DESIGN AND FABRICATION OF A REMOTE CONTROLLED SYSTEM FOR A HYDRAULIC JACK

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ABSTRACT - *A project work on design and fabrication of a remote controlled system for a hydraulic jack which consist of a base, gearing system and crank mechanism is presented. The prototype includes motor powered from a 12v battery of a tractor through a car adapter or from a lighter adapter in vehicles. The motor with gearing system will be the lifting mechanism. When an equipment is needed to be lifted, just press the button on the remote device, firstly to lock the hydraulic jack valve, then pressing again will start the lifting operation and afterwards the button is released at a desired height level. The common problem faced by the current available hydraulic jacks in the market is that it is manually operated and needed physical effort to lift the vehicle or heavy equipment. Hydraulic jacks available at the market also has some disadvantages such as requiring more energy to operate, are not suitable for women and cannot be used on an uneven surface. The purpose of this project is to modify the design of the existing hydraulic jack in terms of its functionality and also human factor considerations This work was done based on the mechanism of hydraulic power system method, fabrication processes of marking out, cutting, assembling and finishing were employed where necessary. All the analysis and results such as the required torque and gearing ratio which are important in this project where all determined before the development and incorporations. Several tests were carried out to determine the effectiveness of the device in lifting loads of 1 ton, 2 ton, 3 ton, 4 ton and 5 ton respectively. This work would help to overcome drudgery, musculoskeletal disorders, injuries, increase timeliness and efficiency in the farm while carrying out maintenance works, would also help in reducing size, space occupied, cost employed in maintenance operations.*

Keywords: *fabrication, remote, hydraulic jack, load, drudgery*

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

A hydraulic jack is a mechanical device used as a lifting device to lift heavy loads or apply great forces. A hydraulic mechanical jack employs the mechanism of a hydraulic power system in the lifting of heavy equipment (Brian, 2006). The most common form is a car jack, floor jack or garage jack which lifts vehicles or trucks so that maintenance can be performed. Hydraulic jacks are usually rated based on its maximum lifting capacity which could include: 1.5 tons, 3 tons, 20 tons or 30 tons (William, 2001).

A remote controlled hydraulic jack is a type of jack designed to incorporate a d c motor control and link mechanisms having an infra-red transmitter and receiver circuits which processes and decodes the control signals for the upward and downward movement of the hydraulic jack (Oshevire, 2014). This works in such a way that it can be used to lift heavy duty trucks very smoothly without any impact force and also a simple operation so that even unskilled labour can use it with ease. This is an era of automation where it is broadly defined as the replacement of manual effort with mechanical power in all degrees. The mechanical automation remains to be an essential part of the system although it comes with some physical changes on the jack; the degree of mechanization is greatly increased.

According to ezinearticles.com, the origin of hydraulic jacks can be dated several years ago when Richard Dudgeon, the owner and inventor of hydraulic jacks, started a machine shop. In the year 1851, he was granted a patent for his hydraulic jack. In the year 1855, he literally amazed onlookers in New York when he drove from his abode to his place of work in a steam carriage. It produced a very weird noise that disturbed the horses and so its usage was limited to a single street. Richard made a claim that his invention had the power to carry near about 10 people on a single barrel of anthracite coal at a speed of 14 m.p.h. Dudgeon deserves a special credit for his innumerable inventions including the roller boiler tube expanders, filter press jacks, pulling jacks, heavy plate hydraulic hole punches and various kinds of lifting jacks (Muchnik, 2007).

Hydraulic jacks uses fluid, which is incompressible, that is forced into a cylinder by a pump plunger (Elliot, 2006). Hydraulic oil is used since it is self lubricating and stable. When the plunger pulls back, it draws oil out of the reservoir through a suction check valve into the pump chamber. When the plunger moves forward, it pushes the oil through a discharge check valve 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 forced shut and oil pressure builds in the cylinder. In other cases, some hydraulic jacks have horizontal pistons which push on the short end of a bell crank, with the long arm providing the vertical motion to a lifting pad, kept horizontal with a horizontal linkage. The incorporating of castors and wheels allows for the compensation of the arc taken by the lifting pad; this mechanism provides a low profile when collapsed, for easy maneuvering underneath the truck while allowing considerable extension (Fauzi, 2011). The d c motor is coupled with the hydraulic jack by gear arrangement with the rotation of the d c motor determining the lifting speed of the hydraulic jack.

1.2 STATEMENT OF PROBLEM

Nowadays in this country, the most available jacks are manually powered, we found out that these manual hydraulic jacks were very difficult to be used by our farmers especially the female ones because of the strength and energy needed to operate it making it to be time consuming; furthermore, in scenarios of these manual hydraulic jack malfunctioning and subsequently the collapse of the machine under maintenance could lead to musculoskeletal disorders, injuries of the neck, back and shoulder. Thus, to overcome this problem of drudgery, musculoskeletal disorders, injuries, increase timeliness and efficiency in the farm while changing tires and carrying out some other maintenance works beneath the tractor prompted the design of a remote controlled motorized hydraulic jack for tractors.

