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). 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. The need for the use of lift is very paramount and it runs across labs, workshops, factories, residential/commercial buildings to repair street lights, fixing of bill boards, electric bulbs etc. expanded and less-efficient, the engineers may run into one or more problems when in use. Considering the need for this kind of mechanism, estimating as well the cost of expanding energy more that result gotten

I. INTRODUCTION
A scissor lift or mechanism is a device used to extend or position a platform by mechanical means. The term “scissor” comes from the mechanic which has folding supports in criss cross “X” pattern. The extension or displacement motion is achieved by the application of force to one or more supports, resulting in an elongation of the cross pattern. The force applied to extend the scissors mechanism may be hydraulic, pneumatic or mechanical (via a lead screw or rack and pinion system). The need for the use of lift is very paramount and it runs across labs, workshops, factories, residential/commercial buildings to repair street lights, fixing of bill boards, electric bulbs etc. expanded and less-efficient, the engineers may run into one or more problems when in use. Before this time scissors lift existing use mechanical or hydraulic system powered by batteries for its operations. Several challenges were encountered in this very design. Some amongst many include; low efficiency, risk of having the batteries discharged during an emergency, extended time of operation, dependent operation, as well as maintenance cost. It is the consideration of these factors that initiated the idea of producing this hydraulically powered scissors lift with independent operator. The idea is geared towards producing a scissors lift using one hydraulic ram placed across flat, in between two cross frames and powered by a pump connected to a motor wheel may be powered by a pump generator. Also, the individual ascending / descending is still the same person controlling it. I.e. the control station will be located on the top frame. A scissors lift is attached to a piece of equipment having a work station known as scissors lift table that houses the pump, the reservoir, the generator, control valves and connections and the motor. A scissors lift does not go as high as a boom lift; it sacrifices heights for a large work station. Where more height is needed, a boom lift can be used.

II. STATEMENT OF THE PROBLEM
A problem remains a problem until a solution is proffered. With the limitations encountered in the use of ropes, ladders, scaffold and mechanical scissors lifts in getting to elevated height such as the amount of load to be carried, conformability, time consumption, much energy expended etc. the idea of a hydraulically powered scissors lift which will overcome the above stated limitations is used.

SCOPE OF THE STUDY
The design and construction of the hydraulic scissors lift is to lift up to a height of 3.2m and carrying capacity of less than 500kg (500 kilograms) with the available engineering materials. However, there is for academic purpose, a similar project for general carrying – capacity with a selection of better engineering materials.

IMPORTANCE / SIGNIFICANCE OF THE STUDY
The design and construction of a hydraulic scissors lift is to lift a worker together with the working equipment comfortably and safely to a required working height not easily accessible. It may be used without a necessary external assistance or assistance from a second party due to the concept of the design. This project will be an important engineering tool or device used in maintenance jobs.

AIMS/OBJECTIVES OF THE STUDY
The project is aimed at designing and constructing a hydraulically powered scissors lift to lift and lowers worker and his working equipment with ease and in the most economical way. The lift is expected to work with minimal technical challenges and greater comfort due to its wide range of application. The device can easily be handled to the site to be used with a tow-van and then powered by a generator. Between the heights of lift (i.e. the maximum height) the device can be used in any height within this range and can be descend immediately in case of emergency, and can be operated independent of a second party.

TYPES OF SCISSOR LIFTS:
Scissor Lifts are one of very popular choice for material handling in Indian Industry and are being used in many applications. A properly designed and equipped scissors lift
enhances the logistics infrastructure, improving facility’s competitiveness. The scissor lifts are available in wide ranges with various options and provide optimum solution for lifting awkward shaped objects to comfortable working heights with least worker fatigue and physical strain. Josts now offers Scissor Lifts for various jobs to suit customer needs and serves variety of application in industries such as General Engineering, Heavy Engineering, Defense, Railways, Manufacturing & Processing Plants, Chemical Industries, Consumer Items, Electrical & Electronics, Logistics, Oil-Gas & Fertilisers, Retail, Steel Industries etc.

**Pit Mounted Scissor Lifts:**
- Ideal for loading / unloading operations.
- Used where height difference is beyond the range of Dock Levelers.
- Capacity from 500 kg up to 20000 kg.
- Lift heights up to 12000 mm.
- Available in variations of Heavy duty and Medium duty lifts.

**Tandem Scissors Lifts:**
- Ideal for heavy duty assembly shop & Production shop applications.
- It is used for Jobs requiring long platforms.
- Capacities up to 20,000 kg.
- Lift heights up to 3000 mm.
- Two or more scissor pairs in combination and operated by single hydraulic system.

**Floor Mounted Scissor Lifts:**
- Extensively used in light duty applications for lifting goods to various lift height.
- Ideal for shop floor, assembly line, production line applications as lift tables.
- Capacity up to 2000 kg.
- Lift Heights up to 3000 mm.
- Also available as Low Profile floor mounted scissor lift with the platform at the ground level.

**Twin Scissors Lifts:**
- Ideally suited in assembly shop application for heavy duty jobs.
- Capacities up to 6000 kg.
- Lift heights up to 3000 mm.
- Two scissor lifts in tandem operation co-ordinated by single hydraulic circuit.

**Figure.1. Pit Mounted Scissor Lifts**

**Figure.2. Tandem Scissors Lifts**

**Figure.3. Floor Mounted Scissor Lifts**

**Figure.4. Twin Scissors Lifts**

**Semi-Electric Mobile Scissor Lifts:**
- Extensively used for light duty applications for lifting goods to various lift heights.
- Ideal for carrying out maintenance as well as house keeping jobs at desired heights.
- Capacity up to 1000 kg.
- Lift Heights up to 12000 mm.
- Easily tow-able either manually or by powered vehicles.
- Earth locking arrangements for greater stability.

**Figure.5. Semi-Electric Mobile Scissor Lifts**

**Self Propelled Scissor Lifts:**
- Ideal for Maintenance jobs as well as Order Picking applications.
- Capacity up to 1500 kg.
- Lift Heights up to 12000 mm.
- Driven by AC / DC motor and MOSFET controller which can be operated from lift platform itself.
- Quiter, Cleaner operation for a variety of environments.
- Narrow width fits most standard doorways and tight aisles.

**Figure.6. Self Propelled Scissor Lifts**

**Vehicle Mounted Scissor Lifts:**
- Ideal for Maintenance purpose, Stationary shifting & Order Picking jobs.
- Capacity up to 1000 kg.
- Lift Heights up to 8000 mm.
- Available in variations of Pedestrian operated or Ride-on models with Jost’s trucks.

**Figure.7. Vehicle Mounted Scissor Lifts**

**Goods Scissor Lifts (Mast Lifts):**
- Ideal for lifting loads to various levels in warehouses, offices and retail back end stores.
- Capacity up to 2000 kg.
- Lift Heights up to 12000 mm.
Availabe with variations of single mast or double mast construction.

