Design and Fabrication of a Simplified Motorized Scissor Jack with Load-Adaptive Drive

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Abstract - The scissor jack is a commonly used lifting device for vehicles, but conventional manually operated jacks require significant physical effort and time. This paper presents the design and fabrication of a **simplified motorized scissor jack** powered by a **12 V DC supply**. The proposed system eliminates manual effort and provides safe, smooth, and controlled lifting. A **load-adaptive motor drive concept** is introduced to improve efficiency and reduce motor stress during lifting. Design calculations for the power screw, motor selection, and lifting members are carried out. Experimental testing is performed under different loading conditions, and the results demonstrate reliable lifting up to **2 tones**. The developed system is economical, compact, and suitable for diploma-level engineering applications.

***Key Words*:** Motorized Scissor Jack, Power Screw, DC Motor, Vehicle Lifting, Load-Adaptive Mechanism

1. INTRODUCTION

The vehicle jack is considered an important accessory utilized as assistance in lifting the car while changing tyres. The lower model manual jack provided with the car is compact, involving non-stop cranking by hand. It is impractical for senior individuals or when emergency situations occur.

To counter these issues, electric jack systems have been introduced. However, the current designs of these systems are quite costly. The aim of this project is to design a simple motorized scissor jack system which is easy to make, inexpensive, and can be powered by the car battery

2. LITERATURE REVIEW

There have been studies conducted on scissor jacks that use mechanical and motorized systems. The use of self-locking scissor jacks is preferred as they are compact. Motorized scissor jacks are expensive and have complex gearing systems.

The reviewed literature has revealed a demand for:

- Simplified production
- Lower component count
- Enhanced safety during lifting.

Therefore, a simplified design for the motorized system with adaptive control is recommended.

3. PROBLEM STATEMENT

A. Manual operation requires high physical effort
B. Lifting process is time-consuming
C. Unsafe during roadside emergencies
D. Difficult for elderly and physically challenged users

4. PROPOSED METHODOLOGY

The proposed system consists of:

- Mild steel scissor arms
- Trapezoidal threaded power screw
- 12 V DC gear motor
- Control switch and wiring
- Base plate and load saddle

Fig 1: 3D Model of Scissor Jack

When the motor rotates the power screw, the scissor arms expand vertically and lift the vehicle. The self-locking screw prevents reverse motion.

5. Design Analysis

5.1 Design of Power Screw

A) Calculation of Diameter (dc):

Material	Value Of Tensile Stress	Value Of Tensile Shear Stress
Mild Steel	130MPa	230MPa

Table -1: Stresses Value and Material

To lift a weight of 2000 Kg (20000N), mild steel being a ductile material.

$$\sigma = \frac{P}{\frac{\pi}{4} \times {d_c}^2}$$

$$130 = \frac{20000}{\frac{\pi}{4} \times {d_c}^2}$$

$$d_c = 0.014m$$

From the normal series Trapezoidal thread table (PSG design data book), the nominal diameter 16 mm with pitch, p = 4mm is choose.
The core diameter, $\boldsymbol{d_c}$ = 14mm
The major diameter, dmaj = 16 mm
The mean diameter, dm = 15mm

B) Calculation of Twisting Moment (Mt):
Twisting moment required to lift the load is given by,

$$M_t = \frac{F \times d_p}{2} \times \left[\frac{\mu\pi d_p + L\, cos\alpha}{\pi \times d_p\, cos\alpha - \mu L}\right] + (\mu F \times \frac{d_c}{2})$$

Axial force (231.91N)

d_p– Diameter of pitch, m
L – Thread lead, m
α – thread radial angle
d_c – Core diameter, m
μ - co-efficient of sliding friction **(0.25)**

$$\boldsymbol{M_r} = 231.911 \times \frac{0.015}{2}\left[\frac{(0.25 \times \pi \times 0.015) + (0.004 \times cos30)}{(\pi \times 0.015 \times cos30) - (0.25 \times 0.004)}\right] + \left[\frac{0.25 \times 231.911 \times 0.015}{2}\right]$$

$$\boldsymbol{M_r} = 1.1Nm$$

C) Check for Shear Stress (τ):
Maximum shear stress,

$$\tau_{max} = \frac{16 \times M_r}{\pi \times {d_c}^3}$$

$$\tau_{max} = \frac{16 \times 1.1}{\pi \times 0.014^3}$$

$$\tau_{max} = 2.043 \times 10^6 N/m^2$$

The calculated value is less than the maximum value. Therefore, **Design is safe.**

D) Check for Strength:

Twisting moment on thread,

$$M_t = P\frac{d_p}{2}tan(\beta + \rho) + M_t$$

$$M_t = P\frac{d_{red}}{2}\mu$$

$$M_t = 231.911 \times \frac{0.015}{2} \times tan6^o$$

$$M_t = 0.183Nm$$

$$M_t = 231.911 \times \frac{0.015}{2}tan(3.64 + 6) + 0.183$$

$$M_t = 0.478Nm$$

$$\tau = \frac{(16 \times 0.478)}{(\pi \times 0.014^3)}$$

$$\tau = 8.87 \times 10^5 N/m^2$$

This value is less than theoretical value (230 MPa).
Hence, design is safe.
Normal stress in the screw, $\sigma = \frac{4P}{\pi \times {d_c}^3}$

$$\sigma = \frac{(4 \times 231.911)}{\pi \times 0.014^3}$$

$$\sigma = 1.07 \times 10^8 N/m^2$$

Where,
Mt – torque transmitted by the screw (Nm)
β – Helix angle of the screw,
ρ – Friction angle 6° to 8° for self-locking β < ρ
Mf – Friction moment on the end or support, Nm
Dred – reduced diameter of friction forces on the pivot, m
μ – Co efficient of friction, tan ρ