1.3 OBJECTIVES

The purpose of this work is as follows:

(i) To design a remote controlled system for a hydraulic jack ,
(ii) To fabricate a prototype of a remote controlled system for a hydraulic jack,
(iii) To test for efficiency of the designed and fabricated remote controlled system for a hydraulic jack.

1.4 JUSTIFICATION

This work tries to modify a hydraulic jack by incorporating a prime mover and a remote control system all together in order to make load lifting easier and safer. In this design, the plunger is actuated through a connecting gear with the pinion gear when electrical power flows through the lighter receptacle connected to the motor, plugged to the automobile 12 V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the pinion gear meshing with the bigger gear connected to the plunger lever to be oscillated with required speed reduction and increased torque to drive the hydraulic piston totally displacing manual handling of hydraulic jacks.

1.5 SCOPE OF STUDY

This project will build a prototype of a remote controlled system for a hydraulic jack with 30 ton maximum lifting capacity that could be used in lifting heavy equipment in farms, industries and workshops. In this study, we examine necessary stages involved in the design and fabrication of a remote controlled system for a hydraulic jack with all necessary calculations and drawings.

CHAPTER TWO

LITERATURE REVIEW

2.1 DEFINITION OF MECHANICAL JACKS

A mechanical jack is a device which lifts heavy equipment and vehicles so that maintenance can be carried out underneath (Budynas, 2008).
A hydraulic jack is a device that uses a liquid to push against a piston. This is based on Pascal's Principle. The principle states that pressure in a closed container is the same at all points. If there are two cylinders connected, applying force to the smaller cylinder will result in the same amount of pressure in the larger cylinder. However, since the lager cylinder has more area, the resulting force will be greater. In other words, an increase in area leads to an increase in force. The greater the difference in size between the two cylinders, the greater the increase in the force will be. A hydraulic jack operates on this two cylinder system (Muchnik, 2007).
Many trends (screw or hydraulics) have gone down around the lifting applications in the automobile workshops. Increasing the mechanical advantage of doing work remains the objective of these developments (Muchnik, 2007).

2.2 HISTORICAL BACKGROUND OF LIFTING DEVICES

Primitive techniques back in ancient Egyptian cultures used log rollers, greased logs, ropes, and droves of manual labour. Buoyancy in ships made of reeds and grass were loaded with sand to lower a boat in the water. Stones were rolled on, and then sand emptied out to make the boat float. Sand piles, and smaller stone wedges were used in conjunction with the physics of a Fulcrum, in order to use a stone's own weight to stand it upright (for pillars and columns). "Block and Tackle" was the next mechanical evolvement (use of pulleys) to lift objects (Wale, 2002).

The advent of the industrial revolution which saw the major transition in the history of manufacturing and engineering processes nurtured the acquisition of great momentum in technological and economical advancement. "For the first time in history, the living standards of the masses of ordinary people have begun to undergo sustained growth. Nothing remotely like the economical behavior has happened before" (Lucas, 2002).

The first cranes are thought to have been developed by ancient Egyptian, Greek and Roman builders. Some think it was dated as far back as the 6th century (515BC) (Coulton, 2004). All of these cultures developed strong skills in construction - as evidenced by the buildings they created that still exist today. These early cranes would have used animal or man power to lift weight. Larger cranes would have a human-powered treadmill.

Fast-forward to the medieval era, and technology in lifting equipment had not progressed, although cranes, hoists and other equipment were in limited use in warehouses and mills. As the industrial revolution progressed, technology improved. Whereas equipment had always been made largely of wood, stronger materials such as steel began to be used. There was also a move away from human powered devices, to those which harnessed new-found technologies and fuels. Steam powered cranes for example, were introduced, especially for work on railways. Progress was slow though: cranes powered by treadmill and hand winches continued to be used throughout the nineteenth century and beyond (Coulton, 2004).

Today, technology has developed to cover an incredibly wide range of uses, and it takes many different forms. There is a piece of lifting equipment for pretty much any job, and a wide range of different kinds of equipment to meet varying needs. Among the most common pieces of lifting equipment available are: crane, jack, lever, lift, hydraulic ram, block and tackle, wedge, forklift, and escalator (Muchnik, 2007).

It's therefore obvious that Lifting technology really didn't emerge until the start of the Industrial Revolution in approximately 1812. Incremental stages that increased productivity were Steam Engines, followed by the Combustion Engine, followed by Hydraulics and Electrical Motors, and now magnetic levitation is a science incorporated into the newest high-speed trains (Coulton, 2004).

