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Design And Optimization of a Low Effort Screw Jack Mechanism

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Abstract

We take an opportunity to present this on "Low Effort Jack", and put before reader some useful information regarding our project. We have made some sincere attempts and taken every care to present this matter in precise and compact form. The language being as simple as possible. We are sure that the information contain in this volume would certainly prove useful for better insight in the and dimension of this project in its true perspective. The task of completion of this project through being difficult was made quite simple, interesting and successful due to deep involvement and complete dedication of our group member.

Keyword

Worm and worm wheel, Screw rod, Bearing, Nut, AutoCAD.

Introduction

The screw jack is a device for lifting heavy loads by applying comparatively small at its handle. In its common form screw jack consists of threaded rod called as screw rod or power screw. The screw has threads on its outer surface which bits into the internal threads of the nut. The load to be lifted is placed on the screw head and the application of effort at the end of handle lifts or lower the same. A common conventional screw jack is shown below.

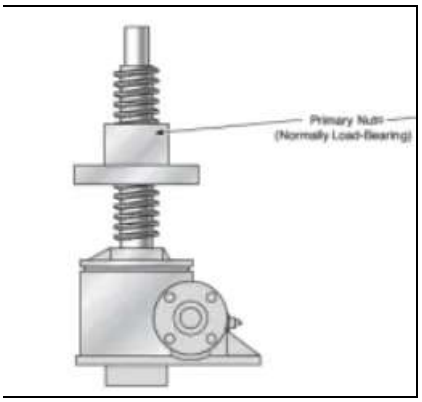

Figure 1. Conventional Screw Jack

Commercially available jacks.

1. Bottle type jack
2. Hydraulic jack
3. Pneumatic jack

1.Bottle type jack

It consists of screw at the top on which load to be lifted is placed. The load is prevented from rotation by providing a swivel. The nut is press-

fitted in the maintenance body which is usually made of cast iron. The effort is applied by mean of Tommy bar which is inserted in a suitable hole provided in the head or up of screw.

Advantages
1. Cost is less.
2. Light in weight, hence portable.

Disadvantages
1. As load increases effort required increases more rapidly.
2. In case of over loading damage may occur.

2.Hydraulic Jack

It consists of piston reciprocating inside cylinder, tank containing hydraulic fluid, pump driven by motor, control valves and pedal. It is operated manually by pressing the Pedal which in turn pumps the fluid into cylinder and raises the load. On operating release- valve the fluid is pumped back to fluid chamber which results in lowering of piston and hence the load.

Advantages
1. Lifts heavy load with less effort.
2. Movement from standstill is possible with full force.
3. Compact in construction.
4. Protection from overload damage.

Disadvantages
1. Cost is high.
2. Overall system is bulky.
3. Efficiency is less.
4. Noisy due to shocks in piping.

3.Pneumatic Jack

Its components are same as hydraulic jack except the air is used as working medium instead of oil. The high-pressure air from the compressor is compressed in the cylinder which moves the piston up and lifts the load gradually. To lower the load, the return valve is operated and compressed air is exhausted to atmosphere.

Advantages
1. Operation is cleaner than hydraulic jack.
2. Protection from overload damage.

Disadvantages.
1. Working cost is high due to high compression cost.
2. Actuators are bulky than hydraulic jack.
3. Speed of piston is not uniform.
4. Produces noise due to exhaust of high-pressure air.

Modified screw Jack

The common problem faced in the conventional screw jack is that it requires great efforts to raise or lower the load. For heavy goods carrier vehicle, this jack is not useful and hence hydraulic jack is preferred which is costlier. Today's requirement of jack is that it should require low effort and low cost, so the 'modified jack' is compromise between hydraulic jack which is costlier and conventional screw jack which requires high effort for heavy load.

Literature Review

A long time ago when vehicles came into existence, much more was not decided about the maintenance especially when tyre gets punctured. At that time, to remove the wheel of medium size vehicles (Tempos, Rickshaws, Jeeps, Cars) and heavy vehicles (Buses, Trucks, Big tempo's) small stones and cubic timbers were used. These are placed below the axle of the vehicles and lifted manually thus laborious work was consuming more time and energy of man. Afterwards to avoid such laborious work the Engineers had invented a device called screw jack in which a significant mechanical element called a screw plays an important role in lifting of the load. This screw was given the vertical motion by the fixed nut inside jack, which is again given power by Tommy-bar. This jack was requiring high force and hence to eliminate this disadvantage later on hydraulic and pneumatic jack are invented. The specialty of hydraulic and pneumatic jack is less effort required in lifting the load. But these jacks cost more while purchasing and have costlier maintenance. So, to eliminate the disadvantage of high effort required by the conventional screw jack and high cost of hydraulic and pneumatic jack, so the compromise of the product is the need of the time. This jack is named as "Power Lifting Machine". This jack combines the advantage of less cost of conventional jack and less effort of hydraulic and pneumatic jack.

