International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 8 Issue 12 December - 2024, Pages: 1-9

Design Analysis of a Remote Controlled Hydraulic Jack

Wali S. A.1 and Akaninwor G. C.2

1Department of Mechanical Engineering Rivers State University Port Harcourt, Nigeria.
E-mail: walistanleyaleruchi@gmail.com

2Department of Mechanical Engineering Rivers State University Port Harcourt, Nigeria.
E-mail: godsonakaninwor@gmail.com

Abstract: *With the growing stages in generation, the efforts required in reaching the favored output can correctly and economically be reduced with the aid of the implementation of better designs. Power screws are used to convert rotary motion into translatory motion. A hydraulic jack is an instance of a power screw in which a small pressure carried out in a horizontal plane is used to raise and lower load. The mechanical gain of a hydraulic jack is the ratio of the load implemented to the effort applied. The hydraulic jack is operated manually or robotically with the help of fluids present in the cylinder. The peak of the jack is adjusted via plunger inside the cylinder and this adjustment may be done either manually or with the aid of integrating an electric motor. This research work analyzes the change of the present motor hydraulic jack by way of incorporating an electric powered circuit with the intention to make load lifting less difficult. On this modified layout, the crank wheel is rotated by way of connecting motor through regularly occurring coupling, plugged to the auto 12 volts battery source to generate energy for the high mover (motor), which transmits its rotating speed to the crank wheel to be rotated with required speed discount and extended torque to pressure the crank wheel. For every cycle of the crank, the piston plunger makes a movement from the Top Dead Centre (TDC) to the Bottom Dead centre (BDC). For this to be done, the ram makes a 4mm displacement and maximum lift of ram of 257.5mm. The hydraulic jack had an efficiency of 86 percent and maximum capacity of 5 tonne. The significance and motive of this work is to alter the prevailing car jack on the way to make the operation less difficult, more secure, and greater dependable with a purpose to reduce health risks especially lower back ache issues related to doing work in a bent or squatting position for an extended period of time.*

Keywords: Hydraulic jack, Micro-controller, Remote control, Mechanical advantage, Design Analysis

1.0 INTRODUCTION

The application of a jack in automobile is generally for raising up vehicles so that auto mechanics/technicians can have more work space or easy access to perform various tasks underneath the vehicle. Jacks are commonly applicable to cars but are also used in several mechanical applications including industrial machineries [4]. There two major types of jack namely, hydraulic jack and mechanical jack. In a typical hydraulic jack which usually consists of a cylinder and piston mechanism, the upward or downward movement of the piston rod is mainly used to raise or lower the load, whereas, mechanical jacks can either e hand operated or power driven [3]. The type of car jack used will determine the amount of physical labour needed to raise the car up to the required height which sometimes may result in much exertion from the operator and could be time and energy consuming [1]. Hydraulic, jacks are typically used for shop work, rather than as an emergency jack to be kept in the trunk of a vehicle. Use of jacks of designed for a specific vehicle requires more than the usual care in selecting ground conditions, the jacking points o the vehicle, ad to ensure stability when the jack uses a incompressible fluid that is forced into a cylinder by a pump plunger (this depends on the pressure generated by the pump), and oil is generally used because of its lubricating effects on the moving parts [5]. A typical bottle jack is compact in size, but are designed and built for maximum performance and efficiency. In recent times, the hydraulic jack design is replaced by a bottle jack which takes the shape of a bottle, having a cylindrical body and neck from which the hydraulic ram emerges. In the bottle jack, a vertical piston directly supports a bearing pad which in turn serves as a support for the load being lifted. With a single action of the piston, the lift is slightly less than twice the collapsed height of the jack [2].

2.0 MATERIALS AND METHODS

2.1 Description of Components

Power Source

The jack was powered by a voltage receptacle from vehicle direct current receptacle part rating 12DC. It is a 12V, 6.5A lead acid dry cell rechargeable battery of mean dimension.