Figure 8. Goods Scissor Lifts (Mast Lifts)

III. METALLURGICAL PROPERTIES OF MATERIALS

Aluminum:
After iron, aluminum is now the second most widely used metal in the world. The properties of aluminum include: low density and therefore low weight, high strength, superior malleability, easy machining, excellent corrosion resistance and good thermal and electrical conductivity are amongst aluminum’s most important properties. Aluminum is also very easy to recycle.

Properties of aluminum
- Weight
- Strength
- Linear expansion
- Machining
- Formability
- Conductivity
- Joining
- Reflectivity
- Screening EMC
- Corrosion resistance
- Non-magnetic material
- Zero toxicity

After oxygen and silicon, aluminum is the most common element in the Earth’s crust. Aluminum compounds also occur naturally in our food.

Figure 9. Microstructure of aluminum

STAINLESS STEELS
Stainless steels are iron-base alloys containing at least 11 wt.% Chromium. They typically contain less than 30 wt.% Cr and more than 50wt.% Fe. Stainless steels obtain their stainless characteristics because of the formation of an invisible and adherent chromium-rich oxide surface film. This oxide film has so few defects that oxygen cannot easily diffuse through it. The oxide establishes on the surface and heals itself in the presence of oxygen. Some other alloying elements are often added to enhance specific characteristics. They include nickel, molybdenum, copper, titanium, aluminum, silicon, niobium, and nitrogen. Carbon is usually present in amounts ranging from less than 0.03% to over 1.0% in certain martensitic grades (e.g. cutting steels have between 0.3 and 0.6 wt.% C). Corrosion resistance and mechanical properties are commonly the principal factors in selecting a grade of stainless steel for a given application. Stainless steels are commonly divided into four groups:

- Martensitic stainless steels
- Ferritic stainless steels
- Austenitic stainless steels
- Duplex (ferritic-austenitic) stainless steels

Magnesium:
Compared with other metal materials, magnesium and magnesium alloys have many outstanding performance characteristics, which are widely used in automobile, electronics and aviation. However, corrosion and plasticity are the main problems in magnesium and magnesium alloys, which have immensely restricted the wide application of magnesium alloy in the field of engineering, making the excellent properties of magnesium alloy unusable. In contrast, aluminum alloy usually has very good corrosion resistance and plastic form, and its surface can be repaired. Therefore, we coated a layer of corrosion resistant aluminum alloy forming laminated composite material on magnesium alloy surface so we can take full comprehensive performance advantages of the two materials; we expected to further expand their application areas. In this study, we made a more practical method for engineering to prepare the high performance magnesium aluminum composite panel production.

Figure 10. Microstructure of magnesium

PRINCIPLE OF OPERATION OF A HYDRAULIC LIFT (EXTENSION AND CONTRACTION)
A scissors lift is a type of platform that can usually only move vertically. The mechanism to achieve this is the use of linked, folding supports in a criss-cross “X” pattern, known as a scissors mechanism. The upward motion is achieved by the application of pressure to the outer side of the lowest set of supports, elongating the crossing pattern and propelling the work platform vertically. The platform may also have extending “bridge” to allow closer access to the work area, because of the inherent limits of vertical – only movement. The contraction of the scissors action can be hydraulic, pneumatic or mechanical (via a lead screw or rack and pinion system), but in this case, it is hydraulic. Depending on the power system employed on the lift; it may require no power to enter “desert” mode, but rather a simple release of hydraulic or pneumatic pressure. This is the main reason that these methods of powering the lift (hydraulic) is preferred, as it allows a fail – safe option of returning the platform to the ground by release of a manual valve.

DEFLECTIONS IN SCISSORS LIFT

Deflection Defined
Deflection in scissors lifts can be defined as the resulting change in elevation of all or part of a scissors lift assembly, typically measured from the floor to the top of platform deck, whenever loads are applied to or removed from the lift. ANSI MH29.1 - Safety Requirements for Industrial Scissors Lifts states that all industrial scissors lifts will deflect under load”. The industry standard goes on to outline the maximum allowable deflection based on platform size and number of scissors mechanisms within the lift design.
**What Causes Deflection?**

Before attempting to discuss how to limit scissors lift deflection, it is important to understand the contributing factors to a lift’s total deflection. An open, or raised, scissors lift acts very much like a spring would — apply a load and it compresses, remove a load and it expands. Each component within the scissors lift has the potential to store or release energy when loaded and unloaded (and therefore deflect). There are also application-specific characteristics that may promote deflection. Understanding these Top 10 root causes helps to pinpoint and apply effective measures to limit deflection.

**Scissors Legs**

Leg deflection due to bending is a result of stress, which is driven by total weight supported by the legs, scissors leg length, and available leg cross section. The longer the scissors legs are, the more difficult it is to control bending under load. Increased leg strength via increased leg material height does improve resistance to deflection, but can create a potentially undesirable increased collapsed height of the lift.

**Platform Structure**

Platform bending will increase as the load’s center of gravity moves from the center (evenly distributed) to any edge (eccentrically loaded) of the platform. Also, as the scissors open during raising of the lift, the rollers roll back towards the platform hinges and create an increasingly unsupported, overhung portion of the platform assembly. Eccentric loads applied to this unsupported end of the platform can greatly impact bending of the platform. Increased platform strength via increased support structure material height does improve resistance to deflection, but also contributes to an increased collapsed height of the lift.

**Base Frame**

Normally, the lift’s base frame is mounted to the floor and should not experience deflection. For those cases where the scissors lift is mounted to an elevated or portable frame, the potential for deflection increases. To effectively resist deflection, the base frame must be rigidly supported from beneath to support the point loading created by the two scissors leg rollers and the two scissors leg hinges.

**Pinned Joints**

Scissors lifts are pinned at all hinge points, and each pin has a running clearance between the O.D. of the pin and the I.D. of its clearance hole or bushing. The more scissors pairs, or pantographs, that are stacked on top of each other, the more pinned connections there are to accumulate movement, or deflection, when compressing these running clearances under load.

**Hydraulic Circuit – Air Entrapment**

All entrapped air must be removed from the hydraulic circuit through approved “bleeding” procedures — air is very compressible and is often the culprit when a scissors lift over-compresses under load, or otherwise bounces (like a spring) during operation.

**Hydraulic Circuit – Fluid Compressibility**

Oil or hydraulic fluid will compress slightly under pressure. And because there is an approximate 5:1 ratio of lift travel to cylinder stroke for most scissors lift designs (with the cylinders mounted horizontally in the legs), there is a resulting 5:1 ratio of scissors lift compression to cylinder compression. For example: 1/16” of fluid compressibility in the cylinder(s) translates into 5/16” of vertical lift movement.

**Hydraulic Circuit – Hose Swell**

All high pressure, flexible hosing is susceptible to a degree of hose swell when the system pressure is increased. System pressure drops slightly because of this increased hose volume, and the scissors table compresses under load until the maximum system pressure is re-established. And, as with compressibility, the resulting lift movement (deflection) is 5 times the change in oil column height in the hosing.

