Analysis of Pin in Hydraulic Scissor Lift

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Abstract: A Lift is a convenient device to pick up heavy loads such as cars in service station, group of people in a tower or to move goods from a lower level to higher level of grounds in various factories and industries. A lift working on a mechanism similar to that of a pantograph is widely known as scissor lift. It may work on electricity or hydraulic pumps or even on screw jacks which are handled with bare hands. The following paper describes the design of a hydraulically powered scissor lift used to lift loads up to 2 tons at a height of 2 meters. This lift was selected on the basis of available space, type of work and maximum force required by the lift to work within required limits. This type of scissor lift is more compact than others and is practical to use for medium scale work. This paper determines the area where most of the stress is found in a typical hydraulic lift i.e. at the pin. It also analyzes and discusses the design of the pin to obtain suitable dimensions considering the constraint parameters. During analysis and calculations of pin, ANSYS was also used to obtain precise results and all the parameters were checked and compared with the design values.

Introduction

Scissor lifts are typical devices to raise the work platforms at certain height. Their primary function is to elevate workers, tools, and materials to a desired working height, while allowing the operator to control the movement and position of the lift. Compared to a ladder, a scissor lift greatly reduces the psychological stress and the workers have relatively less constraints on their movement at elevated height. Hence, a scissor lift is properly designed and used which greatly increase the workers’ productivity. Scissor lift design is also used due to its ergonomics as compared to other heavy lifting devices available in the market. The frame is very sturdy & strong with increased structural integrity. These lifts can also be made to use at multiple heights which are made up of two or more leg sets. This paper discusses a typical, simple, single scissor hydraulic lift.

Analysis of Scissor Lift Frame:

1. Finite Element Analysis of machine on ANSYS:

1.1. Material Properties & Assumption:

- Material Properties:
  - Material Yield Strength = 250 MPa
  - Torsional Stiffness = 1017000 N.mm/degree

  Material should be selected accordingly; in this case Mild Steel was selected for its satisfying properties with respect to above figures.

- Assumptions:
  - 2 tons load is uniformly distributed over scissor top.
  - Since main objective of analysis is to deduce forces at cylinder region, revolute joints is considered rigid to reduce computational time.

1.2. Loading & Boundary Conditions:

![Figure: 1. Force of 2 tons is distributed equally on four holes.]

Pre-processing of Finite Element Analysis (FEA) which consists of meshing was done as shown in the above figure. The thickness of minimum elements is 5 which should be enough for the desired accuracy and to get precise results.
After applying boundary conditions which also considered the force of 2 ton load acting equally on the four corners of the lift, that is, considering the worst case scenario of the load distribution on the lift, the total deformation was as shown in the above figure. The total deformation is negligible as it is seen from the above figure and thus, the design is considered safe.

From figure 3, it can be noted that:

- Beam forces are compressive
- Beam axial force is equal to -7.758 kN.

To convert a three dimensional structure into a one dimensional structure, beam elements are used which are one dimensional line elements. They have better accuracy during the calculations as compared to shells or solids. In ANSYS, BEAM188 is generally used due to following reasons:

- It can be applied to most of beam structures
- It makes the calculations time efficient
- It’s usage presents no difficulty

It is seen that the maximum stress in the entire model is observed at the pin region. Thus, design of pin is a crucial part of design of the lift which is discussed below:

2. Design of pin:

2.1. Types of Pins:

- Clevis pin
- Straight pin
- Spring pin
- Split pin
In scissor lifts, generally straight pins are used to connect the links. In our case, straight dowel pins were used as these are suitable for the scissor mechanism used in the lift. Dowel pins are solid and are generally used to hold parts together in a fixed alignment. They are usually precision ground to narrow limits for the ability of accurate fitting. Their reliability on the tightness of fit to stay in place is very high. Some applications for such pins require clearance or transition fits on at least one of the components to be fixed.

![Figure 5: Dowel Pin](image)

2.2. Material of Dowel Pin:
- Stainless Steel
- Plain Steel
- Alloy Steel
- Brass
- Aluminum

In this case, Stainless Steel dowel pin is used as it possesses sufficient properties required for a pin used in a hydraulic scissor lift. It has excellent corrosion resistance and good resistance to stress corrosion cracking as well as good formability.

2.3. Dimensions of Dowel Pin:
Pin connects the links with the top frame as well as the bottom frame. In this case, the pin undergoes shear stress. It can be calculated as:

\[
\tau_{\text{all}} = \frac{P}{A}
\]

where:
- \(\tau_{\text{all}}\) = Allowable shear stress in pin (N/mm²)
- \(P\) = Total force applied on pin (N)
- \(A\) = Cross section area under in shear (mm²)

\[
A = \frac{4 \times P}{2 \times \pi \times D^2}
\]

Hence, \(D = 19.54 \approx 20\) mm

As per ISO 2338 (1998), the diameter of the pin is taken as \(D = 25\) mm.

3. Conclusion:

This paper demonstrates that most stressed area in the frame was around the pin. Thus, even though designing the frame and links of the hydraulic scissor lift is important, selection of type of pin, selection of material, calculations of dimensions of pin according to the given constraints which in our case was 2 tons total load acting on the top frame is the most crucial part during designing of the lift.

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References