Electronic control unit (Remote)

International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 8 Issue 12 December - 2024, Pages: 1-9

The electronic control unit was made up of a switch, PIC microcontroller, infra-red light emitting diode (LED), transistor, capacitor and resistor

Cablings

This will be high resistance Electric cables with coating used as extension wire from socket t o direct current receptacle part and for inter connection between socket and battery as well as for motor-micro chip (Electronic control Unit) connection.

Prime Mover

This is a 12V, 312W, 2650rpm DC electric motor of mean dimension with off put shaft splinted to 10mm diameter and 9 teeth, through 18.4mm width (length).

Valve control motor: Low speed, 60 watts, 11.5NM torque, 13.5V DC motor.

Support: These include the 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 cover's a dimension of 216x216x30mm and shell to 4mm thickness. Drills were made for both ways.

Casing: Covers a dimension of 220x220x180mm. It is made of thin sheets of 2mm thickness.

Cover: It 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 were used for temporary joining of non moving parts steel materials while pins were used for temporary joint of moving parts e.g. the joint between connecting rod and lever.

2.2 Materials Selection

The machine is fabricated with mild steel because it meets he above considerations and also due to its machine ability and audibility since the fabrication process involves cutting, folding, bending, welding and other machine operations.

The following materials were selected for the fabrication of the components of units. Cast iron is used for the base of jack housing while mild steel is used for the base of the jack housing seats as it also provide a base support for the housing of the jack. Also, Nickel Chromium steel is used for jack pistons and galvanized steel used to build the housing. The selections of these materials were based on the strict adherence of the above criteria.

A liquid can transmit any external pressure applied to it to all its parts. This property I used in the hydraulic jacks for lifting cars.

In the simplest form it consists of a narrow cylinder connected to a wide cylinder, both containing liquid (usually oil) and fitted with pistons as shown in fig. 1.

Let the area of the primary piston be AP and area of the secondary piston be A_s. Let external force in this case external effort E_p be applied to the primary piston of cross sectional area Ap. This will generate a pressure of magnitude E_p/A_p in the primary cylinder that the pressure at a point in a liquid acts equally in all directions. The pressure E_p/A_p is transmitted throughout the liquid. If the secondary cylinder has a cross-sectional area of A_s, it experiences an upward force F_s

$$F_s = \underline{E_p}\ x A_s = \underline{A_s}\ x\ E_p \qquad (1)$$

$$P = \frac{W}{A} = \frac{F}{a} = \frac{W}{F} = \frac{A}{a} = \frac{Load}{Effort} = MA \qquad (2)$$

Where MA = Mechanical advantage

$$\textit{Velocity Ratio (VR)} = \frac{\textit{Distance moved by effort}}{\textit{Distance moved by load}} = \frac{\textit{Area of ram x leverage}}{\textit{Area of plunger}} \qquad (3)$$

$$\text{Efficiency of jack} = \frac{MA}{VR} \quad (4)$$

Equation 1 shows that the force exerted on the secondary piston will be greater than the force applied on the primary piston.

If $A_s > A_p$

Where VR = Velocity Ratio

Let assume that the external force applied to the primary piston moves it through a downward distance d_p as shown in figure 1. For this downward displacement of the primary piston to occur, a volume liquid must be displaced from the primary cylinder. Volume of liquid displaced from primary cylinder = $A_p D_p$;

Volume of liquid transferred to secondary cylinder = $A_s d_s$

Therefore, $A_p d_p = A_s\, d_s$

$$\frac{dp}{Ap} = \underline{A_s d_s} \quad (5)$$

$$\frac{ds}{As} = \underline{A_p d_p} \quad (6)$$

Since $A_s > A_p$, It therefore implies that the primary piston will move a greater distance that the secondary piston.