**Cylinder Thrust Resistance**

Cylinders lay nearly flat inside the scissors legs when the lift is fully lowered and must generate initial horizontal forces up to 10 times the amount of the load on the scissors lift due to the mechanical disadvantage of their lifting geometry. As a result, there are tremendous stresses (and resulting deflection) placed on the scissors inner leg member(s) that are designed to resist these cylinder forces. And, as already mentioned above with any changes in column length along the line of the lifting actuator(s)/cylinder(s), the resulting vertical lift movement is 5 times the amount of deflection or movement of cylinder hinge points mounted to leg cross members.

**Load Placement**

Load placement also plays a large part in scissors lift deflection. Off-centered loads cause the scissors lift to deflect differently than with centered or evenly distributed, loads. End loads (in-line with the scissors) are usually shared well between the two scissors leg pairs. Side loads (perpendicular to the scissors), however, are not shared as well between the scissors leg pairs and must be kept within acceptable design limits to prevent leg twist (unequal scissors leg pair deflection) — which, in addition to platform movement due to deflection, often results in poor roller tracking, unequal axle pin wear, and misalignment of cylinder mounts.

**Lift Elevation During Transfer**

As mentioned above, degree of deflection is directly related to change in system pressure and change in component stress as a result of loading and unloading. Scissors lifts typically experience their highest system pressure and highest stresses (and therefore the highest potential for deflection) within the first 20% of total available vertical travel (from the fully lowered position).

**What can be done to Limit Deflection?**

There are a variety of proven methods to reduce scissors lift deflection, with varying design and cost impacts to accomplish each. Listed below are the most common of these methods, in no particular order, to provide the reader an understanding of where to begin when attempting to reduce or eliminate deflection during load transfer (i.e. applying a load, or removing a load).

**Select a Lift with a Design Capacity Greater Than Required for the Application**

Most scissors lifts designed for duty at higher capacities will experience less stress in all structural components, as well as lower system pressures, at lower, or de-rated, working capacities. Reduced stresses & pressures always result in reduced deflection. The amount of this reduction varies depending on the lift’s design, so consult the manufacturer to obtain a more specific estimate of reduction in deflection.
Minimize Potential for Air Entrapment
Scissors lift manufacturers provide an approved method of “bleeding” entrapped air from a new or repaired hydraulic system which may have had air introduced. This usually involves operating an empty lift through multiple cycles, and then safely cracking open fittings near high spots in the system where air accumulates. Refer to the O&M manual for this procedure.

Limit or Eliminate Hosing
Flexible hose lengths should be limited wherever possible and replaced with pipe or mechanical tubing as practicable to minimize or eliminate swell as the system pressure fluctuates.

Use Mechanical Actuators in lieu of Hydraulic Actuators
Although it is more difficult, and more expensive, to achieve high vertical lifting forces with mechanical actuators, they do eliminate the issue of fluid compressibility and provide a more accurate and repeatable means of achieving – and holding – a desired transfer elevation.

Avoid Transfer of Loads Within First 20% of Lift’s Travel
To minimize stresses and deflection at transfer elevations, it is critical to design the conveyor or transfer system to ensure that these elevations are above the scissors lift’s “critical zone” of the first 20% of the lift’s available travel.

Transfer Loads Over Fixed End of the Platform
First, if possible, loads should not be transferred over the sides of a raised scissors lift. It is much more difficult to control deflection when the load is not shared equally between the two scissors leg pairs. Make it rule to only transfer over the ends of the lift – in line with the scissors legs. Second, load transfer should be made over the hinged, or fixed, end of the lift platform to avoid placing concentrated loads on the less supported, overhung end of the platform – provided the platform is equipped with “trapped” rollers, or is otherwise capable of withstanding this edge loading without risk of the platform tipping up or losing contact with the rollers.

Ensure that the Base Frame is Lagged Down and Fully Supported
First, base frames should be adequately attached to the surface on which they are mounted. Base frames that are not bolted, welded, or otherwise attached to withstand the upward forces created by eccentric loading of the platform will contribute to deflection by bending or moving while resisting such forces. Next, bases must be rigidly supported beneath the entire perimeter of the frame in order to withstand without deflection the four point loads imposed upon the frame from above by the four scissors legs – (2) moving roller points and (2) fixed hinge points.

Platform Locking Pins
When there is no alternative to transferring loads over the sides of a lift, or whenever lift deflection must be held to near zero in any transfer orientation, consider using platform locking pins. These pins can be manual or powered, and mounted beneath the scissors lift deck or an adjoining fixed landing. The pins are extended into receivers located in the mating elevated structure during load transfer, and then retracted before the lift can be operated again. Use Vertical Acting Actuators in lieu of Horizontal Mounts Some permanent installations may accommodate actuators which are mounted vertically beneath the lift instead of horizontally inside the lift structure. Vertical orientation of the actuators provide a 1:1 ratio of lift travel to actuator stroke instead of the 5:1 ratio normal with horizontal mounting of the actuators inside the scissors. This means a 1:1 ratio of lift deflection to actuator compression, 80% less than the 5:1 ratio experienced normally. Vertical mounting and pushing upward against underneath side of the platform to raise the lift also eliminates the high stresses usually exerted at the actuator thrust inner leg member(s).

DESIGN THEORY AND CALCULATION
In this section all design concepts developed are discussed and based on evaluation criteria and process developed, and a final here modified to further enhance the functionality of the design. Considerations made during the design and fabrication of a acting cylinder is as follows:

a. Functionality of the design
b. Manufacturability
c. Economic availability, i.e. General cost of materials and fabrication techniques employed.

DESIGN THEORY
In this chapter, mathematical relationships are developed for the various parameters necessary for the implementation of this design and arranged in sections below corresponding to the sequence of their implementation. Hydraulic systems are used to control and transmit power. A pump driven by a prime mover such as an electric motor creates a flow of fluid, in which the pressure, direction and rate of flow are controlled by values. An actuator is used to convert the energy of the fluid back into mechanical power. The amount of output power developed depends upon the flow rate, the pressure drop a cross the actuator and its overall efficiency. Most lifting devices are powered by either electricity, pneumatic or mechanical means. Although these methods are efficient and satisfactory, they exist lots of limitations and complexity of design of such lifts as well as high cost of electricity, maintenance and repairs does not allow these lifts to exist in common places.

CYLINDER SELECTION
The hydraulic cylinder (or the hydraulic actuator) is a mechanical actuator that is used to give a unidirectional stroke. It has many applications, notably in engineering.

Single Acting Cylinders
Single acting cylinders use hydraulic oil for a power stroke in one direction only. The return stroke is affected by a mechanical in one direction only. The return stroke is affected by a mechanical spring located inside the cylinder. For single acting cylinders with no spring, some external actin force on the piston rod causes its return.

