** The simplicity of their design also allows for greater manufacturability, making them less expensive to fabricate and purchase even with highly specific or customized dimensions.
- v. **Efficiency:** Spur gear systems have power transmission efficiencies between 95% and 99% and can transfer large amounts of power across multiple gears with minimal power loss.

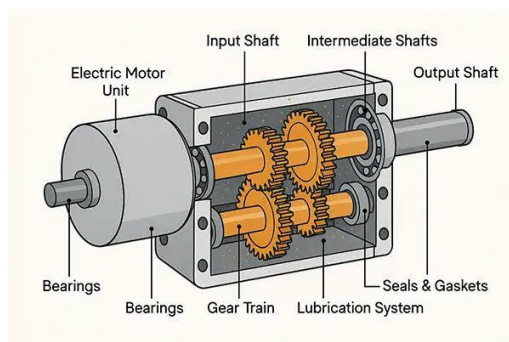


Figure 3.11: DC motor couple to hear axle

### **3.6.3 Universal Joint**

Universal joint, also called Cardan Joint is a mechanism for variable angle power transmission, used to change the direction of the drive line, which is an automotive drive system “Joint” parts. The universal joint combined with drive shaft is called universal joint drive.

The universal joint is subjected to a variety of forces (torsional, centrifugal, etc.) during high-speed movement. It is also in a hard-acting area and is subject to harsh working conditions. It is easily worn out and is a fragile part. In use, grease should be injected into the grease nipple to maintain good lubrication. Under normal conditions, the universal joint has a service life of 100,000 to 120,000 km, but due to the short service life of the four needle roller bearings on the cross shaft, the bearings are normally not replaced separately, but with the complete cross shaft universal joint. When it is sold and supplied, it is supplied as an assembly, not as a cross shaft or bearing, so the useful life of the universal joint assembly is only 50,000 to 60,000 kilometers.

### **3.6.4 Universal joint material:**

The most commonly used material for manufacturing Universal joints are 20MnVB and 20 0CrMnTi alloy steel. Both materials have excellent physical properties, such as wear resistance, high strength, good flexibility, and corrosion resistance. They are also cost-effective and widely available on the market. Furthermore, these materials can be machined easily with precision to achieve the tight tolerances required for universal joints in various applications.

The universal joint is the main component of the universal joint drive axles and is used to connect the angled two shafts (the output shaft of the transmission in this case D.C motor to the input shaft power screw). While rotating, the driven shaft is allowed

to swing at an angle that still normally transfers torque to suit the jack needs in supporting load and vibrations.



Figure 3.12: Universal joint

### 3.7 Assembling

This operation involves coupling together all components of the motorized screw jack. Firstly, the screw jack was mounted on the base plate and welded to the base plate, we choose welding here to obtain a flat base as against use of bolt and nut. The measured u-channel was mounted unto the screw jack pin, the D.C motor was attached to the spur gear axle and bolted to the u-channel.

A universal joint was used to connect the gear shaft to the power screw. The control switch was connected to the D.C motor through the wire, for simplicity we decided to use a manual control switch mounted on the D.C motor.

All bolts and nuts were tightened, the universal joint and the power screw was well greased to reduce friction during operation and the jack was tested.



Figure 3.13: Assembled motorized screw jack.

## CHAPTER FOUR

### 4.1 TESTING

After successful design and fabrication, the motorized screw jack was tested in the following areas;

Polarity; and

Effectiveness in lifting the load

There was zero tail pipe emission and the powering of the jack was solely on the battery

The table below shows the result of lifting operations obtained at varying loads with different time intervals.

LOAD (Kg)	TIME OF LIFTING (sec)	LIFTING HEIGHT (mm)
0	12.55	110
200	17.27	110
300	22.26	110
400	27.50	110
500	31.65	110
600	36.25	110
700	41.75	110
800	47.76	110

Table 4.1: Results of lifting operation

### 4.2 Analysis of Result

From Table 4.1, it was observed that at no load condition the motorized jack performed with minimum time, subsequently varying loads of (400kg – 1000 kg) was introduced at a lifting speed of 2600rpm which reduces as the power screw comes in contact with the load, the loads were lifted with ease showing that the loads lifted are

within the capacity range for which the device can lift. The varying loads of 400kg and 600 kg were lifted up to a regulated height as desired depending on the required space for the underneath equipment maintenance to be carried out. When lifting the loads of 700kg, 800kg and 900kg respectively, it was observed that the increase in the time of lifting indicated an addition of extra load. The effectiveness of the motorized jack was appraised using some performance parameters such as jack efficiency, lifting time, and comparing these parameters with a manually operated jack.

The design efficiency of a jack is calculated by:

Recall  $\tan\theta = 0.1$

$$\eta = (1 - \sin 5.71)/(1 + \sin 5.71)$$

$$\eta = 0.819 = 81.9 \%$$

The effectiveness of the developed Jack was appraised using some performance parameters such as Jack efficiency, lifting time and comparing these parameters with manually operated Jack.

Jack efficiency,  $\eta = \text{Actual load} / \text{design load}$

From the table above

Actual load is termed the load at which the jack performs optimally; which is calculated from the time average =  $(17.27 + 22.26 + 27.50 + 31.65 + 36.25 + 41.75 + 47.76 + 54.40)/8$

$$= 242.59/8$$

=30.32, Optimal carrying load that fits into the average category is taken as 500kg,

Thus actual load is 500kg

Jack efficiency  $\eta, = 500/750$

$$= 0.66 = 67\%$$

The efficiency of the jack was 67%, this is attributed to strength of the D.C motor and gear system used.