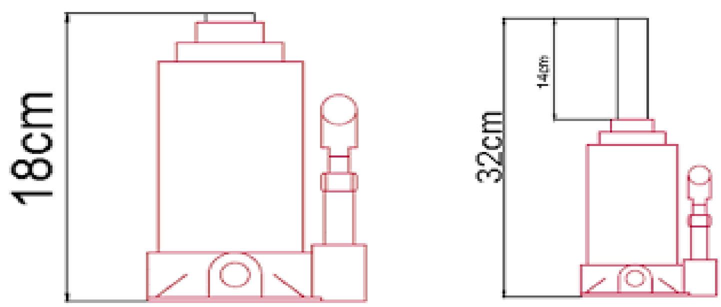
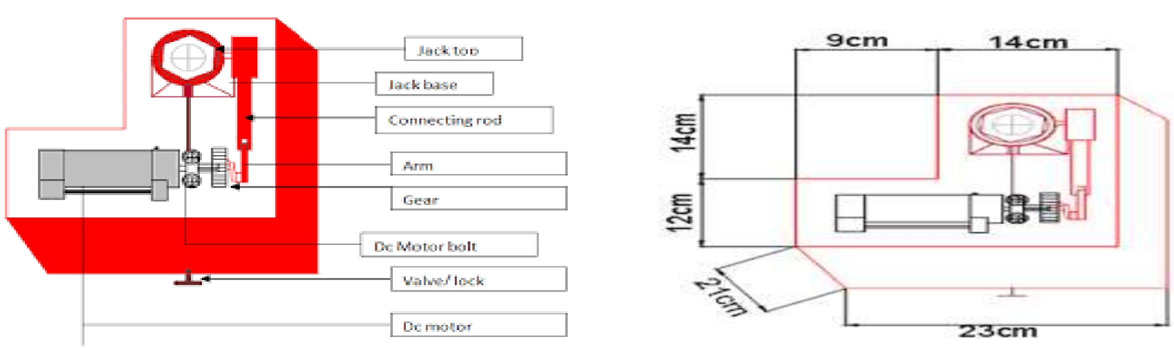


Fig. 1. Diagram Showing the Height of Lifting

Jack Control Motor Mechanism

This stage consists of mechanism that controls the car jack, this mechanism consist of the D.C motor and the gear and link mechanism for transmission of movement from the motor to the jack. This link mechanism function is to convert the rotary movement to linear movement.



(a)

(b)

Fig. 2. External Dimensions of the Car Jack

International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 8 Issue 12 December - 2024, Pages: 1-9

Construction and Testing

The construction involves two parts namely, the control circuit and the mechanism. The construction started with mounting of the component on a project board, the project board circuit arrangement started with the power supply consisting of the limiting resistor and the voltage regulator since the other stages would need power for testing. An assembly language code was developed for the microcontroller to the control circuit. The code was written for the microcontroller to the monitor the output of the infrared sensor and the decode it for the upwards movement of the jack.

