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DESIGN AND FABRICATION OF MOTORIZED SCREW JACK, USINGLOCAL CONTENT FOR HIGHER WORKSHOP PRODUCTIVITY.

Osueke, G. O.[1*], Obot, O. W.[2], Emeka-Opara, F. O[3], and Oguh, E. N[4]
*[1]*Mechanical engineering Dept, Federal University of Technology, Owerri. Nigeria.*
[2]*Dept. of Mechanical engineering, University of Uyo. Nigeria.*
[3]*National Productivity Centre, Abuja. Nigeria.*
*[1]*E-mail: osueke2009@yahoo.com*

Corresponding Author: -
E-mail: osueke2009@yahoo.com

Abstract: -

The design and fabrication of this motorized screw jack was carried out using locally available materials. The machine comprises of a jack, Electric motor, gear, shaft, 12V battery that drives the electric motor. The fabrication was carried out, using electric arc welding machine for major joinery while other fastening devices such as bolts and nuts were applied in the finishing stages. During the test runs, the jack performed very satisfactorily for loads varying from 2 tonnes to 5 tonnes. It will therefore serve effectively for lifting of workshop equipment and cars within its range of capacity.

Keywords: - *Design, Fabrication, Motorized, Screw jack, Higher productivity.*

INTRODUCTION

Power screws are used to convert rotary motion into translatory motion. A screw jack is an example of a power screw in which a small force applied in a horizontal plane is used to raise or lower a large load. The principle on which it works is similar to that of an inclined plane.

The mechanical advantage of a screw jack is the ratio of the load applied to the effort applied. The screw jack is operated by turning a lead screw. The height of the jack is adjusted by turning a lead screw and this adjustment can be done either manually or by integrating an electric motor. By integrating an electric motor with the screw jack, the mechanical advantage of a hand driven jack can be increased. So in lesser time, much work can be done, and at the same time with less effort, thereby increasing the productivity of such workshop operation.

The lead screw can be short, tall, fat or thin depending on the amount of pressure they will be under and space that they need to fit into. It is made of various types of metals but the screw itself is made of lead. A large amount of heat is generated in it and long lifts can cause serious overheating. To retain the efficiency, it must be used under ambient temperatures, otherwise lubricants must be applied. These are oil lubricants intended to enhance the equipment's capabilities. Apart from proper maintenance, to optimize the capability and usefulness of lead screw it is imperative to employ it according to its design and construction. Also in this system is a regulator or controller for creating variable speed while lifting or lowering, an electric motor which converts the electrical energy to mechanical energy with the aid of electromagnetic.

The need for automating the screw jack and incorporating the DC motor has been an existing problem yet to be solved. It has been an outstanding issue in automotive maintenance on how (a) to reduce human effort in load carriage, and (b) to increase the efficiency/productivity of the screw jack applicable in automotive workshops.

Materials and Method.

Shaft, jack, D.C Motor, Battery, Gear, Angular iron, Flat plate, Wires for connection, Bolts and nuts. These materials are locally available.

Torque Required to Raise Load by Square Threaded Screws

The torque required to raise a load by means of square threaded screw was determined by considering a screw jack as shown in Fig. 1. The load to be raised or lowered is placed on the head of the square threaded rod which is rotated by the application of an effort at the end of lever for lifting or lowering the rod.

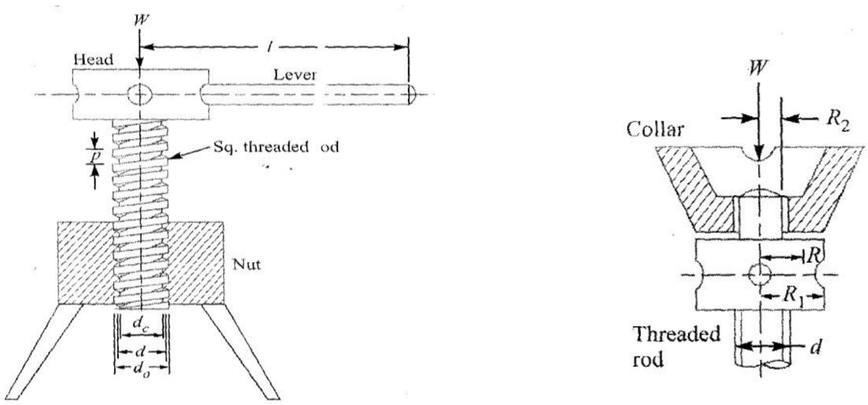

FIG.1. Screw Jack

A little consideration will show that if one complete turn of a screw thread be imagined to be unwound, from the body of the screw and develop, it will form an inclined plane as shown in Fig.3.7.

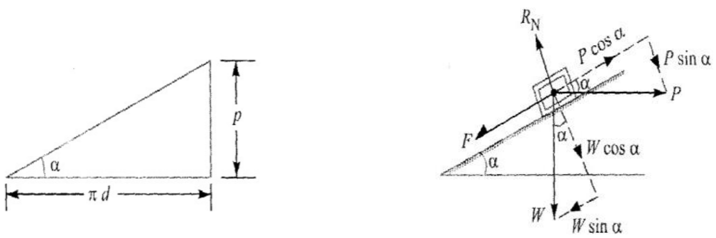

Fig. 2. Inclined planes.