Double Acting Cylinders
Double acting cylinder uses compressed air or hydraulic fluid to pour both the forward and return strokes. This makes them ideal for bushing and pulling and pulling within the same application they are suitable for full stroke working only at slow speed which results in gentle contact at the ends of stroke.

DESIGN THEORY AND CALCULATION
In this section all design concepts developed are discussed and based on evaluation criteria and process developed, and a final here modified to further enhance the functionality of the design. Considerations made during the design and fabrication of a single acting cylinder is as follows:

a. Functionality of the design
b. Manufacturability
Hydraulic cylinder:
The hydraulic cylinder is mounted in inclined position. The total load acting on the cylinder consists of:

- Mass to be put on lift: 500 kg Taking FOS = 1.5 for mass in pallet 500 x 1.5 = 750 kg rounding the mass to 800 kg
- Mass of top frame: 22.5 kg
- Mass of each link: 5 kg (5 x 8) = 40 kg
- Mass of links of cylinder mounting: 4 kg Mass of cylinder: 8.15 kg
- Total Mass: 22.5 + 40 + 8.150 + 4 + 800 = 874.65 kg
- Total load: 874.65 x 9.81 = 8580.316 N

Scissors lift calculations:
For a scissors lift Force required to lift the load is dependent on:

- Angle of link with horizontal Mounting of cylinder on the links Length of link. Formula used Where W = Load to be lifted
S = a2 + L2 - 2aL * cos α
S = Distance between end points of cylinder.
L = length of link = 0.6 m
α = angle of cylinder with horizontal.
Now the maximum force will act on the cylinder When the cylinder is in shut down position i.e when the scissors links are closed. For calculations we will consider α = 300
Thus substituting α = 300 in eqn (1), We get F = 8580.316 N

Selecting 63 mm diameter cylinder
Area of the cylinder = Force/Pressure = (8580.316/3117.24 mm2) = 27.52 bar

DESIGN OF LINK
Now Let Hy0 = Mass applied on the lift = 800 kg
B = Mass of the lift which the cylinder needs to lift = 74.65 kg
Hyi = Total weight = 8580.316 N

- Only two forces are calculated here
1. Forces at the end of link: as forces at ends of link are same in magnitude.
2. Force at middle of link.

In our case, the levels are numbered from the top.
For level 1 X1 = XB1 - 1
For level 2 X 2 = XB1
The angle of cylinder with horizontal is θ = 200.
Hyi = 8580.316 N
X2 =Hyi1 = 8580.316 x 1 x 0.5 x (cot 20/2) = 11787.112
Resultant of X 2 & HYi/4
R1 = √(11787.112)2 + (8580.316/4)2 = 11980.708 N.

Above force will act on all the joints at end of each link.

STRESSES IN CYLINDERS
When cylinders are subjected to internal fluid pressure, the following types of stresses are developed:

- Hoop or circumferential stress.
- Longitudinal stress.

Hoop stress is produced as a result of forces applied from inside the cylindrical pipe pushing against the pipe walls. Hoop stress is the result of forces pushing against the circumferential cylinder walls. While, longitudinal stress is as a result of forces pushing against the top ends of a cylinder. These forces are derived using Newton’s first law. Let d = internal diameter of cylinder

T = thickness of cylinder
P = internal pressure (gauge) in the cylinder
σc = circumferential or hoop stress
σl = longitudinal stress
L = length of cylinder or pipe
Hoop stress σc = pd/2t
Longitudinal stress σl = pd/4t
Bursting force (pressure) = pdL
Resisting strength = 2Ltσc
Bursting force = resisting strength ( pdL = 2Ltσc )
Note: the maximum stress developed must not exceed the permissible tensile stress (σl) of the material.

BASIC DIMENSIONS OF COMPONENT MEMBER.

Lift Extension
At maximum extension, an “X” arrangement of the lift moves 0.9 m = 900 mm.
Total number of tiers of scissors (combined) = 3
Thus, total height of extension = 3 x 0.9 = 2.7 m.
Length of base = 1400 mm
Width of base = 800 mm
Height of base from ground = 500 mm
At maximum extension, Angle of inclination = 50
At maximum extension, distance between two scissors feet = 800 mm
Distance moved by sliding foot to full extension = 400 mm

Bearings
Number of ball bearings = 4
Number of shell bearings = 36
Internal diameter of ball bearings = 30 mm
Internal diameter of shell bearings = 11 mm
External diameter of ball bearings = 50 mm
External diameter of shell bearings = 15 mm
Pivot pin diameter = 14.6 mm

Platform
Total height of platform = 1400 mm.
Total width of platform = 800 mm
Total height of platform = 800 mm
Permissible load on platform + platform weight = 300 kg = 2.94 kN.

Jointed Members
Thickness of rectangular pipe = 3 mm
Thickness of angle bar = 3 mm.

Scissors Arm
The material used for the scissors arms (members), is stainless steel. With the density and the dimensions of the scissors arms known, the mass can be calculated using the relationship.

Density (ρ) = Mass (M) / Volume

Mass = ρv
Density of stainless steel (type 304) = 7900 kg/m3
Area (cross sectional area) = A1 = A2
A1 = Outer cross sectional area
A2 = Inner cross sectional area
A1 = Height x breadth = h x b
A2 = (h - t)(b - t)
Where h = scissors arm height
b = breadth
t = thickness of material.
Volume \( (v) = \text{area} \times \text{length} \ V = AL \ \text{(m}^3) \)

IV. INTRODUCTION TO CAD/CAM

COMPUTER AIDED DESIGN (CAD):
Computer Aided Design (CAD) is the use of wide range of computer based tools that assist engineering, architects and other design professionals in their design activities. It is the main geometry authoring tool within the product life cycle management process and involves both software and sometimes special purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design models.

REVIEW OF RELATED LITERATURE
Mans quest for improvement has never been satisfied. The drive towards better and greater scientific and technological outcome has made the world dynamic. Before now, several scientist and engineers have done a lot of work as regards the scissors lift in general. A review of some of that work gives the design and construction of a hydraulic scissors lift a platform.

UPRIGHT’S SCISSORS LIFT
In Selma California, there is a manufacturer of aerial platforms by name “UPRIGHT”, this world – wide company was founded in 1946, and now it manufactures and distributes its product. According to Wikipedia article, upright was founded by an engineer, Walke Johnson who created and sold the first platform which was called a “scissors lift” due to the steel cross bricking that supported the platform giving it the product name “magic carpet”. The magic carpet was able to provide instant revenue for the young company due to its quick popularity among its companies.

Wikipedia further explained that the company constructed innovating and by early 1930s their product included the X – series scissors lift. By 1986, they had introduced their first sigma arm lift, model SL20. In 1990, they improved upon their product line by introducing the sigma arm speed level. This feature continued to be unique to upright product and allow self-leveling of the platform on rough terrains Upright introduced an equal innovative family of boom lift in 1990s. In 1995 they produced their first trailer mounted boom. The 8P37 (known as AS38) in 1996. This truly innovated company has left their mark with the other products including compact scissors design and modular alloy bridging, as well as expanding the versatility of instant span towers with aircraft docking and faced system, you will find upright products, especially the scissors lift, as standard equipment for a variety of application it is now a visual application in numerous fields and locations.