2.3 COMMON TYPES OF MECHANICAL JACK

2.3.1 HYDRAULIC BOTTLE TYPE JACKS

These jacks have outweighed conventional screw jacks that were in use at some point in time. They consist of two cylinders joined together. It works on the principle of Pascal's law which suggests that when there is an increase in pressure at any point in a container of fluid, there is an equal increase in pressure at every other point in the container (Muchnik, 2007).

Pressure on a confined fluid is transmitted undiminished and acts with equal force on equal areas and at 90 degrees to the container wall. A fluid such as hydraulic oil, is displaced when either piston which is proportional to the ratio of areas of the heads of the pistons. Therefore, the small piston must be moved a large distance to get the large piston to move significantly. The distance the large piston will move is the distance that the small piston is moved divided by the ratio of the areas of the heads of the pistons. This is how energy, in the form of work in this case, is conserved and the Law of Conservation of Energy is satisfied. Work is force times distance, and since the force is increased on the larger piston, the distance the force is applied over must be decreased (Parr, 2003).

FIGURE 2.1 A HYDRAULIC BOTTLE JACK

Source: edutwin.com

This jack also known as a whiskey jack is a hydraulic jack which resembles a bottle shape, having a cylindrical body and a neck, from which the hydraulic ram emerges. They have a capacity of up to 50 tons and may be used to lift a variety of objects. Typical uses include the repair of automobiles and house foundations. These are fully self contained jacks with integral pumping units and oil reservoirs. A detachable hand lever is provided for operation of pump. A calibrated load gauge is supplied with each jack. Lifting handle is also provided on the jack (William, 2001).

2.3.2 PNEUMATIC JACK

A pneumatic jack is a hydraulic jack that is actuated by compressed air instead of human work. This eliminates the need for the user to actuate the hydraulic mechanism, saving effort and potentially increasing speed (Norman, 2009). 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.

FIGURE 2.2 A PNEUMATIC JACK

Source: wikipedia.com

2.3.3 STRAND JACK

A strand jack is a specialized hydraulic jack that grips steel cables; often used in concert, strand jacks can lift hundreds of tons and are used in engineering and construction.

FIGURE 2.3 A STRAND JACK

Source: hydraulicOnLine.com

2.3.4 LONG RAM JACKS

This is a hydraulic jack with a long size ram. Its lever handle is quite easy to use. It is primarily used for performing various types of repairing work.

FIGURE 2.4 A LONG RAM JACK

Source: hydraulicOnLine.com

2.3.5 SHOP PRESS JACK

This is greatly used in press jobs where there arises a need to generate tremendous pressure with minimum effort.

FIGURE 2.5 A SHOP PRESS JACK

Source: wikipedia.com

2.4 HYDRAULIC JACK SYSTEMS

Hydraulic engineering got its insight from the hydraulic press, an invention by Joseph Bramah alongside William George Armstrong whose operation depends on the Pascal's principle (Parr, 2003).

Since the knowledge of hydraulics came vast, it has in a wide way been the principle behind a very lot of inventions, machines and components directly or indirectly. This is the basics of the bottle jack.

2.4.1 HISTORY OF THE HYDRAULIC BOTTLE JACK

The origin of hydraulic jacks can be dated several years ago when Richard Dudgeon, the owner and inventor of hydraulic jacks, started a machine shop. In the year 1851, he was granted a patent for his hydraulic jack. In the year 1855, he literally amazed onlookers in New York when he drove from his abode to his place of work in a steam carriage. It produced a very weird noise that disturbed the horses and so its usage was limited to a single street. Richard made a claim that his invention had the power to carry near about 10 people on a single barrel of anthracite coal at a speed of 14 m.p.h. Dudgeon deserves a special credit for his innumerable inventions including the roller boiler tube expanders, filter press jacks, pulling jacks, heavy plate hydraulic hole punches and various kinds of lifting jacks (Muchnik, 2007).

2.4.2 BASIC COMPONENTS OF A HYDRAULIC JACK

I. **HYDRAULIC PUMP:** Hydraulic pumps supply fluid to the components in the system.
II. **CONTROL VALVES:** Directional control valves route the fluid to the desired actuator.
III. **RESERVOIR:** This helps holds excess hydraulic fluid to accommodate volume changes from cylinder extension, contraction, temperature driven expansion and leaks. The reservoir is also designed to aid in separation of air from the fluid.
IV. **PUMP**: This draws fluid from the reservoir on its up, suction or intake stroke then creates pressure on its down/power stroke pushing the fluid.
V. **CHECK VALVE**: Allows fluid to pass from the reservoir to the pump then checks off the return port to the reservoir and directs the pressurized fluid.
VI. **RAM PISTON:** This is forced out or upwards as the main cylinder is filled with pressurized fluid.
VII. **RELEASE VALVE:** When this is opened, the fluid is ported back into the reservoir.

