# Design and Analysis of an Aerial Scissor Lift

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**Abstract:** — *Aerial scissor lifts are generally used for temporary, flexible access purposes such as maintenance and construction work or by fire-fighters for emergency access, etc which distinguishes them from permanent access equipment such as elevators. They are designed to lift limited weights — usually less than a ton, although some have a higher safe working load (SWL). The increasing demand of Aerial Scissor Lifts in companies in order to improve their manufacturing flexibility and output by providing variable height access to their work. This is especially true when the work being accessed is raised off the floor and outside an operator's normal ergonomic power zone. In either case, it is much more economical to bring the worker to the work rather than bringing the work to the worker.*

*In this project, we have modeled a aerial scissor lift by using ANSYS software which is one of the software used for modeling components in most of the design based industries. While the modeling of the components the material selection is carried out simultaneously based on the design considerations related to loads, etc. Later the stress and strain concentration, deformation on the aerial scissor lift have been found by applying certain load on the lift's platform, using the Finite Element Analysis (FEA) by using ANSYS software that provides best output within few seconds. Finally the stress and strain concentration, deformation results are presented in the report section of this document.*

## I. INTRODUCTION

Any vehicle-mounted device, telescoping or articulating, or both, which is used to position personnel is called aerial device. Any aerial device used to elevate personnel to job sites above ground including extensible boom platforms, aerial ladders, articulating boom platforms and vertical towers is called aerial lift. A mobile supported scaffold which can be powered or unpowered is portable and caster or wheel-mounted is called scissor lift. Aerial scissor lifts pose a serious safety hazard if not used properly. Scissor lifts are the elevating platforms that can be raised or lowered to various heights. The platform can be positioned horizontally beyond the base. These lifts are increasingly being used in various industries because they are mobile and provide workers access to elevations to perform required tasks.

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 lifts can be classified as follows:-**

- Classification based on the type of energy used

(a) Hydraulic lifts
(b) Pneumatic lifts
(c) Mechanical lifts

- Classification based on their usage

(a) Scissor lifts
(b) Boom lifts
(c) Vehicle lifts

## II. DESIGN OF DIFFERENT COMPONENTS OF AERIAL SCISSOR LIFT

Fixtures must always be designed with economics in mind; the purpose of these devices is to reduce costs, and so they must be designed in such a way that the cost reduction outweighs the cost of implementing the fixture. It is usually better, from an economic standpoint, for a fixture to result in a small cost reduction for a process in constant use, than for a large cost reduction for a process used only occasionally.

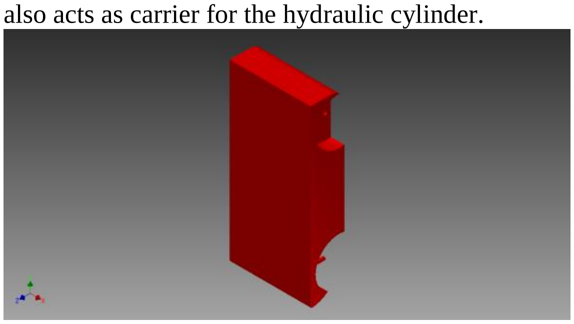
Most fixtures have a solid component, affixed to the floor or to the body of the machine and considered immovable relative to the motion of the machining bit, and one or more movable components known as clamps. These clamps (which may be operated by many different mechanical means) allow work pieces to be easily placed in the machine or removed, and yet stay secure during operation. Many are also adjustable, allowing for work pieces of different sizes to be used for different operations. Fixtures must be designed such that the pressure or motion of the machining operation (usually known as the feed) is directed primarily against the solid component of the fixture. This reduces the likelihood that the fixture will fail, interrupting the operation and potentially causing damage to infrastructure, components, or operators.

Fixtures may also be designed for very general or simple uses. These multi-use fixtures tend to be very simple themselves, often relying on the precision and ingenuity of the operator, as well as surfaces and components already present in the workshop, to provide the same benefits of a specially-designed fixture. Examples include workshop vises, adjustable clamps, and improvised devices such as weights and furniture. Each component of a fixture is designed for one of two purposes: location or support.