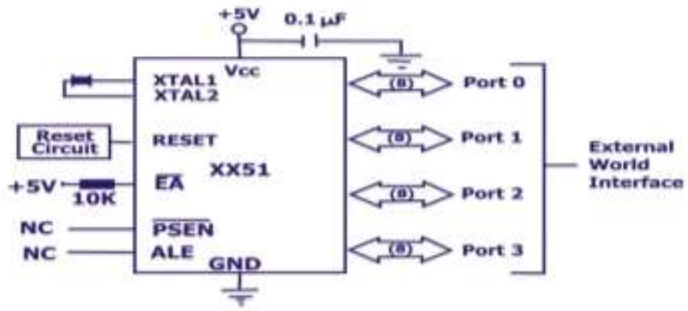


Fig. 3. Schematic Representation of the Micro-controller

Working Drawings

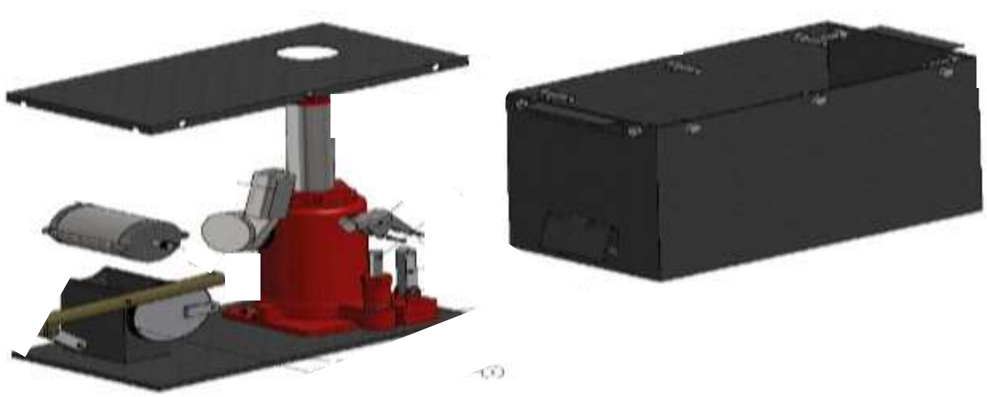


Fig. 4. Isometric View of the Hydraulic Jack

3.0 RESULTS AND DISCUSSION

The results of the kinematic analysis of the Remote Controlled Hydraulic Jack are presented in fig. 5 to 12.

This is a graph of distance moved by effort against distance moved by load which implies velocity ratio. The graph procedures a straight progression which means the more the distance the effort moves, the more the distance the load will also move. The gradient of this graph shows that the velocity ratio of the jack is 7, that is the gradient of the graph is 7/1

Fig. 5. Velocity Ratio Plot.

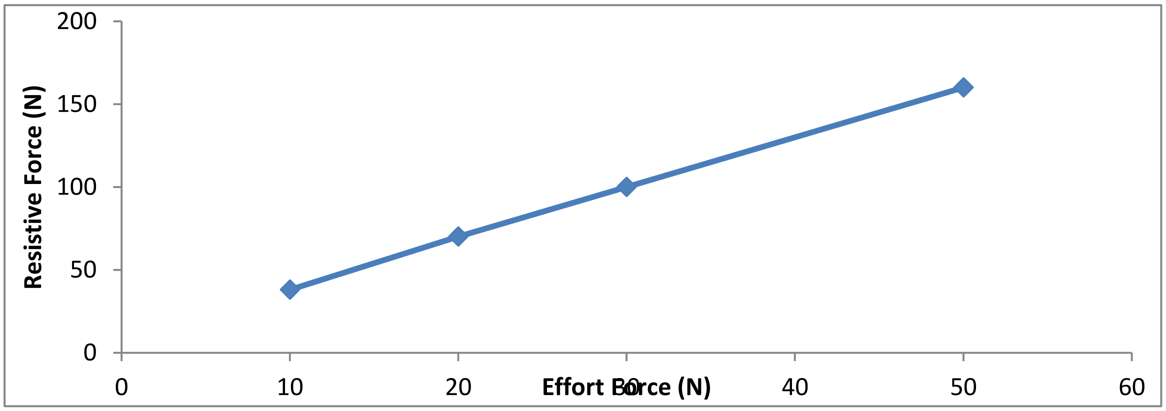


Fig. 6. Mechanical Advantage Plot

Fig. 6 is a graph of load against effort and it is also a straight line progression graph which means that the load is directly proportional to the effort, that is, the bigger the load, the more the effort is required to lift it. This is the mechanical advantage and it has a value of 30/5.