SCAFFOLD
Scaffold allows workers to transport themselves and their materials to elevated heights, usually up and down in an unfinished building. Scaffolds are designed to allow workers get to elevated heights; they are used in building sites and construction sites but used mainly in building sites. According to Google internet search machine, scaffold is cross section of pipes, irons or woods which are arranged in such a way that workers or operators can climb on the arranged pipes to get to elevated heights. Scaffolds cannot be adjusted automatically and they only can remain fixed the way it is arranged unless rearranged. The tubes are either steel or aluminum, although composite scaffolding using filament wound tubes of glass fiber in a nylon or polyester matrix. If steel, they are either “black” or galvanized. The tubes come in a variety of length and a standard diameter of 48.3mm. The basic difference between the two types of tubes is the lower weight of aluminum tubes (1.7kg/m as opposed to 4.4kg/m) and also a greater flexibility and so less resistance to force. Tubes are generally bought in 6.3m length and can be cut down to certain typical sizes. Boards provide a working surface for users of the scaffold. They are seasoned wood and are very strong. Scaffolds for increased height are preferably made of hardened materials like metal pipes. After arranging the pipes, a flat materials usually made of wood is placed on top so that the worker can stand comfortable on top.

BOOM LIFT
Boom lifts are used for lifting materials especially on construction sites, they are designed to carry heavy equipment and materials from one place to another. They are usually connected to cars or trucks that move from one place to another. Boom lifts can lift materials and equipment high to height so great that carrying this equipment by other means will almost be impossible. According to material handling equipment from ask search engine, Boom lifts can move vertically, horizontally and sideways and some can even rotate depending on the circumstance. Boom lifts are very complex iron design and the jointed parts should be lubricated to reduce friction and improve efficiency. Boom lifts are formed mainly in construction sites and building sites. They are also utilized by Electrical companies and firms such as PHCN (Power Holding Company of Nigeria) Plc. They are very expensive and are not available in crude or semi mechanized type of production. Boom lift possess advantage over other types of lifts because it can lift heavy materials, keep them at elevated heights for a long period of time; rotate and the lift span of the equipment is long. Boom lift can fold together to become compressed and portable. There are two basic types of boom lifts: straight boom lift and articulated boom lift. These units are often hydraulically powered.

THE STRAIGHT BOOM LIFTS
Straight boom lifts are generally used for jobs that required a high reach without obstruction. The machines turntable can rotate 360o with an extensible boom that can be raised vertically to below horizontally. The operator can maneuver and steer the vehicle while the boom is fully extended. It is available in gas, propane or diesel-powered models with two or four wheel drive.

ARTICULATED BOOM LIFT:
Articulated boom lifts are used for jobs that require reaching up and over obstacles to gain access to a job not easily achieved by a straight telescopic boom. This lift is nearly identical to the straight boom lift in every aspect; except in the boom’s ability to articulate. Articulation points on the boom allow it to bend in any number of different directions enabling it to maneuver around various obstacles on a job site. Boom lifts can be equipped with out riggers to stabilize the unit while the boom is fully extended.

MECHANICAL SCISSORS LIFT
The mechanical scissors lift is used for lifting materials especially on construction sites. This is one of the most recent advancement on scissors lift. There, the lift utilizes a belt drive system connected to a load screw which constructs the “X” pattern on tightening and expands it on loosening. The lead screw actually does the work, since the applied force from the wheel is converted to linear motion of the lift by help of the lead screw. This can be used to lift the working and equipment
to a height. A general knowledge however, regarding screws will reveal the loss due to friction in the screw threads. Therefore, the efficiency of this device is low due to losses in friction. Also, the power needed to drive the machine is manual, and much energy is expanded to achieve a desired result. Its suitability however, cannot be overemphasized as it can be used in almost every part of the country whether there is availability of electricity or not.

HYDRAULIC LIFT:
Hydraulic lift is a device for carrying persons and loads from one floor to another, in a multi-storey building. The hydraulic lifts are of the following types.
1. Direct acting hydraulic lift and
2. Suspended hydraulic lift.
The direct acting hydraulic lift consist of a ram sliding in a cylinder. A platform or a cage is fitted to the top end of ram on which goods may be placed or the persons may stand. As the liquid under pressure is admitted to the cylinder, the ram moves up and the cage is lifted. The lift of the cage is equal to the stroke of the ram. The cage moves in the downward direction when the liquid from the fixed cylinder is removed. The suspended hydraulic lift is a modified form of the direct acting hydraulic lift. It is fitted with a jigger which is exactly, same as in the case of a hydraulic crane. The cage is suspended by ropes. It runs between guides of hard wood round steel. In order to balance the weight of the cage sliding balance weights are provided. [Gupta, 2006]

HYDRAULIC SCISSORS LIFT
Scissors lifts has developed overtime, and at each stage of its development, critical problems are solved. The hydraulic type, but this time, the load screw is replaced by a hydraulic ram powered by a pump and on electric motor and generator. One outstanding feature about this design however. Is its independent operation and increased efficiency. Fluid power is one of the greater form of power where small input results in a very large output. This scissors lift can be handled by one person to a place of use, and power the generator. The lift does not lifting immediately, the operators climbs on the platform and switches open the hydraulic circuit thereby leading to an upward extension. When the required height is reached the circuit is closed, and lifting stops the control panel or station is located on the top frame. When work is done, the scissors lift is folded by hydraulic means and handled back to the point of collection.

PRINCIPLE OF OPERATION OF A HYDRAULIC LIFT (EXTENSION AND CONTRACTION)
A scissors lift is a type of platform that can usually only move vertically. The mechanism to achieve this is the use of linked, folding supports in a cross-cross “X” pattern, known as a scissors mechanism. The upward motion is achieved by the application of pressure to the outer side of the lowest set of supports, elongating the crossing pattern and propelling the work platform vertically. The platform may also have extending “bridge” to allow closer access to the work area, because of the inherent limits of vertical – only movement. The contraction of the scissor action can be hydraulic, pneumatic or mechanical (via a lead screw or rack and pinion system), but in this case, it is hydraulic. Depending on the power system employed on the lift; it may require no power to enter “desert” mode, but rather a simple release of hydraulic or pneumatic pressure. This is the main reason that these methods of powering the lift (hydraulic) is preferred, as it allows a fail – safe option of returning the platform to the ground by release of a manual valve

DEFLECTIONS IN SCISSORS LIFT

Deflection Defined
Deflection in scissors lifts can be defined as the resulting change in elevation of all or part of a scissors lift assembly, typically measured from the floor to the top of platform deck, whenever loads are applied to or removed from the lift. ANSI MH29.1 - Safety Requirements for Industrial Scissors Lifts states that all industrial scissors lifts will deflect under load”. The industry standard goes on to outline the maximum allowable deflection based on platform size and number of scissors mechanisms within the lift design.