2.5 EARLIER MODIFICATIONS

Making the hydraulic jack automatic is one significant idea evolving, though the very ideas featured in this project seems pioneered. Researches on previous and similar projects saw similar works but working on a different mechanisms.

2.5.1 DOUBLE SPEED HYDRAULIC BOTTLE JACK

This utility model is a hydraulic jack, in particular a dual speed vertical hydraulic jack with fast lifting at no load and slows driving under load. The task of this utility model is to provide a type of dual speed vertical hydraulic jack of simple oil path structure, easy processing and assembling, and fully ensured fast lifting at no load and slow driving under load (Jiang, 2008).

FIGURE 2.6 A DOUBLE-SPEED HYDRAULIC BOTTLE JACK

Source**:** wikipedia.com

2.5.2 FOOT PEDAL HYDRAULIC JACK WITH TWO SPEED PUMP

One kind of foot pedal hydraulic jack with two speed pump, and there is a pneumatic set to lift piston quickly on the jack. This invention involves a type of hoisting tool, especially a type of pneumatic non-load quick dual-speed hydraulic jack (Zhigiang, 2013).

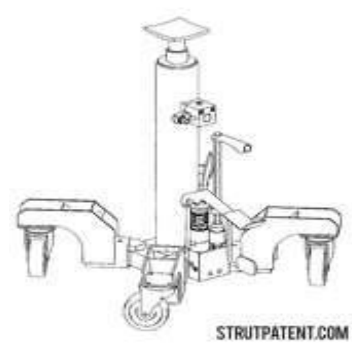


FIGURE 2.7 A FOOT PEDAL HYDRAULIC JACK WITH TWO SPEED PUMP

Source**:** wikipedia.com

2.5.3 MULTI-SPEED HYDRAULIC JACK

A multi-speed jack, having a pump assembly including a pump block having a first cylinder and a second cylinder defined therein, a piston assembly movable within the pump block, the piston assembly having a first portion configured with the seal ability engage with the first cylinder and a second portion configured to sealable engage with the second cylinder, a reservoir for storing hydraulic fluid and coupled to the pump block so that when the piston assembly is moved in a first direction, hydraulic fluid in the reservoir is supplied to the first cylinder and the second cylinder, a lifting assembly having a ram chamber and a ram rod, the ram chamber coupled to the pump assembly and configured to receive fluid from the first cylinder and the second cylinder when the piston assembly is moved in a second direction so as to raise the ram rod and a bypass check valve provided in the first cylinder. The bypass check valve is configured so that when the piston assembly is moving in the second direction and the pressure in the first cylinder exceeds a threshold pressure, the hydraulic fluid in the first cylinder returns to the reservoir. The second cylinder may be much smaller to provide leverage to move a far greater load though at a much slower rate (Jackson, 2009).

FIGURE 2.8 MULTI-SPEED HYDRAULIC JACK

Source: hydraulicOnLine.com

2.6 GENERAL MEASURES AND TREND OVER TIME (agency report, 2000).

The negative health effects of manual handling can be prevented by trying to eliminate or at least reduce the risk factors involved. The following hierarchy of prevention measures should be used.

(i) ELIMINATION

First, can the work be designed and organized in such a way that manual handling can be avoided completely, or at least restricted (e.g. using powered or mechanical handling equipment such as conveyor belts, lift trucks, electric hoists or gravity-inclined roller track).

(ii) TECHNICAL MEASURES

If manual handling cannot be avoided, automation, mechanization and the use of lifting and transport equipment should be considered (e.g. conveyors, hoists, cranes, vacuum lifting devices, lift tables, pallet trucks, lift trucks, barrows, trolleys).

However, attention should be paid to ensure that new work risks are not created (e.g. through noise, or hand-arm vibration).

(iii) ORGANIZATIONAL MEASURES

Organizational or administrative measures should only be considered if elimination of manual handling is not possible, and if technical measures are not effective in reducing the risks involved in manual handling.

nual handling tasks should be l people or, if possible, the should be reduced or the load split into smaller ones (Van et al, 2004).

The rate of manual handling should not be set by a machine, supervisor or colleagues. The time taken to carry out manual handling tasks should be extended by taking breaks, or by alternating them with other tasks so that the muscles have time to recover.

(iv) PROVIDE INFORMATION AND TRAINING TO WORKERS

If workers have to carry out manual handling activities, they should be informed of the risks of accidents and ill health, particularly concerning their specific tasks. They should also receive training on the use of equipment and on correct handling techniques (Van et al, 2004).

2.7 THE ADVANTAGES OF A REMOTE CONTROLLED HYDRAULIC JACK

Well functioning remote controlled hydraulic unit can yield a whole range of benefits for their users, the society and the environment in the:

I. Reduces drudgery during maintenance operations, manual power not required.
II. Increases timeliness and efficiency in maintenance operations.
III. Reduces the risk of getting injury in the case of malfunctioning of the device.