Note that efficiency is equal to mechanical advantage/velocity ratio x 100/1

Efficiency of the Jack = $\frac{6}{7}$ x $\frac{100}{1}$ = 86%

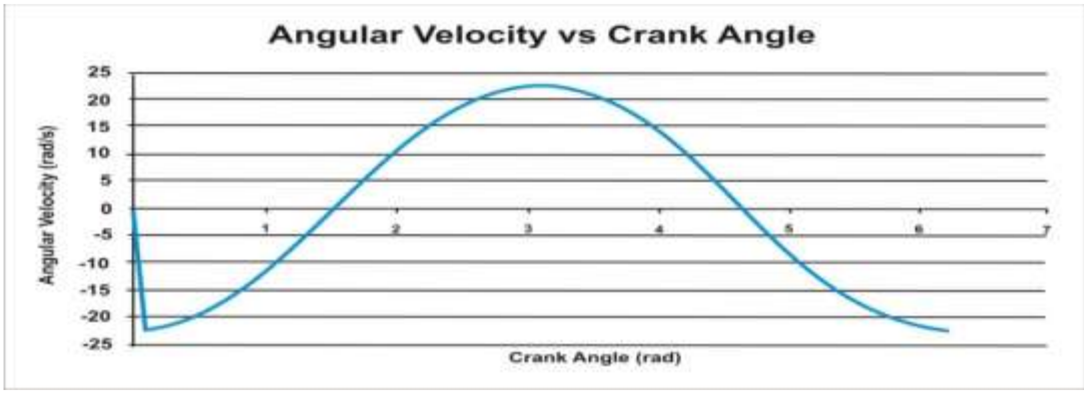


Fig. 7. Displacement – Crank Angle Graph

The Fig. 7 shows the crank displacement against crank angle. The graph shows a quadrant characteristic.

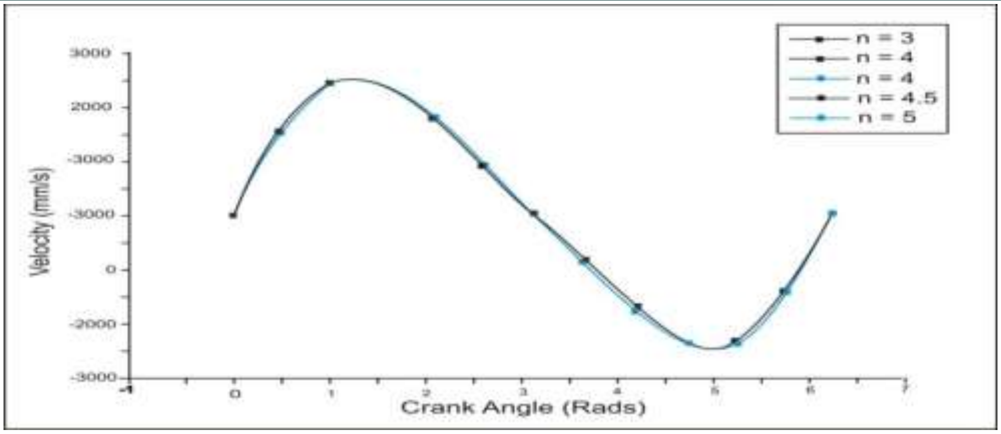


Fig. 8. Velocity – Crank Angle Plot

Also, fig. 8 shows the velocity crank angle plot. The relationship between the piston velocity against the crank angle characteristics from both figures are both the displacement and velocity will go back to its initial condition after completing one evolution cycle. The higher the ratio (n=1/R), the lower the maximum point of its displacement. The maximum velocity for all the plots occur at an angle of 90 and 70 as stated in the literature.

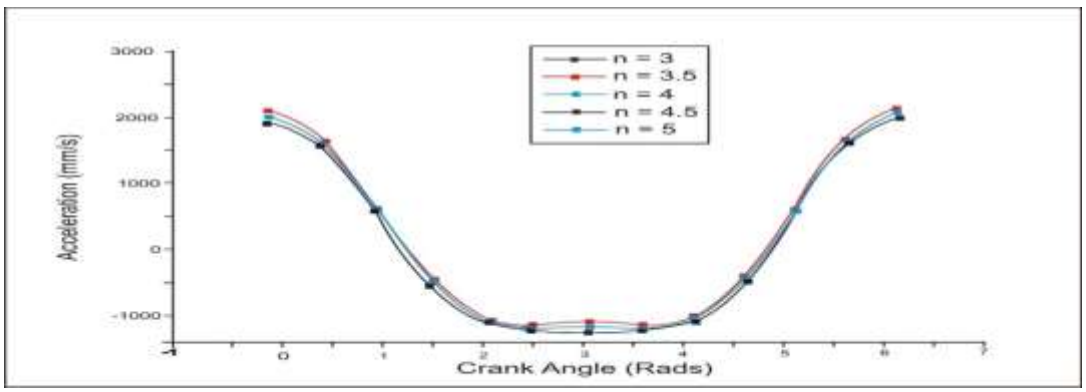


Figure 9. Acceleration – Crank Angle Plot

This gives the plot of acceleration against crank angle. It is found that the maximum acceleration is about 2156m/s^2 and it occurred at an angle of about 350degree to 360 degree. The maximum acceleration and the maximum velocity do not occur at the same crank angle. At the angle where maximum velocity occurs, the acceleration must have a value of zero.

