Alternative Lift Mechanism using Power Screw (20ft)

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Abstract – *This abstract is about alternate mechanism for scissor lift. This innovation deals with the concept of lead screw mechanism of lathe to lift platform for lifting operations. Here there are two lead screws which take the platform up and down with the help of motor and speed reduction drive. The loads are equally distributed among the two screws. This is a simple mechanism where platform height can be easily adjusted by rotating the motors. The platform can also be angled to small angles when one screw is rotated, this helps the platform to be flat even though the wheels of the lift are uneven. High loads can be lifted using these type of power screws. Power screws also has self-locking ability to lock the platform. These screws can be easily actuated electronically using a three phase induction motor. The overall cost and size of the lift is reduced. Maintenance of the motors is simple and easy.*

***Key Words*:** **Lathe, Lead Screw, Screw, Bolt, Nut, Power Screw, Power, Screw Conveyor, Motor, Speed Reduction Drive**

1. INTRODUCTION

This mechanism provides alternative mechanism for currently used scissor lift up to 20 ft. Currently hydraulic scissor lifts are used to lift platforms up to 20 ft. Hydraulic components are subjected to leaks and frequent breakdown Costs more due to more number of components used in the scissor lift. This innovation comes handy as it only has a simple mechanism to lift the platform.

Since load carrying capacity of power screws are high, load of the platform can be easily lifted with comparatively smaller effort. Maintenance of this lifting mechanism is easy.

1.1 Problem Definition and Solution

Current design has a hydraulic cylinder to lift the platform in vertical direction. Hydraulic operation is subjected to leaks and repairs, also it cost more. Problem is that they are costly and less efficient. There are many components used in this type of mechanism. This type of problem can be eradicated by means of bringing a simple mechanism to lift the platform. Hydraulic system are meant to carry very high loads. But for platform lifting mechanisms the loads are considerably low around 1000Kgf. These loads can be carried easily by power screws

Two power screws which take the platform up and down with the help of motor and speed reduction drive. The loads are equally distributed among the two screws this is a simple mechanism where platform height can be easily adjusted by rotating the motors. The platform can also be angled to small angles when one screw is rotated, this helps the platform to be flat even though the wheels of the lift are uneven. High loads can be lifted using these type of power screws. Power screws also has self-locking ability to lock the platform. These screws can be easily actuated electronically using a three phase induction motor. The overall cost and size of the lift is reduced. Maintenance of the motors is simple and easy.

Fig -1: Existing Hydraulic Scissor Lift

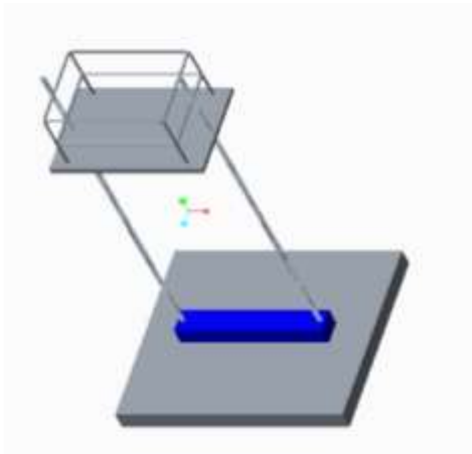

Fig -2: Designed Power Screw Lift

2. DESIGN OF POWER SCREW LIFT

The complete design of the lift mechanism is designed, making both economically feasible and improve productivity. The calculations and diagrams of the design are shown below.

Abbreviations

E = Young's modulus (kgf/cm^2)
I_{min} = Least moment of Inertia of core section (cm^4)
L_c = Length of the power screw (cm)

P_c = Buckling Load of the screw (kgf)
d = Diameter of the core in (cm)
N = Speed of the motor (rpm)
P = Power of the Motor in (KW)
P = Pitch of the screw (mm)

2.1 Load Considerations

Considering 3 persons with an average weight with tools to carry of 100 kg, Platform weight and self-weight of the screw to considered as maximum of 50kg

Total Load = (350 + 50) * Factor of Safety
= (350 + 50) * 3
= 1050kgf

2.2 Design of Core Diameter of Power Screw

Since the L by D ratios are high here the main load that is to be considered is the buckling load

Critical or Buckling load for a power screw is given by the formula

$$P_c = \frac{\Pi^2 * E * I_{min}}{l_c^2}$$

The moment of Inertia of the screw of a circular cross section is given by the formula

$$I_{min} = \frac{\Pi(d^4)}{64}$$

Therefore

$$P_c = \frac{\Pi^3 E d^4}{64 l_c^2}$$

By rearranging formula to find the core diameter

$$d^4 = \frac{P_c * 64 * l_c^2}{\Pi^3 * E}$$

As per Design there are two power screws to distribute the load and to maintain the balance of the setup

