DESIGN AND ANALYSIS OF AN AERIAL SCISSOR LIFT

JAYDEEP M. BHATT, MILAN J. PANDYA

1 M.E. student (Thermal Engineering), Mechanical Engineering Department, 2 Asst. Professor, Mechanical Engineering Department, L. J. Institute of Engineering and Technology, Gujarat Technological University, Ahmedabad – 382210, Gujarat, India.

ABSTRACT:
The following paper describes the design as well as analysis of a simple aerial scissor lift. Conventionally a scissor lift or jack is used for lifting a vehicle to change a tire, to gain access to go to the underside of the vehicle, to lift the body to appreciable height, and many other applications. Also such lifts can be used for various purposes like maintenance and many material handling operations. It can be of mechanical, pneumatic or hydraulic type. The design described in the paper is developed keeping in mind that the lift can be operated by mechanical means so that the overall cost of the scissor lift is reduced. Also such design can make the lift more compact and much suitable for medium scale work. Finally the analysis is also carried out in order to check the compatibility of the design values.

KEY WORDS: Aerial work platform, pantograph, lead screw, helix angle, Von Misses stress.

1. Introduction
A scissor lift is a type of platform which moves in vertical direction. The mechanism incorporated to achieve this function is the use of linked, folding supports in a criss-cross 'X' pattern, known as a pantograph. The upward motion is achieved by the application of pressure to the outside of the lowest set of supports, elongating the crossing pattern, and propelling the work platform vertically upwards. The platform may also have an extending 'bridge' to allow closer access to the work area (because of the inherent limits of only vertical movement).

The operation of the scissor action can be obtained by hydraulic, pneumatic or mechanical means (via a lead screw or rack and pinion system). Depending on the power system employed on the lift, it may require no power to enter 'descent' mode, but rather a simple release of hydraulic or pneumatic pressure. This is the main reason that these methods of powering the lifts are preferred, as it allows a fail-safe option of returning the platform to the ground by release of a manual valve.

Types of Aerial Scissor lift
The aerial scissor lifts can be classified as follows:

1. Classification based on the type of energy used
   (a) Hydraulic lifts
   (b) Pneumatic lifts
   (c) Mechanical lifts

2. Classification based on their usage
   (a) Scissor lifts
   (b) Boom lifts
   (c) Vehicle lifts

2. Design of Different Components of Aerial Scissor Lift
Aerial Scissor Lifts comprises of six components. There is no concrete design procedure available for designing these components. The main components of the lift are Base plate, Upper plate, lead screw, nut, links and pins. On the basis of certain assumptions the design procedure for each of the components has been described as follows:

Design of Base Plate
The base plate in a scissor lift only provides proper balance to the structure. Considering the size constraints, the dimensions of the base plate are taken as under. Also it has been found that not much of the stresses are developed in the base plate.

Length of the plate (L) = 450 mm and Width of the plate (B) = 300 mm
Weight of the plate (W) = 250 N

![Figure 1 Dimensions of the Base Plate.](All dimensions in mm)
Design of Upper Plate
The upper plate in a scissor lift is used to place the load and transfer it to the links. The designing of the upper plate is undertaken similar as the base plate. The upper plate has the similar requirements as the base plate. Also it has been found that not much of the stresses are developed in the upper plate as well.

Design of Lead Screw
Lead screw is the ultimate component that takes up the load that is to be lifted or lowered by lift. It also delivers torque from the motor to the nut and also prevents falling of the lift due to its own weight. Link length is assumed to be 385 mm.

Effort required to rotate the screw while increasing the height, \( P = W \times \tan (\alpha + \Phi) = 135.23 \text{ N} \)
Similarly effort required to reduce the height, \( P = W \times \tan (\alpha - \Phi) = 80.5 \text{ N} \)
Torque required in rotating the screw, \( T = P \times (d/2) = 878.9 \text{ N.mm} \)
Torsional shear stress (calculated) = 10.36 N/mm²
Direct tensile stress (calculated) = 4.76 N/mm²
Maximum principle stress (calculated) = 13 N/mm²
Maximum shear stress (calculated) = 10.63 N/mm²
It has been found that all the above calculated values are within the permissible limits. Therefore all dimensions considered are correct.

Design of Nut
The material of the nut is assumed to be mild steel. And therefore the bearing pressure of mild steel = 20 N/mm².
Assumed that the load W is uniformly distributed over the cross sectional area of the nut, therefore the bearing pressure between the threads is given by \( P_b = W / (\pi/4) \times [(d_o^2) - (d_c^2)] \times n \)
Thus we get \( n = 0.1903 \) (n is the number of threads in contact with screw)
In order to have good stability and also to prevent the undesirable movement of screw in the nut, take \( n = 4 \)
Now thickness of nut \( t = n \times p = 24 \text{ mm} \) and width of nut \( b = 1.5 \times d_o = 27 \text{ mm} \)

Figure 2 Dimensions of the Upper Plate. (All dimensions in mm)

Figure 3 Scissor lift showing maximum and minimum positions.

Design of Link
Load acting on one link = \( F / 2 = 269 \text{ N} \)
The link is designed for buckling load, assuming factor of safety (FOS) = 5
Thus critical buckling load = \( 269 \times 5 = 1345 \text{ N} \)
Assume width of link = 3 x thickness of link and c/s area of link = 3 x thickness²
Moment of Inertia = 2.25 x thickness⁴
Radius of gyration = 0.866 x thickness
Since for buckling of the link in the vertical plane, the ends are considered as hinged, therefore equivalent length of the link is, \( L = 385 \text{ mm} \).
Considering the Rankine’s Formula, we find Thickness of link = 5 mm and Width of link = 15 mm
Design of Pin
The pins will be in double shear conditions. Thus the diameter of pin is calculated as 10 mm.
4. Results of Analysis

The result analysis for nut is as under

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<th>Name</th>
<th>Type</th>
<th>Min</th>
<th>Max</th>
</tr>
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<tr>
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<td></td>
<td>Mises</td>
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The result analysis for link is as under

<table>
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<tr>
<th>Name</th>
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5. CONCLUSION

With such a design of an aerial scissor lift, the complexities in the design can be reduced. Also with such design parameters, the manufacturing time of an aerial scissor lift can be reduced. So such a design can be used for production in industries. The analysis on ANSYS has also shown that the design is safe under certain accepted parameters. Also further modifications can be implemented for optimizing the design and further analysis can also be carried out by finding other important parameters related to aerial scissor lifts.

6 REFERENCES:


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