Objective

- To design and develop a low effort jack that can lift heavy loads with minimum human force.
- To reduce manual effort by using suitable mechanisms such as hydraulic system, gears, or screw arrangement.
- To ensure safe and stable lifting operation during use.
- To improve efficiency compared to conventional jacks.
- To fabricate a working model using available materials and components.
- To analyze the performance of the jack in terms of load capacity and effort required.
- To make the system cost-effective and user-friendly for practical applications.
- To study the working principle of mechanical advantage in lifting devices.

System Components

- Base Frame
- Lifting Arm / Platform
- Screw Rod (Lead Screw)
- Bearing

Scope of the Project

The scope of this project includes the design, fabrication, and testing of a low effort jack that can lift heavy loads with reduced manual input. The project focuses on improving efficiency and ease of operation compared to conventional jacks.

It covers the following aspects:

- **Design and Development**

Designing a compact and efficient jack using suitable mechanisms like screw, gear, or hydraulic system.

- **Reduction of Human Effort**

Incorporating mechanical advantage techniques to minimize the input force required.

- **Fabrication of Model**

Manufacturing a working prototype using easily available materials and standard components.

- **Performance Evaluation**

Testing the jack for load capacity, stability, and effort required during operation.

- **Safety Considerations**

Ensuring safe lifting with proper balance and structural strength.

- **Cost Effectiveness**

Developing a system that is economical and practical for real-world use.

- **Applications**

Suitable for automobiles, small workshops, garages, and light industrial purposes.

Component

1. Worm and worm wheel:- Worm gear pair is used to transmit.

2. Screw rod:- Screw and nut always comes in pair for the engagement. The material
commonly used for screw rod is plain steel.

3.Types of screw thread:-

a) Square thread.

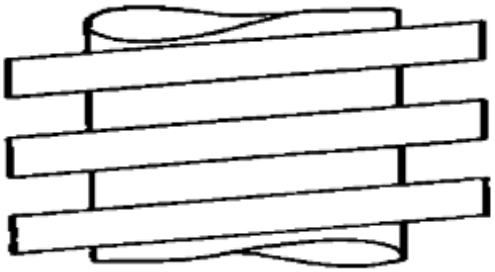

Figure 2. Square Thread

4. Bearing

Figure 3. Bearing

Design and Construction

The design of the low effort jack is based on the following factors:

- Load Capacity: The jack is designed to lift a specified load (e.g., 500 kg – 1500 kg).

- Mechanical Advantage: Use of screw threads, gears, or hydraulics to reduce input effort.
- Stability: A wide and strong base is provided to avoid tilting.
- Material Strength: Components are selected to withstand stress and load.
- Ease of Operation: The mechanism should require minimum human effort.

Main Design Elements

1. **Base Frame**
   - Made of mild steel
   - Provides rigid support and stability
2. **Lead Screw (Threaded Rod)**
   - Converts rotary motion into linear motion
   - Designed with suitable pitch to reduce effort
3. **Nut Mechanism**
   - Engages with the lead screw
   - Moves vertically to lift the load
4. **Gear System (Optional)**
   - Reduces input force
   - Increases torque applied to the screw
5. **Handle / Lever**
   - Used to rotate the screw or gear
   - Designed for comfortable grip
6. **Lifting Platform**
   - Flat surface placed on top
   - Directly supports the load
7. **Support Structure (Scissor or Link Mechanism)**
   - Ensures smooth vertical movement
   - Distributes load evenly.

The low effort jack is designed to provide maximum lifting with minimum input force using mechanical advantage. Proper design and construction ensure efficiency, safety, and durability.