What Causes Deflection?
Before attempting to discuss how to limit scissors lift deflection, it is important to understand the contributing factors to a lift’s total deflection. An open, or raised, scissors lift acts very much like a spring would – apply a load and it compresses, remove a load and it expands. Each component within the scissors lift has the potential to store or release energy when loaded and unloaded (and therefore deflect). There are also application-specific characteristics that may promote deflection. Understanding these Top 10 root causes helps to pinpoint and apply effective measures to limit deflection.

Scissors Legs
Leg deflection due to bending is a result of stress, which is driven by total weight supported by the legs, scissors leg length, and available leg cross section. The longer the scissors legs are, the more difficult it is to control bending under load. Increased leg strength via increased leg material height does improve resistance to deflection, but can create a potentially undesirable increased collapsed height of the lift.

Platform Structure
Platform bending will increase as the load’s center of gravity moves from the center (evenly distributed) to any edge (eccentrically loaded) of the platform. Also, as the scissors open during raising of the lift, the rollers roll back towards the platform hinges and create an increasingly unsupported, overhung portion of the platform assembly. Eccentric loads applied to this unsupported end of the platform can greatly impact bending of the platform. Increased platform strength via increased support structure material height does improve resistance to deflection, but also contributes to an increased collapsed height of the lift.

Base Frame
Normally, the lift’s base frame is mounted to the floor and should not experience deflection. For those cases where the scissors lift is mounted to an elevated or portable frame, the potential for deflection increases. To effectively resist deflection, the base frame must be rigidly supported from beneath to support the point loading created by the two scissors leg rollers and the two scissors leg hinges.

Pinned Joints
Scissors lifts are pinned at all hinge points, and each pin has a running clearance between the O.D. of the pin and the I.D. of its clearance hole or bushing. The more scissors pairs, or pantographs, that are stacked on top of each other, the more pinned connections there are to accumulate movement, or
deflection, when compressing these running clearances under load.

**Hydraulic Circuit – Air Entrapment**

All entrapped air must be removed from the hydraulic circuit through approved “bleeding” procedures – air is very compressible and is often the culprit when a scissors lift over-compresses under load, or otherwise bounces (like a spring) during operation.

**Hydraulic Circuit – Fluid Compressibility**

Oil or hydraulic fluid will compress slightly under pressure. And because there is an approximate 5:1 ratio of lift travel to cylinder stroke for most scissors lift designs (with the cylinders mounted horizontally in the legs), there is a resulting 5:1 ratio of scissors lift compression to cylinder compression. For example: 1/16” of fluid compressibility in the cylinder(s) translates into 5/16” of vertical lift movement.

**Hydraulic Circuit – Hose Swell**

All high pressure, flexible hosing is susceptible to a degree of hose swell when the system pressure is increased. System pressure drops slightly because of this increased hose volume, and the scissors table compresses under load until the maximum system pressure is re-established. And, as with compressibility, the resulting lift movement (deflection) is 5 times the change in oil column height in the hosing.

**Cylinder Thrust Resistance**

Cylinders lay nearly flat inside the scissors legs when the lift is fully lowered and must generate initial horizontal forces up to 10 times the amount of the load on the scissors lift due to the mechanical disadvantage of their lifting geometry. As a result, there are tremendous stresses (and resulting deflection) placed on the scissors inner leg member(s) that are designed to resist these cylinder forces. And, as already mentioned above with any changes in column length along the line of the lifting actuator(s)/cylinder(s), the resulting vertical lift movement is 5 times the amount of deflection or movement of cylinder hinge points mounted to leg cross members.

**Load Placement**

Load placement also plays a large part in scissors lift deflection. Off-centered loads cause the scissors lift to deflect differently than with centered or evenly distributed, loads. End loads (in-line with the scissors) are usually shared well between the two scissors leg pairs. Side loads (perpendicular to the scissors), however, are not shared as well between the scissors leg pairs and must be kept within acceptable design limits to prevent leg twist (unequal scissors leg pair deflection) – which, in addition to platform movement due to deflection, often results in poor roller tracking, unequal axle pin wear, and misalignment of cylinder mounts.

**Lift Elevation During Transfer**

As mentioned above, degree of deflection is directly related to change in system pressure and change in component stress as a result of loading and unloading. Scissors lifts typically experience their highest system pressure and highest stresses (and therefore the highest potential for deflection) within the first 20% of total available vertical travel (from the fully lowered position).

**What can be done to Limit Deflection?**

There are a variety of proven methods to reduce scissors lift deflection, with varying design and cost impacts to accomplish each. Listed below are the most common of these methods, in no particular order, to provide the reader an understanding of where to begin when attempting to reduce or eliminate deflection during load transfer (i.e. applying a load, or removing a load).

**Select a Lift with a Design Capacity Greater Than Required for the Application**

Most scissors lifts designed for duty at higher capacities will experience less stress in all structural components, as well as lower system pressures, at lower, or de-rated, working capacities. Reduced stresses & pressures always result in reduced deflection. The amount of this reduction varies depending on the lift’s design, so consult the manufacturer to obtain a more specific estimate of reduction in deflection.

**Minimize Potential for Air Entrapment**

Scissors lift manufacturers provide an approved method of “bleeding” entrapped air from a new or repaired hydraulic system which may have had air introduced. This usually involves operating an empty lift through multiple cycles, and then safely cracking open fittings near high spots in the system where air accumulates. Refer to the O&M manual for this procedure.

**Limit or Eliminate Hosing**

Flexible hose lengths should be limited wherever possible and replaced with pipe or mechanical tubing as practicable to minimize or eliminate swell as the system pressure fluctuates.

**Use Mechanical Actuators in lieu of Hydraulic Actuators**

Although it is more difficult, and more expensive, to achieve high vertical lifting forces with mechanical actuators, they do eliminate the issue of fluid compressibility and provide a more accurate and repeatable means of achieving – and holding – a desired transfer elevation.

**Avoid Transfer of Loads Within First 20% of Lift’s Travel**

To minimize stresses and deflection at transfer elevations, it is critical to design the conveyor or transfer system to ensure that these elevations are above the scissors lift’s “critical zone” of the first 20% of the lift’s available travel.

**Transfer Loads Over Fixed End of the Platform**

First, if possible, loads should not be transferred over the sides of a raised scissors lift. It is much more difficult to control deflection when the load is not shared equally between the two scissors leg pairs. Make it rule to only transfer over the ends of the lift – in line with the scissors legs. Second, load transfer should be made over the hinged, or fixed, end of the lift platform to avoid placing concentrated loads on the less supported, overhung end of the platform – provided the platform is equipped with “trapped” rollers, or is otherwise capable of withstanding this edge loading without risk of the platform tipping up or losing contact with the rollers.