So the load carried by the two screws are equally distributed among them

Load carried by the each screw is 525Kgf or 5250N

By rearranging the formula to find the minimum diameter of the screw for this load is given by

$$d^4 = \frac{P_c * 64 * l_c^2}{\Pi^3 * E}$$

$$d = \left(\frac{525 * 64 * 620^2}{\pi^3 * 2 * 10^6}\right)^{\frac{1}{4}}$$

By resolving the equations the mimimum diameter of the screw is calculated as 3.79cm or 37.9mm

2.3 Selection of Standard Dimensions of the Power Screw

Trapezoidal thread or acme thread is preferred because the while reversing the direction the losses are less in the case of Acme threads or Trapezoidal Threads. The material of the screw is C40.Length of the Screw is 610cm

Standard Dimensions from PSG Design Data
Standard Dimensions of screw available are
Minor diameter or core diameter of screw = 39.5mm
Major diameter of screw = 48mm
Pitch circle Diameter = 44mm
Pitch = 8mm
E = 2.79mm

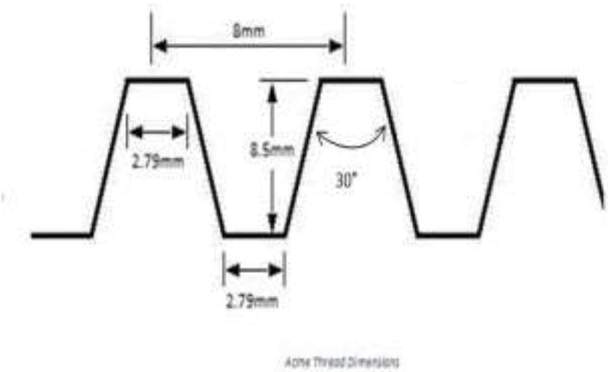

Fig -3: Standard Dimensions of the Power Screw

The material of the nut is Bronze,

The nut material is selected as bronze to reduce the friction between the screw and the nut

2.4 Check for Self-Locking

Power screws have property of Self-locking, large frictional forces cause most screws in practical use to be "self-locking", also called "non-reciprocal" or "non-overhauling".

$$\tan\beta = \frac{p}{\pi * d}$$

$$\beta = \tan^{-1}\left(\frac{p}{\pi * d}\right)$$

$$\beta = \tan^{-1}\left(\frac{8}{\pi * 44}\right) = 3.312^o$$

$\beta = 3.312^0$
Friction angle (ρ) is usually 6^0 to 8^0
$\beta < \rho$ so self-locking is attained

2.5 Selection of Motor for the Application

Assuming the Speed of the platform to be 0.48m/s and given that the pitch of the thread is 8mm

To achieve a speed of 0.48m/s the power screw must rotate at a speed of 6rps

So, the required speed of the motor or the speed of the the power screw is 360rpm

Required Torque in the Thread is given by the formula

$$T = \frac{Q * p}{2\pi}$$

$$T = (\frac{3500 * 8 * 10^{-3}}{2\pi}) = 4.45Nm$$

Hence the Required power of the motor is

$$P = (\frac{2\pi * N * T}{60 * 1000})(KW)$$

$$P = (\frac{2\pi * 360 * 4.45}{60 * 1000}) = 0.16776KW$$

Power of the motor is obtained as 0.167KW Standard power of the motor available in the market is 0.25HP or 0.18KW Motor A three phase induction motor is selected so that direction can be reversed to bring the platform down Speed control drive is used to reduce speed of the motor from 1440 rpm to 360 rpm With speed control drive, feed of the platform can be changed dynamically Electronic control can be provided for precise movement of motors