IV. Hydraulic systems have large load carrying capacity.
V. High efficiency with minimum friction loss keeps the cost of a power transmission at a minimum.
VI. Hydraulic systems are smooth and quiet in operation, vibration is kept to a minimum control.
VII. Handling, control of a wide range of speed and forces is easy.
VIII. Repairing and replacement of parts is easy.

2.8 THE DISAVANTAGES OF A REMOTE CONTROLLED HYDRAULIC JACK

The disadvantages of a remote controlled hydraulic jack are as highlighted below:

I. The high cost of hydraulic devices.
II. Dirt and oil deterioration can affect the device.
III. The main disadvantage of a hydraulic system is maintaining the precision parts when they are exposed to bad climates and dirty atmospheres.
IV. The unavailability of this device in every area where it is needed.

CHAPTER THREE

MATERIALS AND METHOD

3.1 DESIGN CRITERIA

Hydraulic jacks are mechanical devices used in lifting heavy equipment in farms, industries and workshops. To achieve this aim of lifting a heavy load, the mechanism of hydraulic power system is implemented in fabricating the system.

The mechanism of hydraulic power system is achieved by tapping 12v voltage (either from the car or the battery) as the source of power to drive the prime mover (electric motor) by whose rotation of its output spline (designed for 10mm diameter) generates a torque transmitted to the meshed gear of larger diameter; thereby achieving speed reduction for higher torque. Cranking now does its job of converting this rotary motion to rectilinear motion. The whole of these process does the job of man in a convention bottle jack to and fro actualization process. Therefore at this stage the so called to and fro motion is produced necessary for actuating the hydraulic system. Valve controlling in bottle hydraulic jack are a little complicated, a one way valve is used to ensure one way flow during lifting; in a closed position, lifting is carried out and in open position, a backward flow to the reservoir (acting weight of load causes this) is seen, this is the lowering. The Electric Control Unit (ECU) is there to allow for control system between the input voltages (V) to the output forceful motion (X).

3.1.1 OPERATING SYSTEMS

3.1.1.1 POWER SOURCE

Voltage is to be primarily sourced from the direct current receptacle on any vehicle's dashboard. A secondary provision complements with the addition of a rechargeable battery from any of which the prime mover is powered.

Power provision is completed with the work of a prime mover; an electric motor in this design.

3.1.1.2 ELECTRONIC CONTROL UNIT

Further explained later in this work, a system of Electronic Control Unit joins the guiding mechanism in a big way. The system services as a measure of the control system between the user and the device through a remote or switch controlled operation. This control posed a lot of difficulty because for it to control a lifting and lowering process altogether, a provision for the valve control must be made.

3.1.1.3 GEARING SYSTEMS 1 AND 2

Two different gearing assemblies were made:

1. To transfer the torque/motion of the prime mover to the crank link.
2. To transfer the motion of an auxiliary gear to control the opening and closing of the check valves (no return valve).

Speed reduction for torque multiplication and more power are the guiding desires for the choice of NO.1 gear assemble. All systems here obey the gear laws.

3.1.1.4 THE CRANK MECHANISM AND LINKAGE SYSTEM

Aimed at achieving motion conversion, this serves as a measure of additional mechanical advantage and conversion of the rotary motion of the gear to a rectilinear motion needed by the jack plunger (piston).

3.1.1.5 THE LEVER SYSTEM

This system was simply added as a measure of mechanical advantage and its efficiency as a simple machine.

3.1.1.6 HYDRAULIC SYSTEM

Based on the principle of Pascal's law, this system guiding the bottle jack itself is the most essential in this design.

3.1.1.7 VALVE CONTROL

The normal operation of a bottle jack (manually) involve a step of either closing or opening a check valve to permit lifting and lowering process respectively. It is in replacement of this manual control as well that a valve control system is added. This system wholly controlled by the ECU has a gearing system as its primary control.

3.2 MATERIALS

The general consideration in designing this machine is producing a machine that can be easily assembled and disassembled, a machine in which loads will be lifted effectively with minimum power.

3.2.1 DESCRIPTION OF THE COMPONENTS

3.2.1.1 POWER SOURCE

- Voltage receptacle from vehicle direct current receptacle part rating 12 DC.
- 12v, 6.5A lead-acid Dry cell rechargeable battery of mean dimension.

3.2.1.2 ELECTRONIC CONTROL UNIT (Remote)

K

- eypad switch, PIC microcontroller, infra-red light emitting diode (LED), transistor, capacitor, resistor.

3.2.1.3 CABLINGS

- High Resistance Electric cables with coating.
- For extension wire from socket to direct current receptacle part.
- For inter connection between socket and Battery and as well for both between motor and micro chip (Electronic Control Unit).