**Ensure that the Base Frame is Lagged Down and Fully Supported**

First, base frames should be adequately attached to the surface on which they are mounted. Base frames that are not bolted, welded, or otherwise attached to withstand the upward forces created by eccentric loading of the platform will contribute to deflection by bending or moving while resisting such forces. Next, bases must be rigidly supported beneath the entire perimeter of the frame in order to withstand without deflection the four point loads imposed upon the frame from above by the
four scissors legs – (2) moving roller points and (2) fixed hinge points.

Platform Locking Pins
When there is no alternative to transferring loads over the sides of a lift, or whenever lift deflection must be held to near zero in any transfer orientation, consider using platform locking pins. These pins can be manual or powered, and mounted beneath the scissors lift deck or an adjoining fixed landing. The pins are extended into receivers located in the mating elevated structure during load transfer, and then retracted before the lift can be operated again. Use Vertical Acting Actuators in lieu of Horizontal Mounts Some permanent installations may accommodate actuators which are mounted vertically beneath the lift instead of horizontally inside the lift structure. Vertical orientation of the actuators provide a 1:1 ratio of lift travel to actuator stroke instead of the 5:1 ratio normal with horizontal mounting of the actuators inside the scissors. This means a 1:1 ratio of lift deflection to actuator compression, 80% less than the 5:1 ratio experienced normally. Vertical mounting and pushing upward against underneath side of the platform to raise the lift also eliminates the high stresses usually exerted at the actuator thrust inner leg member(s).

Summary on Deflection
Deflection is a normal and expected characteristic of industrial scissors lifts. And though odds are that most scissors lift users have not had to concern themselves with this issue because their lifting application is fairly immune to the effects of deflection, there is always a chance that it matters greatly. ANSI MH29.1accurately points out that “It is the responsibility of the user/purchaser to advise the manufacturer where deflection may be critical to the application.” Though deflection is easier to qualify than it is to quantify, there are industry best practices which can be applied to reduce the impact or amount of deflection being experienced.

DESIGN THEORY AND CALCULATION
In this section all design concepts developed are discussed and based on evaluation criteria and process developed, and a final here modified to further enhance the functionality of the design. Considerations made during the design and fabrication of a single acting cylinder is as follows:
- Functionality of the design
- Manufacturability
- Economic availability. i.e. General cost of materials and fabrication techniques employed.

DESIGN THEORY
In this chapter, mathematical relationships are developed for the various parameters necessary for the implementation of this design and arranged in sections below corresponding to the sequence of their implementation. Hydraulic systems are used to control and transmit power. A pump driven by a prime mover such as an electric motor creates a flow of fluid, in which the pressure, direction and rate of flow are controlled by values. An actuator is used to convert the energy of the fluid back into mechanical power. The amount of output power developed depends upon the flow rate, the pressure drop across the actuator and its overall efficiency.

Most lifting devices are powered by either electricity, pneumatic or mechanical means. Although these methods are efficient and satisfactory, they exist lots of limitations and complexity of design of such lifts as well as high cost of electricity, maintenance and repairs does not allow these lifts to exist in common places. The idea of a hydraulically powered scissors lift is based on Pascal’s law employed in car jacks and hydraulic rams which states that “pressure exerted anywhere in a conformed incompressible fluid is transmitted equally in all directions throughout the fluid such that the pressure ratio remains the same”.

CYLINDER SELECTION
The hydraulic cylinder (or the hydraulic actuator) is a mechanical actuator that is used to give a unidirectional stroke. It has many applications, notably in engineering.

Single Acting Cylinders
Single acting cylinders use hydraulic oil for a power stroke in one direction only. The return stroke is affected by a mechanical in one direction only. The return stroke is affected by a mechanical spring located inside the cylinder. For single acting cylinders with no spring, some external actin force on the piston rod causes its return.

Double Acting Cylinders
Double acting cylinder uses compressed air or hydraulic fluid to pour both the forward and return strokes. This makes them ideal for bushing and pulling and pulling within the same application they are suitable for full stroke working only at slow speed which results in gentle contact at the ends of stroke.

DESIGN THEORY AND CALCULATION
In this section all design concepts developed are discussed and based on evaluation criteria and process developed, and a final here modified to further enhance the functionality of the design. Considerations made during the design and fabrication of a single acting cylinder is as follows:
- Functionality of the design
- Manufacturability
- Economic availability. i.e. General cost of material and fabrication techniques employed

Hydraulic cylinder:
The hydraulic cylinder is mounted in inclined position. The total load acting on the cylinder consists of:
- Mass to be put on lift : 500 kg Taking FOS = 1.5 for mass in pallet 500 x 1.5 = 750 kg rounding the mass to 800kg
- Mass of top frame= 22.5 kg
- Mass of each link:5kg(5*8)=40kg
- Mass of links of cylinder mounting=4kg Mass of cylinder=8.150kg
- Total Mass : 22.5+40+8.150+4+800 = 874.65 kg
- Total load = 874.65x 9.81 = 8580.316N

Scissors lift calculations:
For a scissors lift Force required to lift the load is dependent on, Angle of link with horizontal Mounting of cylinder on the links Length of link. Formula used Where W = Load to be lifted S= a2 + L2 -2aL*cos α
- S = Distance between end points of cylinder.
- L= length of link = 0.6 m
- α = angle of cylinder with horizontal.
- Now the maximum force will act on the cylinder
- When the cylinder is in shut down position i.e when the scissors links are closed .For calculations we will consider α=300
- Thus substituting α=300 in eqn (1), We get F=8580.316N
- Selecting 63mm diameter cylinder
- Area of the cylinder= force/pressure

http://ijesc.org/
Area=(3.14*632)/2
=3117.24mm²

Pressure =(Force/Area)
=(8580.316/3117.24*10⁻⁶)
=27.52bar

DESIGN OF LINK

Now Let \( H_0 \) = Mass applied on the lift = 800 kg
\( B \) = Mass of the lift which the cylinder needs to lift = 74.65 kg
\( H_y \) = Total weight = 8580.316 N
- Only two forces are calculated here
  1. Forces at the end of link: as forces at ends of link are same in magnitude.
  2. Force at middle of link.
- In our case, the levels are numbered from the top.
  For level 1 \( X_1 = X_B - 1 \)
  For level 2 \( X_2 = X_B \)

The angle of cylinder with horizontal is \( \theta = 200 \).
\( H_y = 8580.316N \)
\( X_2 = H_y * \frac{1}{4} \)
= 8580.316 * 1 * 0.5 * (cot20/2)
= 11787.112 N

Resultant of \( X_2 \) & \( H_y \)/4
\( R_1 = \sqrt{11787.112^2 + (8580.316/4)^2} \)
\( R_1 = 11980.708N. \)
Above force will act on all the joints at end of each link.

STRESSES IN CYLINDERS

When cylinders are subjected to internal fluid pressure, the following types of stresses are developed.
- Hoop or circumferential stress.
- Longitudinal stress.