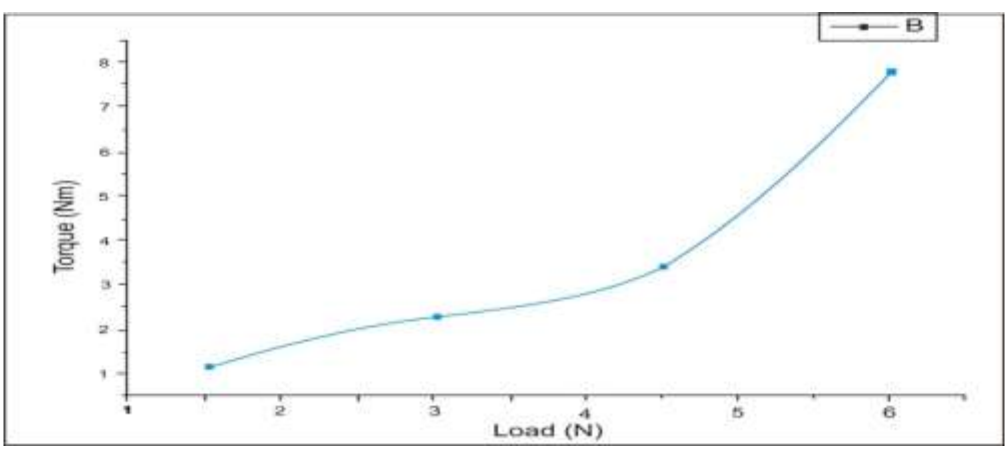


Fig. 10. The Graph of Torque Against Load in Tonne

International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 8 Issue 12 December - 2024, Pages: 1-9

From Fig. 10, it was observed that at no load condition the device performed with minimum time, subsequently varying mass of (1 tonne -5 tonne) was introduced at a lifting speed of 2650rpm which reduce as the hydraulic piston comes in contact with the load , the loads were lifted with ease showing that the device can lift. The varying mass of 1 tonne and 2 tonne were required space for the underneath equipment maintenance to be carried out. When lifting the loads of 3 tonne, 4 tonne and 5 tonne 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 the device was tested with different loads and found to perform satisfactorily.

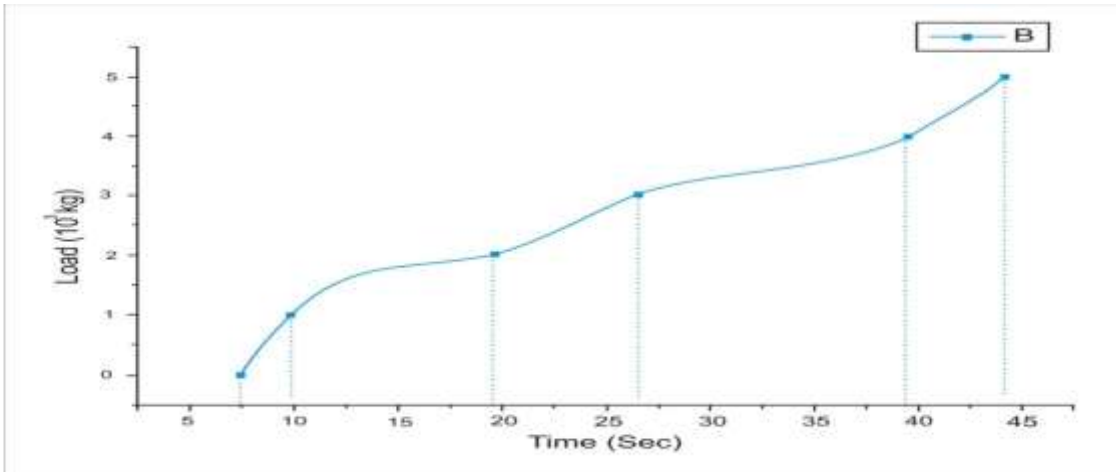


Fig. 11. Graph of Load (Tonne) Against Time (Sec)

Shown in the fig. 11 is a graph of load against time. It shows that the bigger the load, the more time it required to lift it.