3.2.1.4 PRIME MOVER

12v, 312W, 2650rpm electric motor of mean dimension with off put shaft splined to 10mm diameter and 9 teeth, through 18.4mm width (length).

3.2.1.5 THE BODY

- **Valve control motor**: Low speed, 60 watts, 11.5NM torque, 13.5V DC motor.
- **Support**: These include the component's stands, i.e. motor stand, battery barrier and gear support welded to base plate and of steel material.
- **Bottom/Base plate:** Steel metals, cut and welded and covers a dimension of 216x216x30mm and shell to 4mm thickness. Drills were made for both ways.
- **Casing:** Covers a dimension of 220x220x180mm. Made of thin sheet 2mm thickness. Cut out of switches, sensors, bolts.
- **Cover:** Covers a dimension of 216x216x30mm. With a thickness of 2mm and cut away for the ram.
- **Joining:** Three major types of joints were used. Screw, Pin and Weld.
- **Bolt and nuts:** Used for temporary joining of non moving parts 10mm and 14mm sizes (steel material).
- **Pin:** Used for temporary joint of moving parts e.g. the joint between connecting rod and lever (steel material).

3.2.2 MATERIALS SELECTION

The following were considered in the selection of materials;

(i) Availability of materials so that the parts can be manufactured locally,
(ii) Costs of materials to enable us fabricate a machine that is affordable and economical,
(iii) Durability of the machine, because the operating environment may be harsh which can lead to deterioration of machine parts.

The machine will be fabricated with mild steel because it meets the above considerations and also due to its machinability, formatting, and weldability since the fabrication process involves cutting, folding, bending, welding, and other machine operations.

3.3 SIZING/FUNCTIONAL RELATIONSHIP
3.3.1 GEARING SYSTEM

SPUR (DRIVING GEAR)

To maintain the rpm of the electric motor and also to encourage compactness, the input gear of the motor was adopted.
No. Of teeth (T_p) = 9
Diameter (D_p) = 10mm
Speed (N_p) =2650rpm.
Power (P) = 312watts

- **Torque generated**

$$T_p = \frac{P \times 60}{2\pi N_p} = \frac{312 \times 60}{2 \times \pi \times 2650} = 1.12NM \text{ .... (1)}$$

(Khurmi and Gupta, 2005)

- **Gear Module**

$$\frac{D_p}{T_p} = \frac{10}{9} = 1.11mm$$

This will be same for both gears Face width 18mm

- **Driven Gear**

No. Of teeth (T_G) = 62
Diameter (D_G) = 69mm
Speed (N_G) =584rpm
These parameters show a desire for speed reduction for torque multiplication

- **Torque / gear ratio**

Often also known as its mechanical advantage, it is determined by the gear ratio (Paul, 1979).

$$\frac{N_p}{N_G} = 6.9$$

- **Torque Generated**

Since torque ratio equals to 6.9

$$T_G = T_p \times \text{gear ratio} = 7.75 \text{ NM} \text{... (2)}$$

Where T_G = Torque generated (Driven Gear)

T_p = Torque generated (Driving Gear)

This consideration is to achieve a torque multiplication from 1.12NM to 7.75NM.

3.3.2 Mechanism

To convert rotary motion of the motion to a rectilinear (to and fro) motion of the plunger. A crank mechanism is used; a four link (bar) mechanism is the basis of this conversion with an arm of increasing the mechanical advantage.

3.3.3 The Crank system

- **Length of connecting rod**

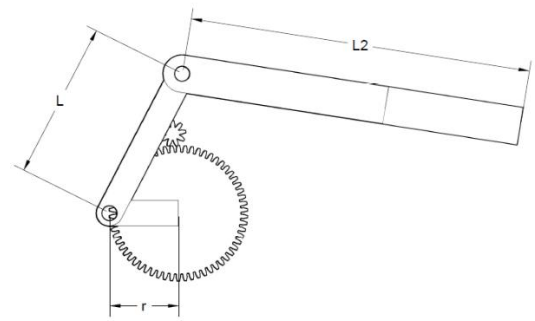


Fig 3.1 Diagram of the Crank System

After optimum consideration, the n valve of 3 was adopted,

Therefore l = nr = 3 x 39.99
=119.97mm.. (3)

- **Linkage Diagram**

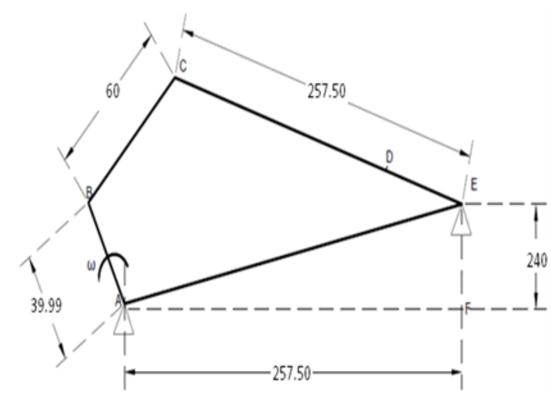


Fig 3.2 Linkage System Design Diagram

AB = r = Crank = 39.99mm

BC = L = Connecting rod = 119.97mm

CE = Le = Lever arm = 257.50mm

EF = Distance between axis along x-axis= 240mm

AF = Distance between axis along y-axis = 257.50mm

3.4 FABRICATION PROCESSES

Some manufacturing processes were carried out during the fabrication of the machine, they include;