2.6 3D Model of the Concept

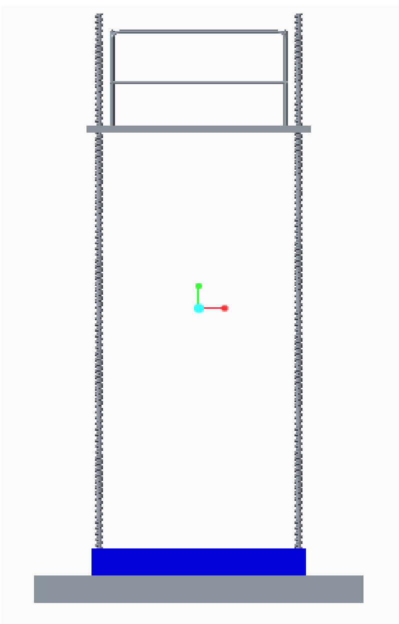

Fig -4: Front view of the Lift

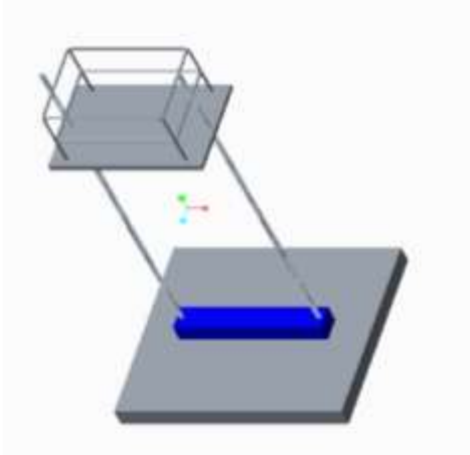

Fig -5: Isometric view of the lift

2.7 Analysis of the Screw Geometry

Analysis of the thread is done by considering a single thread of screw as a cantilever beam and subjecting it to a maximum axial load of 550kgf
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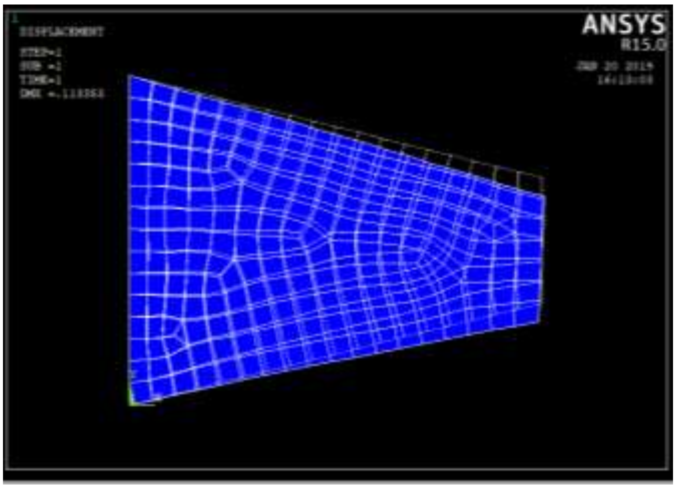

Fig -6: Maximum Deflection of a single thread when subjected to max load

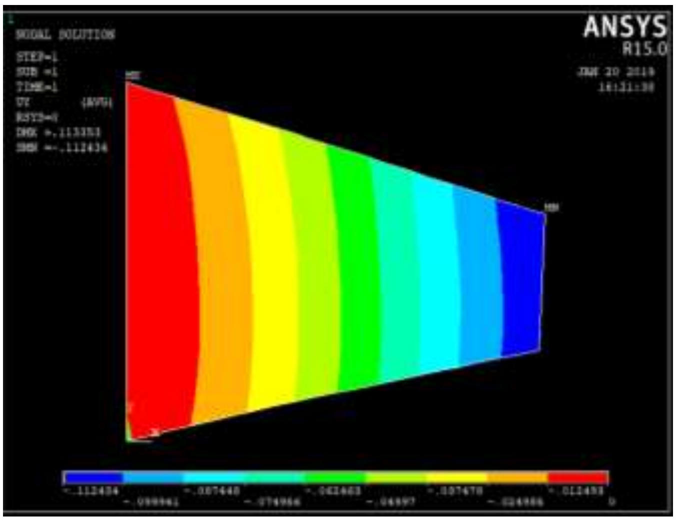

Fig -7: Stress Distribution of Thread Geometry

3. COMPARISON WITH CURRENT SYSTEM

Table -1: Comparison of screw actuated system to hydraulic systems

	Screw actuated system	Hydraulic System
Costs	Moderate initial unit costs. Low operating cost since power is only required during operation. Low maintenance costs.	Low initial outlay if ignoring hydraulic power unit. High installation and maintenance costs. High energy usage due to requirement of pump being in constant use.
Safety	In the event of power loss, screw jacks and linear actuators can be self-locking. There is no chance of a high pressure oil leak.	In the event of power loss or hydraulic leak, without an additional breaking system, the actuator motion is not controlled.
Capacity	Up to 1000kN.	Extremely high. The most powerful option.
Control	Easily compatible with standard electronics.	Compromised through requirement of electronic/fluid interface and valving. Control is complicated by hysteresis, supply pressure and temperature.
Environment	Clean with no hazardous hydraulic fluid. Energy efficient.	Temperature extremes can be a problem as seals are prone to leak. Required disposal of hazardous hydraulic fluid.
Configuration	Non flexible - Fixed configuration.	Flexible hoses/lines with remote power source allows for versatility.
Installation	Simple electrical wiring.	Plumbing, filtering and pumps required.
Accuracy	Very accurate and repeatable.	Very accurate although position sensing and electrohydraulic valving is required. Has tendency to creep due to strains within system.
Life	Millions of cycles are achievable at rated load which is easily calculated. Requires lubrication maintenance.	Usually good. Self-lubricating. Dependent on design, seal wear and maintenance.

4. CONCLUSION

Powers screws are simple mechanisms and can be alternate solution to currently used hydraulic scissor lifts. This opens lot of areas where power screws can be used, it is simple in construction and it shows proving results. Cost of this type of system can be relatively low when compared to current system and this system can be more reliable solution.

5. REFERENCES

[1] PSG Design Data book
[2] V.B Bhandari's "Textbook for Design of machine elements" – Third Edition

6. BIOGRAPHIES

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