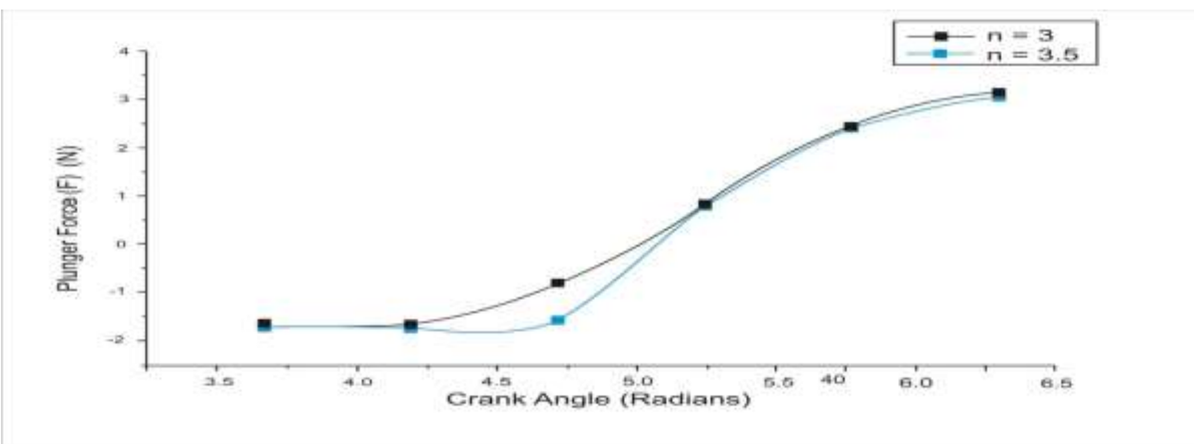


Fig. 12. Minimum Plunger Force against Crank Angle

The fig. 12 shows the minimum plunger force required to lift a load on the jack. The plunger force increases with increase in crank angle between 180 degree and 360 degree.

Conclusion

This work has successfully analyzed the design of a remote controlled hydraulic jack of 5 tonne maximum capacity, thereby eliminating the manual labour and risk associated with the use of ordinary jack with efficiency of 86% and maximum capacity of 5 tonne. From the hydraulic jack specifications, for every cycle of the crank, the piston plunder makes a movement from the Top Dead

Centre (TDC) to the Bottom Dead centre (BDC), for every of this, the ram makes a 4mm displacement and maximum lift of ram is 257.5mm.

REFERENCES

[1] Agu, C. S. & Igwe, J. E. (2016). Design and Construction of a Remote Control Car Jack. American Journal of Engineering Research (AJER), 5(8), 76-80.

[2] Deepa, A., Naveen, K. B. & Sagarnath, G. (2016). Design, Development and Testing of Novel Remote Controlled Electrically Operated Hydraulic Jack. ARPN Journal of Engineering and Applied Science*s*, 11(12), 7958-7961.

[3] Kamalakkannan, A., Kalaiselvan, P., Isaac, R. & Vijay, V. (2016). Automatic Motorized Screw Jack to Reduce Man Power. International Journal of Scientific and Engineering Research, 7(5), 21-24.

[4] Patel, P. M., Patel, P. S., Shah, V. H. ad Shah, S. R. (2016). Automatic Hydraulic Jack Inbuilt in a Four Wheeler. International Journal of Scientific & Technology Research, 5(8), 156-158.

[5] Singh, B. & Mishra, A, (2015). Analysis and Fabrication of Remote Control Lifting Jack. International Journal of Scientific Engineering and Applied Sciences (IJSEAS), 1(3), 308-319.

Authors

Wali S. A.
Lecturer, Department of Mechanical Engineering
Maintenance and Reliability

Akaninwor G. C.
Lecturer, Department of Mechanical Engineering
Production Technology