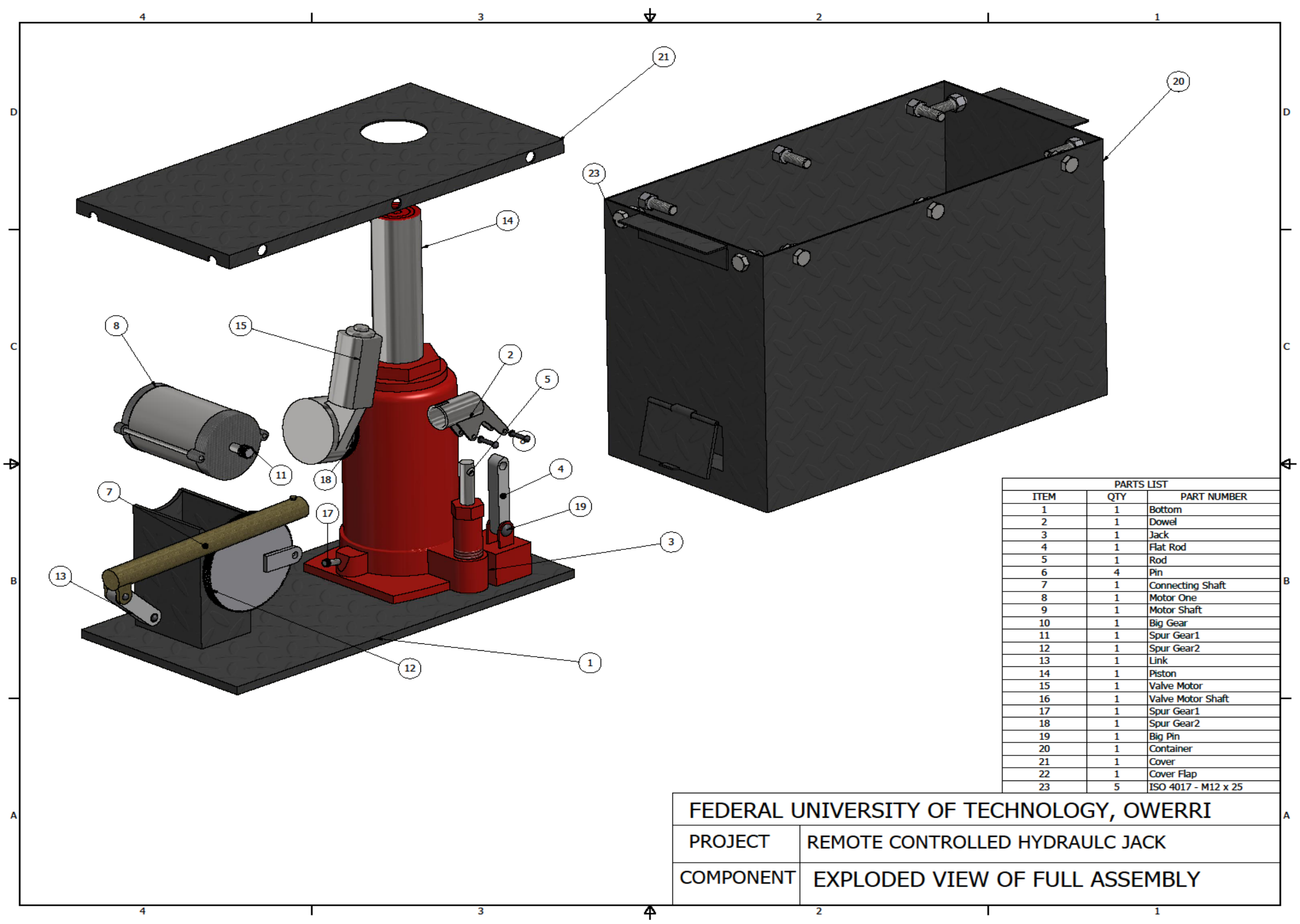
(i) **Marking out**: The actual dimensions of the parts required were obtained by taking measurements with steel tape, measuring tape and necessary marking was made with a divider. Major marking out was done on the materials used for the casing, the cover and joining.

(ii) **Cutting**: Cutting is mainly required in the reduction of length and diameter of the material to get the desired parts.