Hoop stress is produced as a result of forces applied from inside the cylindrical pipe pushing against the pipe walls. Hoop stress is the result of forces pushing against the circumferential cylinder walls. While, longitudinal stress is as a result of forces pushing against the top ends of a cylinder. These forces are derived using Newton’s first law. Let \( d \) = internal diameter of cylinder
\( T \) = thickness of cylinder
\( P \) = internal pressure (gauge) in the cylinder
\( \sigma_c \) = circumferential or hoop stress
\( \sigma_l \) = longitudinal stress
\( L \) = length of cylinder or pipe
Hoop stress \( \sigma_c = pd/2t \)
Longitudinal stress \( \sigma_l = pd/4t \)
Maximum Shear Stress \( T_{max} = pd = \sigma_c - \sigma_l \)
Bursting force (pressure) = \( pdL \)
Resisting strength = \( 2Lt \sigma_c \)
Bursting force = resisting strength ( \( pdL = 2Lt \sigma_c \) )
Note: the maximum stress developed must not exceed the permissible tensile stress (\( \sigma_c \)) of the material.

BASIC DIMENSIONS OF COMPONENT MEMBER.

Lift Extension
At maximum extension, an “X” arrangement of the lift moves 0.9m = 900 mm.
Total number of tiers of scissors (combined) = 3
Thus, total height of extension = 3 × 0.9 = 2.7 m.
Length of base = 1400 mm
Width of base = 800 mm
Height of base from ground = 500 mm
At maximum extension, Angle of inclination = 50
At maximum extension, distance between two scissors feet = 800 mm

Distance moved by sliding foot to full extension = 400 mm

Bears
Number of ball bearings = 4
Number of shell bearings = 36
Internal diameter of ball bearings = 30 mm
Internal diameter of shell bearings = 11 mm
External diameter of ball bearings = 50 mm
External diameter of shell bearings = 15 mm
Pivot pin diameter = 14.6 mm

Platform
Total height of platform = 1400 mm.
Total width of platform = 800 mm
Total height of platform = 800 mm
Permissible load on platform + platform weight = 300 kg = 2.94 kn.

Jointed Members
Thickness of rectangular pipe = 3 mm
Thickness of angle bar = 3 mm.

Scissors Arm
The material used for the scissors arms (members), is stainless steel. With the density and the dimensions of the scissors arms known, the mass can be calculated using the relationship.

Density \( (\rho) = \frac{\text{Mass (M)}}{\text{Volume}} \)

Mass = \( \rho . V \)
Density of stainless steel (type 304) = 7900 kg/m³
Area (cross sectional area) = \( A_1 - A_2 \)
\( A_1 \) = Outer cross sectional area
\( A_2 \) = Inner cross sectional area
\( A_1 = (h - t)(b - t) \)
\( A_2 = h \times b \)
Where \( h \) = scissors arm height
\( b = \text{breadth} \)
\( t = \text{thickness of material} \)
Volume \( (V) = \text{area} \times \text{lengt} \ V = AL \ (m^3) \)

V. MODAL IS DRAWN:

Figure.11. Base part

Figure.12. Bolt
PROCEDURE:
Importing the Model:
In this step the PRO/E model is to be imported into ANSYS workbench as follows:
In utility menu file option and selecting import external geometry and open file and click on generate. To enter into simulation module click on project tab and click on new simulation.

Defining Material Properties:
To define material properties for the analysis, following steps are used:
The main menu is chosen select model and click on corresponding bodies in tree and then create new material enter the values again select simulation tab and select material.

Defining Element Type:
To define type of element for the analysis, these steps are to be followed:
Chose the main menu select type of contacts and then click on mesh-right click-insert method
Method - Tetrahedrons
Algorithm - Patch Conforming
Element Mid side Nodes – Kept

Meshing the model:
To perform the meshing of the model these steps are to be followed:
Chose the main menu click on mesh- right click- insert sizing and then select geometry enter element size and click on edge behavior curvy proximity refinement and then right click generate mesh.
Figure 22. Force acting

ANSYS RESULTS:

Stainless steel

Equivalent stress

Mode 1

Mode 2

Mode 3

Mode 4

Mode 5

Mode 6

Equivalent stress

Total deformation

Mode 1

Mode 2

Mode 3

Mode 4

Mode 5

Mode 6

Aluminum alloy

Equivalent stress

Total deformation

Mode 1

Mode 2

Mode 3

Mode 4

Mode 5

Mode 6

Magnesium alloy

Equivalent stress

Total deformation

Mode 1

Mode 2

Mode 3

Mode 4

Mode 5

Mode 6

Aluminum alloy
VI. RESULTS AND CONCLUSION

Table 1. Stress and deformation

<table>
<thead>
<tr>
<th>Material</th>
<th>Equitant Stress</th>
<th>Total Deformation</th>
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<td></td>
<td>Mini</td>
<td>Max</td>
</tr>
<tr>
<td>Aluminum alloy</td>
<td>0</td>
<td>41.407</td>
</tr>
<tr>
<td>Magnesium alloy</td>
<td>0</td>
<td>40.949</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>0</td>
<td>42.042</td>
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</table>

Table 2. Total deformation

<table>
<thead>
<tr>
<th>Material</th>
<th>Mode 1</th>
<th>de 2</th>
<th>de 3</th>
<th>de 4</th>
<th>de 5</th>
<th>Mode 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum alloy</td>
<td>5.0365</td>
<td>4.4864</td>
<td>1.2897</td>
<td>4.6839</td>
<td>044</td>
<td>4.2924</td>
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<tr>
<td>Magnesium alloy</td>
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<td>4.9799</td>
<td>5.3649</td>
<td>5.9013</td>
<td>762</td>
<td>5.6374</td>
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<tr>
<td>Stainless steel</td>
<td>2.9754</td>
<td>2.6525</td>
<td>2.6049</td>
<td>3.1404</td>
<td>588</td>
<td>2.608</td>
</tr>
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</table>

VII. CONCLUSION

We have developed a final design that will meet the customer requirements using the determined engineering specifications. The following is a final summary of what we did and how we went about it. Stability, comfort, noise level, and hand control were determined to be the most important requirements. All these requirements have been used in developing our concepts and have been implemented in our alpha design, which was then modified to become our final design. We developed and followed through with a fabrication plan that produced a working product. This plan gave a detailed description of the process needed if our work is to be replicated. The validation tests that we conducted on the final lift produced results that exceeded customer and sponsor requirements. The final design has been broken down into four subsections: the scissor lift, the seat mechanism, the lean bar frame and the wheel locking mechanism. We created each of these subsections separate in the machine shop and fabricated these with the plan we have laid 16 out above. We then assembled these sections together and created our final model.

VIII. REFERENCES:


[4]. Material Handling Industry of America (MHIA), Safety Requirements for Industrial Scissors Lifts. 1994, Charlotte: ANSI.