### 4.3 Comparison Test

This shows the difference between the use of manually operated jack compared to the motorized screw jack. The table below shows the performance result

SN	LOAD (Kg)	LIFTING HEIGHT (mm)	MANUAL LIFTING TIME (sec)	MOTORIZED LIFTING TIME (sec)
1	0	110	18.55	12.55
2	200	110	28.60	17.27
3	300	110	33.80	22.26
4	400	110	38.65	27.50
5	500	110	43.50	31.65
6	600	110	46.77	36.25
7	700	110	47.96	41.75
8	800	110	53.55	47.76

Table 4.2 Comparison analysis of the motorized screw jack to a manually operated one.

From the above data the motorized screw jack had a little shorter lifting time for the same amount of load against a manually operated Jack. The magnitude of the load was directly proportional to the lifting time.

### 4.4 Discussion

It was observed that in order to enhance adequate mechanical advantage of the screw jack during lifting operations, the jack cap should be placed directly under the lift point of the load in order to make proper contact with it before the actual lifting operation.

For the loads lifted, it was also observed that with adequate power in the battery, the system could lift a load severally, subsequently the vibrations experienced reduces as the jack cap comes in contact with the load.

A better way to obtain optimal result of the motorized screw jack is to use a powerful D.C motor within the calculated power range, if below the range the screw jack will hardly perform the operation and may tend to cause heavy damage to the machine.

It is also advised to use the motorized jack with a load within calculations. The break point of the motorized jack should also be observed during testing operations.

It is also important to grease and lubricate moving components of the motorized screw jack for easy movement and torque transmission.

## CHAPTER FIVE

### 5.1 Conclusion

From the analysis and result obtained we were able to achieve the aim of the project, mainly reducing human effort on lifting a car for maintenance.

After a careful work done, by using the relationship between power rating, speed and torque an efficient motorized screw jack was designed such that it was able to lift load of about 750kg which is the average weight of a car mostly found on the road.

The motorized jack was fabricated with mild steel for parts needing metal and also use of D.C motor gear system which represent the prime mover. Fabrication processes which include marking out, cutting, welding, assembling were employed.

The screw jack result shows that it is quicker and it saves time compared to the manually operated ones, it is also safe to use.

The screw jack components are also easy to replace and maintain

### 5.2 Recommendations

Based on the experience from engaging this work and results gotten, the following recommendations were made;

- i. The joint components can be equipped with rubber so as to reduce vibrations experienced during lifting.
- ii. The system can also be equipped with a blue-tooth sensor remote controller which makes it easier to control the jack upward or downward.
- iii. The system can be fabricated to be detachable in order to facilitate the ease of use, and maintenance.
- iv. An alternative car battery can also be considered in case the car battery is inaccessible.
- v. A scope can be considered to look beyond a maximum of 750kg vehicle.

## REFERENCE

- Chaudhary S., (2016), "Development of motorized car jack", Journal of Applied Mechanical Engineering. ) PP 216.
- Dr. Ramachandra C G, Krishna P., Shivraj S. and Venugopal R., (2013) "Design and Fabrication of Automotive Hydraulic Jack System for Vehicles," International Journal of Advances in Engineering Research, Vol 6 Issue 6, PP 16-29.
- Ferreira J. J. , Boocock M. G. and Gray M. I. , (2004) " Review of the risks associated with pushing and pulling heavy loads (Health and Safety Laboratory)", Broad Lane Sheffield S3 7HQ.
- J.M. Gere, (2006), "Mechanics of materials", Thomson, 6th Edition.
- Kumar M. N., "Design and fabrication of screw jack using worm gear", International Conference on Systems, Science, Control, Communication, Engineering and Technology, 2016, pp. 794-798.
- Mandavgade N. K. (2012), International Journal of Engineering Development, ISSN 2349 5162; Vol. 5 Issue 9.
- Musa N. , Abodunrin T. and Oladipo S., (2016) "Development of an integrated toggle jack for Lifting Automobiles ", ISDAE, Vol.7 No. 1, pp21.
- Noor M.M., Kadirgama K. and Rahman M.M (2010) "Analysis of Auto Car Jack", National Conference in Mechanical Engineering Research and Postgraduate Students FKM Conference Hall, UMP, Kuantan, Pahang, Malaysia, 26-27, pp 198-203.
- Okoronkwo C. A., "Design of a hand water pump using a quick-return crank mechanism", African Journal of Science, Technology, Innovation and Development. 8(3)(2016)292-298.

Parmeshwar D., Nitesh T., Abhishek G., Sunil S. P., (2019) ISSN: 2395- 0056; Vol:  
Issue: 06.

Prashant K. S., Vipin K. P., Shailesh K. M., Kumar M., (2013) ISSN 2347- IJSER  
3878; , Vol. 03, Ajit Tiwari, Issue: 5.

Radhakrishna.K, K.P.V.S.R Vinay K., Mohan S. M.,Karthik V., Rajesh T., Vinay K.  
M., (2019) IJIEMR,ISSN 2456 5083; Vol 08, Issue 12.

Rajput, R.K., (2010) Strength of Materials" Revised Edition, S. Chand and Company  
Limited., 2010, pp.1448, ISBN 81-219-2594-0.

Rout I. S.I., (2010), "Design and fabrication of motorized automated object lifting  
jack", IOSR Journal of Engineering. 04(05) (2014) 6-12.