5.2 Design of Power Screw
Moment of inertia,

$$I = \frac{bh^3}{12}$$

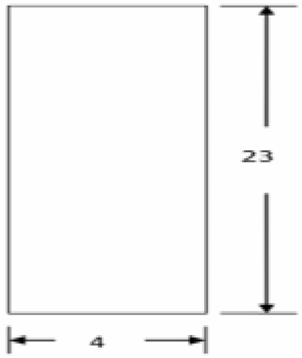

Fig 2: Cross Section of Links

Where,

b= breadth of the member (m)

h=height of the member (m)

$$I = \frac{0.004 \times 0.023^3}{12}$$

$$I = 4.056 \times 10^{-9} m^4$$

Crippling Load,

$$P_c = \frac{\sigma_c \times A}{1 + \alpha (\frac{L_e}{k})^2}$$

Where,

σ_c =Compressive stress (N/m^2)

A- Area(m^2)

B - Le–effective length (m)

Constant, $\alpha = \frac{1}{7500}$ ……

(R.K.Bansal,"$STRENGTH\ OF\ MATERIAL$")

$$A = b \times h$$

$$A = 0.004 \times 0.023$$

$$A = 9.2 \times 10^{-5} m^2$$

$$\sigma_c = 320 \times 10^6 N/m^2$$

…….. (R.K.Bansal,"$STRENGTH\ OF\ MATERIAL$")

$$P_c = \frac{320 \times 10^6 \times 9.2 \times 10^{-5}}{1 + \frac{1}{7500}\left[\frac{\frac{0.17}{2}}{6.639 \times 10^{-3}}\right]^2}$$

Effective length,

$$L_e = \frac{L}{2}$$

$$L_e = \frac{0.17}{2}$$

$$L_e = 0.085m$$

Radius of Gyration,$k = \sqrt{\frac{I}{A}}$

$$k = \sqrt{\frac{4.056 \times 10^{-9}}{9.2 \times 10^{-5}}}$$

$$k = 6.639 \times 10^{-3} m$$

$$P_c = 28.81\ kN$$

5.3 All Values

Sr. No.	Name	Value
01.	Core Diameter	14mm
02.	Twisting Movement	1.1Nm
03.	Shear Stress	$2.043 \times 10^6 N/m^2$
04.	Strength	$8.87 \times 10^5\ N/m^2$
05.	Stress In Screw	$1.07 \times 10^8 N/m^2$
06.	Momement of Inertia	$4.056 \times 10^{-9} m^4$
07.	Area	$9.2 \times 10^{-5} m^2$
08.	Effective Length	0.085m
09.	Radius Of Gyration	$6.639 \times 10^{-3} m$
10.	Crippling Load	28.81kN

Table -2: Value Summary

6. COST ESTIMATION

Sr. No.	Materials	Specification	Cost	Total cost
01	Mild Steel		120/kg	240
02	Motor	12V,DC motor	3400	3400
03	Wires	1 sq. mm	12 (1meter)	120(12 meter)
04	Switch	Forward/Backward	320	320

Table -3: Cost Estimation

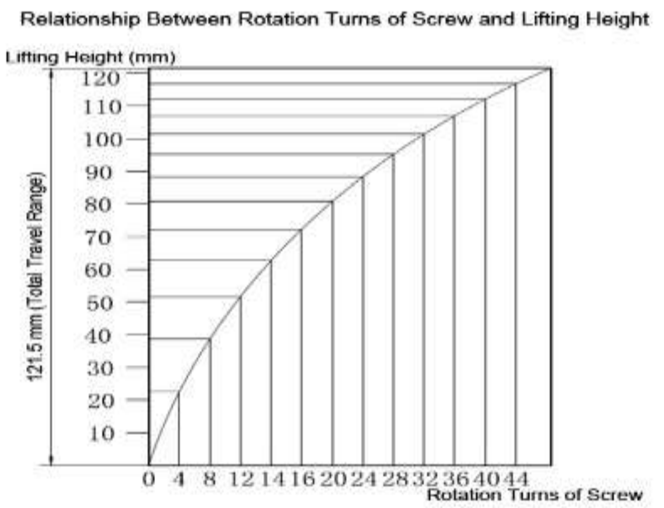

Chart-1: Screw Rotation vs Lifting Height

7. CONCLUSIONS

The simplified motorized scissor jack was successfully designed, fabricated, and tested. The system safely lifts vehicles up to **2 tonnes** with minimal human effort. Experimental results validate the performance and stability of the system. The proposed design is economical, easy to fabricate, and suitable for **diploma engineering academic projects** and real-world applications.

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