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Design of Mechanical Screw Jackfor Mercedes E class

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Abstract: *This paper analyzes the modification of the existing screw jack by incorporating an electric motor in the screw inorder to make load lifting easier. In this modified design, the power screw is rotated through its connecting gear with the pinion gear which transmits its rotating speed to the pinion gear meshing with the bigger gear connected to the power screw to be rotated with required speed reduction and increased torque to drive the power screw. The significance and purpose of this work is to modify the existing car jack in order to make the operation easier, safer and more reliable in order to reduce health risks especially back ache problems associated with doing work in a bent or squatting position for a long period of time. The modified car jack is easy to use by pregnant women or whoever had problem with the vehicle tyre along the road. The designed jack will also save time and requires less human energy to operate. The design when adopted will effectively curb the problems associated with Ergonomics - which is a fundamental concept of design process. The Design a mechanical screw jack is for Mercedes e class having weight 1400kg and ground clearance 180mm.*

Keywords*- Jack, Power Screw, Ergonomic, Pinion Gear, Speed Reduction, Torque*

I. INTRODUCTION

A screw jack is a portable device consisting of a screw mechanism used to raise or lower the load.There are two types of jack.

1. Hydraulic jack- A hydraulic jack consists of a cylinder and piston mechanism. The movement of the piston rod is used to raise or lower the load.
2. Mechanical jack- Mechanical jacks can be either hand operated or power driver. Although a jack is simple and widely used device, the use of any lifting device is subject to certain hazards. In screw jack application, the hazards are dropping tripping or slipping of machines or their parts.

1.1 Causes of failure

The load is improperly screwed on jack. The screw jack is overloaded the centre of gravity of load is off centre with respect to axis of the jack. The screw jack is hot placed on hard and level surface .the screw jack is used for a purpose for which it is not designed.

Essential for a screw jack

Proper size,strength, stability are essential requirement for the design of the screw jack from safety consideration.

1.2 Selection of material

I. Frame - The frame of the screw jack has complex shape. It is subjected to compressive stress. Grey ci of grade FG 200 (s_{ut} =200n/mm) is selected as the material for the frame. Cast iron is cheap and it is given any complex shape without involving any costly machining operations.

II. Screw - The screw is subjected to torsional moment, compressive force and bending moment. From strength consideration plain carbon steel of grade 30c8 (s_{yt} =400n/mm and e =207000 n/mm) is selected as material for the screw.

1.3 Design of screw jack parameters

Total force =300 N
Weight W = 3.4335 KN
FOS = 2.5
S_{yc} =S_{yt} =560 MPA

$$\sigma c = \frac{Syc}{FOS} = 224 \text{ MPA}$$

1.3.1. Core diameter

$$\sigma = \frac{W}{\frac{\pi}{4}(dc)^2}$$

$$dc = 6.2476\ mm$$

1.3.2 For torsional

Let d_c =12 mm
Nominal diameter =16 mm
Pitch =4 mm
d =16 mm
P =4 mm

d_m = d – 0 .5 p
= 16 – 0.5×4= 14mm

For single start
P =4 mm

$$\tan\alpha = \frac{1}{\pi \times dm}$$

$$\alpha = 5.196^{\circ}$$

Let μ = 0.2
Talking into account bad lubrication and operating condition

Tanϕ= μ
Φ= 63.43°

ϕ>α
63.43>5.196
Screw is self-locking

$$T = W \times \frac{dm}{2} \times \tan(\phi + \alpha)$$

T= 61.41× 10^3 Nmm

1.3.3 At section xx

$$\tau\ max = \frac{16\,T}{\pi * dc^3}$$

τ_{max}= 0.18 MPA

$\tau_{permissible}$= $\frac{0.5\ Syt}{FOS}$

$\tau_{permissible=}$ 112 MPA

112 MPA> 0.18 MPA
Hence, Screw is safe in tension

1.3.4 Stress due to bending

M_b= P× L
L = 100 mm
M_b =30 Nm

$\sigma_{\mathbf{bending}}$ =$\frac{32\ mb}{\pi * dc^3}$

$\sigma_{\mathbf{bending}}$ = 176.83 MPA

224 MPA > 176.83 MPA

Hence, Screw is safe in bending

$$\tau_{max} = \sqrt{(\frac{\sigma b}{2})^2 + \tau^2}$$

$$\tau_{max} = 86.41 \text{ MPA}$$

86.41 MPA< 112 MPA

Hence, Screw is safe in combined torsional and bending moment.
End fixity co-efficient (n) is 0.25