P = Effort applied at the circumference of the screw to lift the load,
W = Load to be lifted, and
μ=Coefficient of friction, between the screw and nut
= tan ϕ, where ϕis the friction angle.
From the geometry of the Fig. 3.7we find that

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

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 isconsidered to be horizontal. Since the load is being lifted, therefore the force of friction (F = μ.R_N) will act downwards. All the forces acting on the body are shown asresolving the force along the plane,

$$p\cos\alpha = w\sin\alpha + F = W\sin\alpha + \mu.\ R_N \ldots\ldots\ldots\ldots\text{(i)}$$

and resolving the forces perpendicular to the plane,

$$R_N = P\sin\alpha + W\cos\alpha$$

Substituting this value of RN in equation (i), we have

$$P\cos\alpha = W\sin\alpha + \mu(P\sin\alpha + \mu w\cos\alpha)\ldots\ldots\text{(ii)}$$

$$\text{or}\quad P\cos\alpha - \mu P\sin\alpha = w\sin\alpha + P\sin\alpha = W\sin\alpha + \mu w\cos\alpha$$

$$\text{or } P(\cos\alpha - \mu\sin\alpha) = w(\sin\alpha + \mu\cos\alpha)$$

$$P = wx\frac{(\sin\alpha + \mu\cos\alpha)}{(\cos\alpha - \mu\sin\alpha)}$$

Substituting the value of μ = tan ϕ in the above equation, we get

$$P = wx\frac{\sin\alpha + \mu\cos\alpha}{\cos\alpha - \mu\sin\alpha}$$

Multiplying the numerator and denominator by cos ϕ, we have

$$p = Wx\frac{\sin\alpha + \tan\phi\cos\alpha}{\cos\alpha - \tan\phi\sin\alpha}$$

$$= wx\frac{\sin(\alpha+\phi)}{\cos(\alpha+\phi)} = w\tan(\alpha+\phi)$$

∴ Torque required to overcome friction between the screw and nut.

$$T_1 = pX\frac{d}{2} = w\tan(\alpha+\phi)\frac{d}{2}\ldots\ldots\ldots\ldots\text{(iii)}$$

Torque required to lower load by square threaded screws
A little consideration will show that when the load is being lowered, the force of friction ($F = \mu.\ R_N$) will act upwards. The efficiency will be maximum when $\sin(2\propto+\theta)$ is maximum, i.e. when

$$sin(2\propto+\theta) = 1 \quad \text{or } 2\propto+\theta = 90^o \ldots\ldots\ldots\ldots\text{(iv)}$$

$2\propto = 90^o - \emptyset$ or $\propto = 45^o - \emptyset/2$

Substituting the value of 2 ∝, we have maximum efficiency,

$$\eta_{max} = \frac{\sin(90^o - \emptyset + \emptyset) - \sin\emptyset}{\sin(90^o - \emptyset + \emptyset) - sin\emptyset} = \frac{\sin 90^o - sin\emptyset}{\sin 90^o + \sin\emptyset} = \frac{1-\sin\emptyset}{1+\sin\emptyset}$$

According to Khumin and Gupta (2004), in machine design W 8000kg tan $^{\propto P/\Pi d}$
Pi = 3mm
d = 15mm
N = 3000 rpm

$$\mu = 0.1 = \tan\phi$$

$$Tan\propto = \frac{P}{\pi d} = \frac{3}{\pi 15} = \frac{1}{5} = \frac{0.2}{\pi}$$

$$Tan\propto = 0.064$$

$$\propto = 3.662$$

Speed of the motor (N) = 300 rpm

$$Torque = \frac{Power}{Angularspeed}$$

$$Angularspeed, w = \frac{2\pi N}{60} = \frac{2\pi \times 300}{60}$$

$$10\pi = 31.42rad/S$$

$$Torque = \frac{1492}{31.42} = 47.49Nm$$

So, the maximum toque of the motor can deliver is 47.5 Nm.
Design requirement for lifting a load of 8 tonnes for the jack proposed toggle jack to be used. Pitch, p = 3mm.
Mean Diameter = 15mm

$$Coefficientoffriction, \quad \mu = 0.1 = tan\theta$$

$$\theta = tan^{-1}0.1 = 5.71$$

$$Helixangletan \propto = \frac{P}{\pi d} = \frac{3}{\pi \times 15} = \frac{0.2}{\pi} = 0.064$$

$tan\propto=0.064$, $\propto=3.662$

Torque required to overcome friction between screw and nut

$$T_1 = \omega tan(\propto + \theta)\, {}^{d}/_{2} \ \ldots\ldots\ldots(v) = 8000tan(5.711 + 3.662) \times \frac{0.015}{2}$$

$$T = 9.90345 \cong 10Nm$$

Since the torque required to lift 8 tonnes of load is 10Nm, therefore the torque produced by the motor, which is 47.5, is sufficient to lift the load.

Result and Discussion

After a successful design and fabrication, the jack was tested in the following area; the polarity of the motor, and it effectiveness in lifting load.
There was zero tail pipe emission
The powering of the jack was solely on the battery
The human effort and stress needed to lift a load with a Manuel jack was reduced.

Conclusion

The use of direct current technology for the jack helps to reduce human effort and also much works was achieved in shorter period of time. The simplicity in the design of the jack enables better access to the components, making it easy for maintenance.

References

[1].Bhandari V B (2007) Design Of Machine Element, Tata Mcgraw-Hill,
[2].Brian S. Elliott (2006), "Air-Over-Hydraulic Jacks", Compressed Air Operations Manual, Mcgraw-Hill Professional, Pp. 56–58, ISBN 978-0-07-147526-6.
[3].Degarmo, E. Paul, Black, J T Kohser, Ronald A. (2003), Material And Processes In Manufacturing (9th Ed), Wiley
[4].John Norman (2009), Fire Department Special Operations, Fire Engineering Books, P. 51, ISBN 978-1-59370-193-2
[5].Khurni R.S. And Gupta J.K (2004); "A Textbook Of ; Machine Design", Eurasis Publishing House (PVT) Ltd Ram Nagar, New Delhi
[6].William Cox (July 2007), "Light Talk On Heavy Jacks", Old-House Journal: 37.