Model

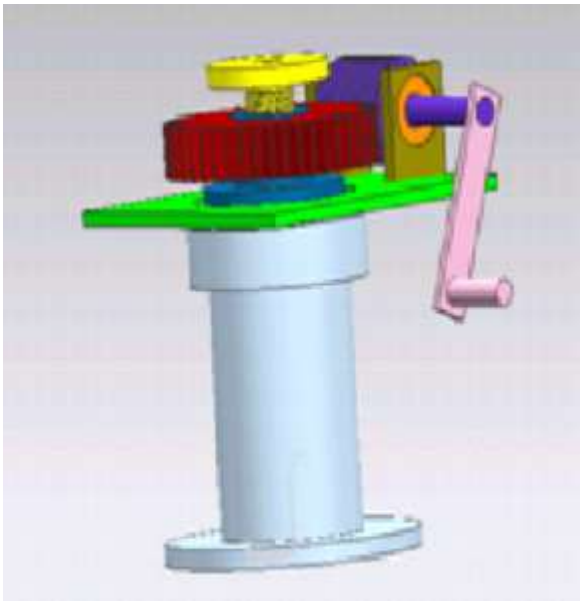

Figure 4. 3D Model of Low Effort jack

Working Principle

The jack consists of worm, worm wheel, screw nut, bearing all housed inside the body of jack. The worm is engaged with worm wheel, when handle is rotated, it rotates worm wheel about vertical axis perpendicular to the axis of rotator of worm. The nut is positioned inside the worm wheel and fixed to the worm wheel rotates along with wheel. The nut is made to rest on the top surface of roller bearing. This thrust bearing takes axial load coming on the nut and screw rod The square threaded screw rod is main part of jack which is meshed with nut and thus allowed to move up and down according to direction of the nut. The key prevents rotational movements of screw rod. A platform with sufficient surface area is provided on top of the screw rod, which is used to rest load on its upper surface while lower surface is screwed to the screw rod. When the handle is rotated in clockwise direction the nut also rotates clockwise direction thus making the screw rod to move up and raises the load and when the handle is rotated anti clockwise, the nut also rotated in anti-clockwise direction thus causing screw rod to move downward so as to lower the load. A washer is provided at the bottom end of screw rod limits the maximum lift of screw rod thus avoiding un meshing of nut and screw. The axial movement of the worm wheel is prevented by body of the housing. The inner surface of the top half of the body just touches worm wheel so the axial

movement of worm wheel is prevented by this arrangement. Handle may be made fix or removable depending upon the requirement when operation need to be performed in compact space, facility of removable handle may be used. When the load is required to be lifted the jack is kept on the lower side of the load, so that the load will rest properly on the platform provided in the top of the screw. When the handle is rotated clockwise it caused worm to rotate and in turn worm wheel to rotate. As the nut is fixed to the worm wheel, the rotation of worm wheel causes nut to rotate. The nut is screwed to the screw rod. So according to rotation of the nut the screw rod moves upwards and the load which is rested on platform is lifted up, when the screw rod moves upwards. Thus lifting of load is carried out, now to lower load, the opposite operation to above is carried out. The handle is rotated in anticlockwise direction thus making the screw rod to move in downward direction and lowering of load is carried out. The key way has been cut along the length of screw rod, which gives axial and linear motion to the screw rod.

Testing and Results

The fabricated low effort jack was tested under different loading conditions to evaluate its performance, efficiency, and safety.

1. **Initial Inspection**
   - Checked all components for proper assembly
   - Ensured smooth movement of screw/gear mechanism
2. **No-Load Test**
   - Operated the jack without load
   - Verified smooth lifting and lowering action
3. **Load Test**
   - Gradually applied load (e.g., 200 kg, 500 kg, up to design capacity)
   - Measured the effort required to lift the load
4. **Stability Test**
   - Observed the balance of the jack during lifting
   - Checked for tilting or vibration
5. **Efficiency Check**
   - Compared input effort with load lifted
   - Evaluated mechanical advantage

Advantages

1. **Less Human Effort Required**
   - Designed to lift heavy loads with minimum physical force
2. **Easy to Operate**
   - Simple mechanism makes it user-friendly
3. **High Efficiency**
   - Provides better performance compared to conventional jacks
4. **Safe Operation**
   - Stable structure reduces risk of accidents
5. **Time Saving**
   - Lifts loads faster with less effort
6. **Cost Effective**
   - Can be made using economical materials and components
7. **Portable and Compact**
   - Easy to carry and use in different locations
8. **Versatile Applications**
   - Useful in garages, workshops, and industries
9. **Reduced Fatigue**
   - Minimizes strain on the operator
10. **Durable and Reliable**

- Strong construction ensures long service life

Applications

1. Automobile Industry

- Used for lifting cars, bikes, and other vehicles during repair and maintenance

2. Garages and Service Centres

- Helpful for tyre changing and underbody inspection

3.Workshops

- **Used to lift heavy machine parts for assembly or repair**

4. Construction Sites

- Lifting structural components and equipment

Results and Discussion

1.The fabricated low effort jack successfully lifted loads up to its designed capacity.

2.The input effort required was significantly reduced due to the use of mechanical advantage (screw/ gear/hydraulic system).

3.The jack showed smooth operation during both lifting and lowering.

4.The structure remained stable and safe under different

loading conditions.
5.The system performed efficiently with minimal friction and energy loss.

Future Scope

1.Automation using Electric Motor
- The jack can be upgraded by adding a DC motor to reduce manual effort completely.

2. Remote Control Operation
- Integration of wireless or remote-control system for easy operation.

3.Hydraulic System Improvement
- Use of advanced hydraulic mechanisms for higher load capacity and smoother

Conclusion

The Low Effort Jack project was successfully designed, fabricated, and tested to achieve efficient lifting of heavy loads with minimum manual effort. The use of suitable mechanisms such as screw, gear, or hydraulic system helped in increasing the mechanical advantage and reducing the input force required. The performance testing showed that the jack operates smoothly and can safely lift loads up to its designed capacity. The structure remained stable during operation, and the system proved to be reliable and user-friendly. This project demonstrates that a cost-effective, efficient, and safe lifting device can be developed using simple engineering principles. It is suitable for applications in automobile garages, workshops, and small industries. Overall, the low effort jack meets the objectives of reducing human effort, improving efficiency, and ensuring safe operation, making it a practical and useful solution for lifting applications.

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