$$\frac{Syt}{2} = \frac{n \times \pi^2 \times E}{\left(\frac{l}{K}\right)^2}$$

$$\frac{I}{K} = 42.709$$

We consider length as 100 mm

$$K = \sqrt{\frac{I}{K}}$$

I = moment of inertia
K= radius of gyration

$$I = \frac{\pi}{4} \times dc^4$$

I = 16286.016 mm^2
A =113.097 mm^2
K= 12
Slenderness ratio= $\frac{l}{K} = \frac{100}{11.5} = 8.333$

$$Pcr = \frac{\pi^2 EI}{\left(\frac{L}{K}\right)^2}$$

$$Pcr = 4560\ KN > 75 KN$$

Bearing pressure between steel screw andbronze nut is 10 MPa

$$Pb = W\left(\frac{\pi}{4}(do^2 - dc^2)Z\right)$$

Z =4

Height (H) = 4×4=16mm

1.3.5 Transverse shear stress

$$\tau = \frac{W}{\pi dTZ}$$

τ = 8.5384 MPa
8.5384<14MPa

Hence, Nut is safe

1.3.6 Transverse shear stress in threads

$$Transverse\ shear\ stress = \frac{3433.5}{\pi \times 12 \times 2 \times 4}$$

= 11.38 MPa<12 MPa

It is safe for the transverse shear stress

1.3.7 Nut design for cross-section

$$\sigma_t = \frac{W}{\frac{\pi}{4}}(Do^2 - Di^2)$$

D_o= 16.008mm

By using empirical relations
D_o= 1.6(16.008)
D_o= 20.8mm

1.3.8. For width column

$$\tau = \frac{W}{\pi \times Do \times t}$$

t = 3.5933 mm

$$\sigma_c = W/\left(\frac{\pi}{4}(Do^2 - Dc^2)\right)$$

σ_c= 24.78 Mpa
=24.78 Mpa < 38 MPa

1.3.9. Design of cup

D = 1.6×d
D=25.6 mm
D^1= 0.8 d
D^1= 12.8 mm

1.3.10. Collar friction

$$T_f = \frac{\mu W}{4}(Do - Di)$$

T_f = 22661.1 Nmm

Therefore, Total torque = T_f +T= 84071 Nmm
This torque operator has to beovercome

$84071=300\times0.9\times2\times L_h$
L_h= 155.687 mm

The length of handle 155.69 mm is practically possible,so no need of thrust ball bearing,length of handle is assumed to be 180 mm.

M_h= F× L_e
= 54000 Nmm

Hence the design is safe.

II. MANUFACTURING METHODS OF SCREW JACK

1. Frame –Gray cast iron of grade FG 200 is selected as the material for the frame. It is technicallyandeconomically advantageous to use cast ironfor the frame. The frame is mainlymanufactured by casting process as it is easier to manufacture complex shapes using casting.
2. Lead screw-For strength consideration plain carbon steel of grade 30c8 is selected as material. It is manufactured by rolling process, metal stock is passed through one or more pairs of rolls to reduce the thickness and to make the thickness uniform.
3. Nut –Since wear occurs between the screw and the nut, it is always desirable that the wear takes place in the nut, so that the nut is replaced. Hence it is made of a softer material cast of phosphorbronze of grade -1.It is selected as the material for the nut. Nut is manufactured by the casting process. Casting process is versatile and light and complex component can be manufactured using casting.
4. Cup–Grey cast iron grade FG 200 is used for the cup. The shape and dimensions of the cup are such that it is easier and economical to make it by casting process.
5. Handle –The yield strength is the criterion for the selection of material. Plain carbon steel of grade 30c8 is selected as material for the handle. It is manufactured by casting process.

III. CONCLUSION

1. Self-locking of the screw is not possible when the coefficient of friction (μ) is low. The coefficient of friction between the surfaces of the screw and the nut is reduced by lubrication. Excessive lubrication may cause the load to descend on its own.
2. The self-locking property of the screw is lost when the lead is large. The lead increases with number of starts. For double-start thread, lead is twice of the pitch and for triple threaded screw, three times of pitch. Therefore, the single threaded screw is better than multiple threaded screws from self-locking considerations.

IV. RECOMMENDATION

1. Further research should be carried out onhow to minimize vibration and noise duringoperation.
2. Design applicable to vehicles weighing over1000 kg should be carried out

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VI. REFERENCE

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