Aerial Scissor Lifts comprises of eight 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:

1. Design of base plate:

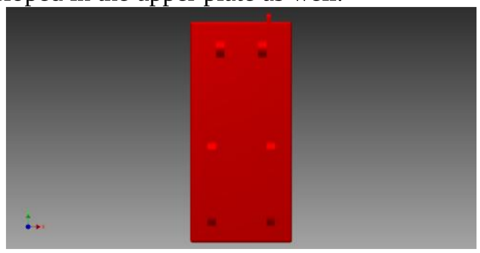
The base plate in a scissor lift only provides proper balance to the structure. Considering the size constraints, the dimensions of the base plate are taken as under. Also it has been found that not much of the stresses are developed in the base plate. It is responsible for the lift to handle the total weight of the lift and the weight to be carried and also acts as carrier for the hydraulic cylinder.



2. Design of upper plate:

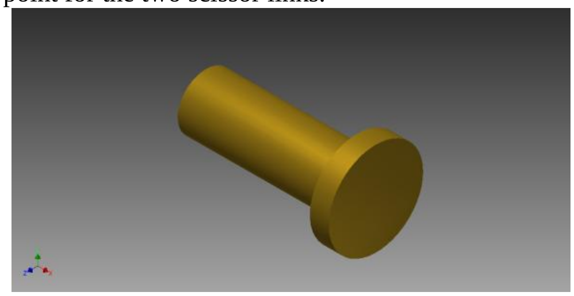
The upper plate in a scissor lift is used to place the load and transfer it to the links.

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.



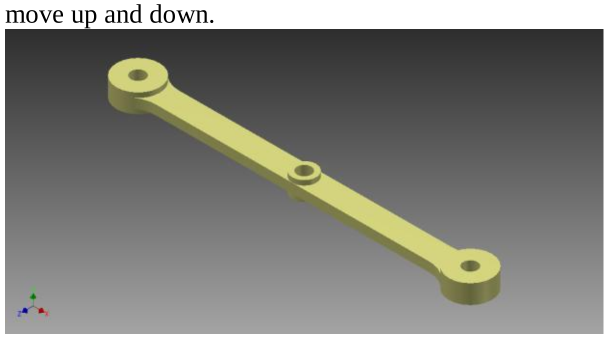
3. Design of bolt:

The bolt is one of the important elements in the aerial scissor lift. The carries major stress during static and dynamic conditions. The bolt is used to join two centers of the scissor links which forms a fulcrum point for the two scissor links.



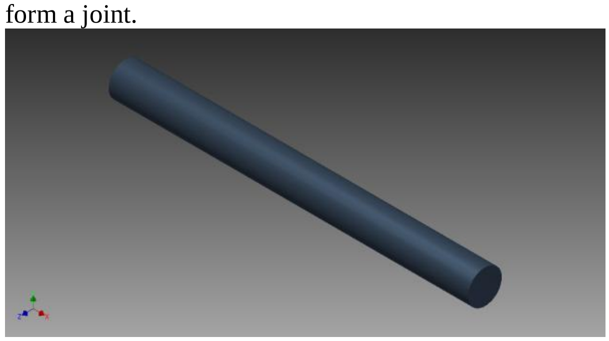
4. Design of scissor link:

The scissor link is responsible for the lift structure to move up and down.



5. Design of pin:

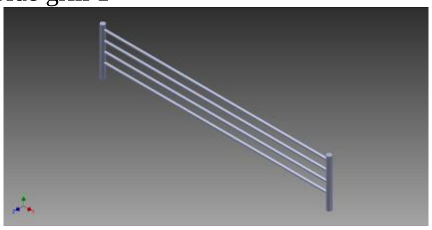
The pin is used to join the two scissor links then they form a joint.



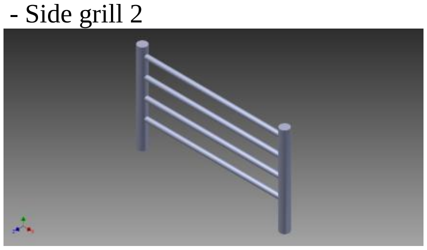
6. Design of side grills:

Here side grills are used for support for the operator and the loads we are carrying. Two types of grills are to be designed for the upper plate for support:

- Side grill 1



- Side grill 2

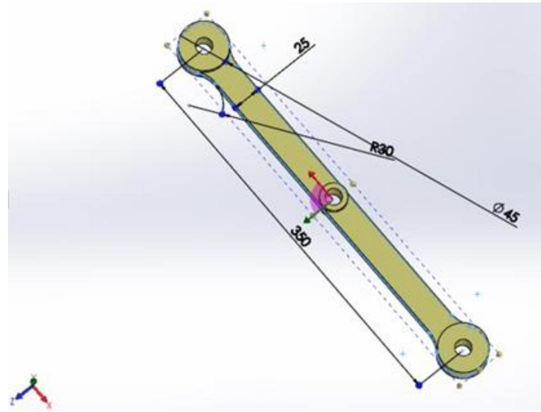


## III. PROCEDURE OF EXPERIMENT

The analysis procedure is carried out on the assembly are as follows:

- Open the tool.
- Then go for the assembly.
- Then import the components required for the assembly to complete.
- After completing the mates, move to the analysis.
- To perform the analysis on the assembly part you must go for office products, in that select "simulation".
- Then you can find a dialogue box at the top, from that select the study advisor.
- Now just click the following options in the said order:
  - I am concerned about excessive loads and deformation.
  - Next
- Now apply the material for the components that are to be analysed.
- Next apply the fixtures and also the loads to be tested.
- After it go for creating the mesh.
- Atlast click the run option to get the results.
- The results can be obtained in the form of analyzed report by clicking the report option found at the centre of the tool box.

## IV. OPERATIONAL DETAILS




Scissor link specifications:

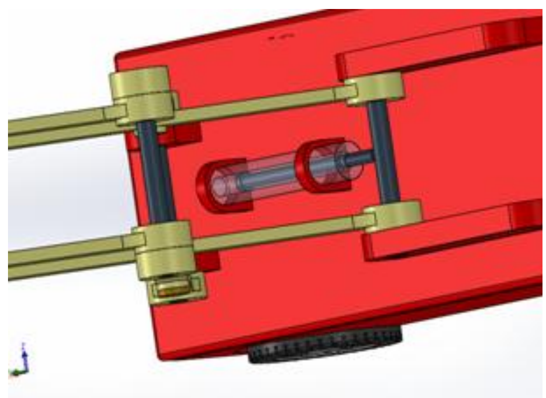
- Thickness of link = 10 mm and
- Width of link = 20 mm

At edges

- Outer circle diameter =45mm and
- Inner circle diameter = 15mm

In the centre

- Outer circle diameter = 25mm and
- Inner circle diameter = 15mm

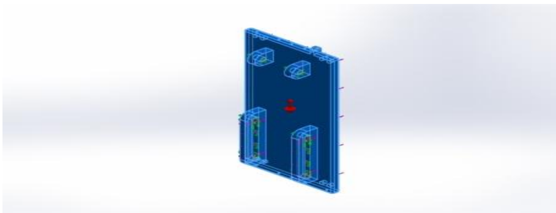


Cylinder specifications:

- The outer diameter of the cylinder is 30 mm
- The inner diameter of the cylinder is 15.10 mm
- The length of the cylinder is 150 mm and
- The stoke length is 145 mm
- The total length of the piston is 157.50 mm.
- The diameter of piston shank is 10 mm.
- The diameter of piston head is 15 mm.
- Thickness of piston is 5 mm
- The length of the grill 1 is 480mm
- The side grill 1 main support diameter is 10mm
- Now the side grill 1 support of diameter is 5mm
- The length of the grill 2 is 160mm

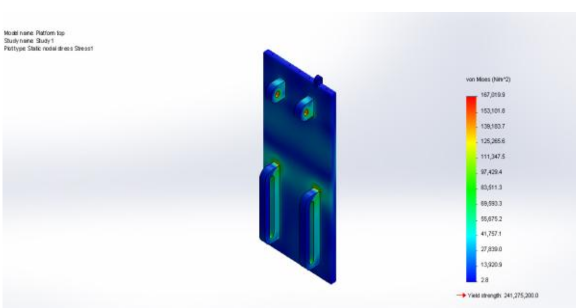
- The side grill 2 main support diameter is 10mm
- Now the side grill 2 support of diameter is 5mm