(iii) **Assembly**: This involves bringing the various parts together to form a single unit. The most essential process in assembling is the welding process. An electric arc welding machine was used in joining the various cover. Other coupling processes employed are use of nuts and bolts.

(iv) **Finishing**: This is the final operation involved in the production of any machine usually to increase the efficiency and improve aesthetics. Painting was done to promote visual inspection.

3.4 WORKING DRAWINGS



PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	Bottom
2	1	Dowel
3	1	Jack
4	1	Flat Rod
5	1	Rod
6	4	Pin
7	1	Connecting Shaft
8	1	Motor One
9	1	Motor Shaft
10	1	Big Gear
11	1	Spur Gear1
12	1	Spur Gear2
13	1	Link
14	1	Piston
15	1	Valve Motor
16	1	Valve Motor Shaft
17	1	Spur Gear1
18	1	Spur Gear2
19	1	Big Pin
20	1	Container
21	1	Cover
22	1	Cover Flap
23	5	ISO 4017 - M12 x 25

Fig 3.3 ISOMETRIC VIEW OF THE HYDRAULIC JACK

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS

Table 4.1 shows the result of the lifting operation obtained at varying loads with different time intervals.

4.1.1 TIME OF LIFTING

TABLE 4.1: Result of lifting operation

LOAD (tonnes)	*TIME OF LIFTING (sec)*
0	*7.36*
1.0	*9.90*
2.0	*19.60*
3.0	*26.67*
4.0	*39.55*
5.0	*44.34*

1) Results maybe prone to different kinds of error like parallax error, timing device lagging or leading.

2)

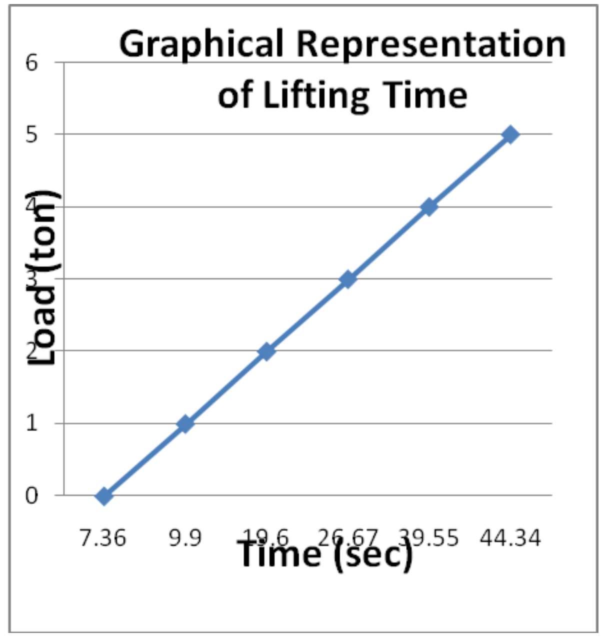


FIG 4.1: Graph of Load (ton) against Time (sec)

4.2 DISCUSSION

From Table 4.1, it was observed that at no load condition the device performed with minimum time, subsequently varying loads of (1 ton – 5 ton) was introduced at a lifting speed of 2650rpm which reduces as the hydraulic piston 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 1 ton and 2 ton 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 3 ton, 4 ton and 5 ton respectively it was observed that the increase in the time of lifting indicated an addition of extra load.

The sizes of the lifted loads were determined as specified by the equipment (load) manufacturer.

Testing the device with varying loads indicated its behavior and response to varying loads.

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

During the lowering of the Load, it was observed that immediately the hydraulic valve was unlocked, the weight of the load pushed down the hydraulic piston down to its normal height, and then the device removed from its position under the load.

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 hydraulic piston comes in contact with the load.
From the hydraulic jack specifications, for every cycle of the crank, the piston plunger makes a movement from the Top Death Center (TDC) to the Bottom Death Center (BDC), for every of this, the ram makes a 4mm displacement and total length of ram is 257.5mm.

Graphically, Fig 4.1 has shown that as load increases, the time required for lifting the load increases.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

After a careful work done, the following conclusions were drawn;

An efficient automated lifting system was designed using the Khurmi and Gupta relationship to determine the required torque with known parameters such as power rating and rotating speed of the motor.

An efficient automated lifting system was fabricated with mild steel for parts needing metals and a hydraulic jack serving as the lifting device. Fabrication processes of marking out, cutting, welding and assembling were employed.
This project work was tested and it worked appropriately. Sizes of loads lifted were determined by the specifications from their manufacturers.

5.2 RECOMMENDATIONS

Based on personal experience on this work, the following recommendations were made;

The system can be equipped with a rubber in the linkages; so that as soon to reduce the vibrations experienced during lifting.

The system can be equipped with a harmonic filter to enhance the efficient functioning of the remote control without experiencing retriggering actions.

This system can be fabricated to be detachable in order to enhance the ease with which its gears could be maintained.

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