**REPORTS**

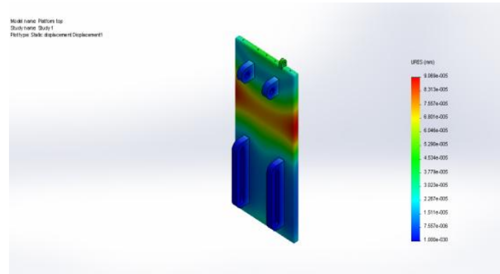


**Properties and study results while using Material-1**

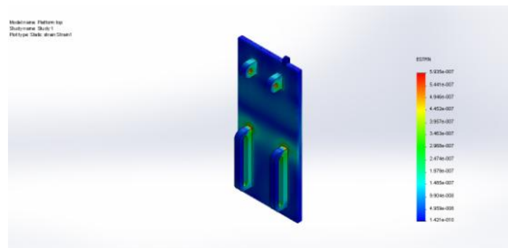
| | |
|---|---|
| Name: | Cast alloy steel |
| Model type: | Linear elastic isotropic |
| Default failure criterion: | Max von mises stress |
| Yield strength: | 2.41275e+008 n/m^2 |
| Tensile strength: | 4.48083e+008 n/m^2 |
| Elastic modulus: | 1.9e+011 n/m^2 |
| Poisson's ratio: | 0.26 |
| Mass density: | 7300 kg/m^3 |
| Shear modulus: | 7.8e+010 n/m^2 |
| Thermal expansion coefficient: | 1.5e-005 /kelvin |



MIN STRESS: 2.82239 N/m^2
MAX STRESS: 167020 N/m^2



MIN DISPLACEMENT: 0mm
MAX DISPLACEMENT: 9.06862e-005 mm

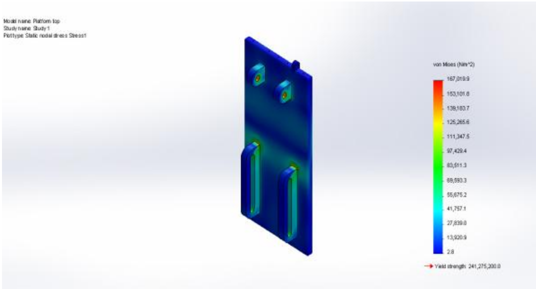


MIN STRAIN: 1.42081e-010

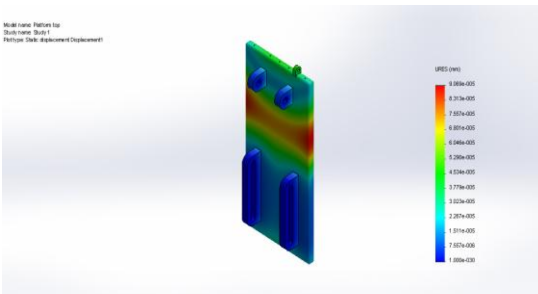
MAX STRAIN: 5.93533e-007

**Properties and study results while using Material-2**

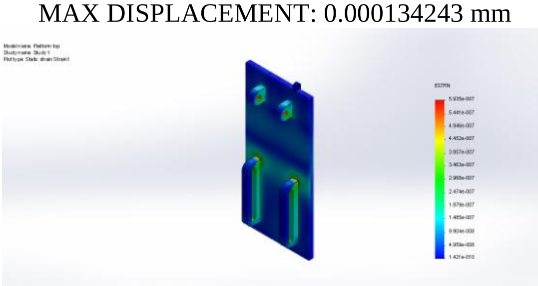
| | |
|---|---|
| Name: | Titanium ti-8al-1mo-1v |
| Model type: | Linear elastic isotropic |
| Default failure criterion: | Max von mises stress |
| Yield strength: | 9.1e+008 n/m^2 |
| Tensile strength: | 9.37e+008 n/m^2 |
| Elastic modulus: | 1.2e+011 n/m^2 |
| Poisson's ratio: | 0.32 |
| Mass density: | 4370 kg/m^3 |
| Shear modulus: | 4.6e+010 n/m^2 |
| Thermal expansion coefficient: | 8.5e-006 /kelvin |



MIN STRESS: 21.8359 N/m^2
MAX STRESS: 147836 N/m^2



MIN DISPLACEMENT: 0mm
MAX DISPLACEMENT: 0.000134243 mm



MIN STRAIN: 3.607e-010

MAX STRAIN: 8.57737e-007

## V. CONCLUSION

The demand of aerial scissor lifts by companies is increasing, as they are proving efficient in improving their manufacturing flexibility and output by providing variable height access to their work. The main reason that supports companies thinking is that it is much more economical to bring the worker to the work rather than bringing the work to the worker. In the above mentioned condition a good design of the aerial scissor lift is necessary such that the complexities in the design and the manufacturing time can be reduced so such a design can be used for production in industries.
In our project we designed a model of the aerial scissor lift that can satisfy the mentioned condition, which is later analyzed using the ANSYS software, the same software used for modeling too. By the analysis it is clearly evident that the design is safe under certain accepted parameters.

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