Design, Manufacturing & Analysis of Hydraulic Scissor Lift

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Abstract— The following paper describes the design as well as analysis of a hydraulic 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 by using pantograph so that the overall cost of the scissor lift is reduced. In our case our lift was needed to be designed a portable and also work without consuming any electric power so we decided to to use a hydraulic hand pump to power the cylinder Also such design can make the lift more compact and much suitable for medium scale work. Finally the analysis of the scissor lift was done in ansys and all responsible parameters were analyzed in order to check the compatibility of the design values

Keywords— Hydraulic scissor lift, pantograph, hand pump, vonmisses stresses, ansys.

Introduction-

A hydraulic pallet lift is a mechanical device used for various applications for lifting of the loads to a height or level. A lift table is defined as a scissor lift used to stack, raise or lower, convey and/or transfer material between two or more elevations. The main objective of the devices used for lifting purposes is to make the table adjustable to a desired height. A scissor lift provides most economic dependable & versatile methods of lifting loads; it has few moving parts which may only require lubrication. This lift table raises load smoothly to any desired height. The scissor lift can be used in combination with any of applications such as pneumatic, hydraulic, mechanical, etc. Lift tables may incorporate rotating platforms (manual or powered); tilt platforms, etc, as a part of the design.

Scissor lift design is used because of its ergonomics as compared to other heavy lifting devices available in the market. The frame is very sturdy & strong enough with increase in structural integrity. A multiple height scissor lift is made up of two or more leg sets. These types of lifts are used to achieve high travel with relatively short platform.

Industrial scissor lifts & tilters are used for a wide variety of applications in many industries which include manufacturing, warehousing, schools, grocery distribution, military, hospitals and printing.

The scissor lift contains multiple stages of cross bars which can convert a linear displacement between any two points on the series of cross bars into a vertical displacement multiplied by a mechanical advantage factor. This factor depends on the position of the points chosen to connect an actuator and the number of cross bar stages. The amount of force required from the actuator is also amplified, and can result in very large forces required to begin lifting even a moderate amount of weight if the actuator is not in an optimal position. Actuator force is not constant, since the load factor decreases as a function of lift height.

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

2.MATERIAL SELECTION

It is necessary to evaluate the particular type of forces imposed on components with a view to determining the exact mechanical properties and necessary material for each equipment. A very brief analysis of each component follows thus:

I. Scissors arms
II. Hydraulic cylinder
III. Top plat form
IV. Base plat form
V. Wheels

Scissors Arms: this component is subjected to buckling load and bending load tending to break or cause bending of the components. Hence based on strength, stiffness, plasticity an hardness. A recommended material is stainless steel.

Hydraulic Cylinder: this component is considered as a strut with both ends pinned. It is subjected to direct compressive force which imposes a bending stress which may cause buckling of the component. It is also subjected to internal compressive pressure which generates circumferential and longitudinal stresses all around the wall thickness. Hence necessary material property must include strength, ductility, toughness and hardness. The recommended material is mild steel.

Top Platform: this component is subjected to the weight of the workman and his equipment, hence strength is required, the frame of the plat form is mild steel and the base is wood.

Base Platform: this component is subjected to the weight of the top plat form and the scissors arms. It is also responsible for the stability of the whole assembly, therefore strength. Hardness and stiffness are needed mechanical properties. Mild steel is used.

3.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
c. 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 scissor 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
$S= a^2 + L^2 -2aL*\cos \alpha$
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 scissor links are closed .For calculations we will consider $\alpha=30^0$
Thus substituting $\alpha=30^0$ in eqn (1), We get F=8580.316N
Selecting 63mm diameter cylinder
Area of the cylinder= force/pressure
Area=$(3.14*63^2)/2$
$=3117.24mm^2$
Pressure =(Force/Area)
$=(8580.316/3117.24*10^{-6})$
=27.52bar

4.DESIGN OF LINK

Now Let H_{y0} =Mass applied on the lift=800kg
B=Mass of the lit which the cylinder needs to lift=74.65kg
H_{yi}=Total weight =8580.316N

- 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 $X_1 = X_{Bi-1}$

For level 2 $X_2 = X_{Bi}$

The angle of cylinder with horizontal is $\theta=20^0$.
H_{yi}=8580.316N
$X_2=H_{yi}*i\frac{\cot\theta}{2}$
=8580.316*1*0.5*(cot20/2)
=11787.112N
Resultant of X_2 & $H_{Yi}/4$
$R_1 = \sqrt{(11787.112)^2+(8580.316/4)^2}$
R_1 = 11980.708N.
Above force will act on all the joints at end of each link.

Now force acting on the intermediate point of link is given by,

$X_{mi}=(2i-1)*H_{yo*}\frac{cot\theta}{2}+(2i^2-2i+1)*b_y{}^{*}\frac{cot\theta}{4}$

$=H_{yo*}\frac{cot\theta}{2}+(2i^2-2i+1)*b_y{}^{*}\frac{cot\theta}{4}$

$= (7848 \text{ X } 0.5 \text{ X } \cot 20^0)+(732.316 \text{ X } 0.25 \text{ X } \cot 20^0)$

$=11512.48N$

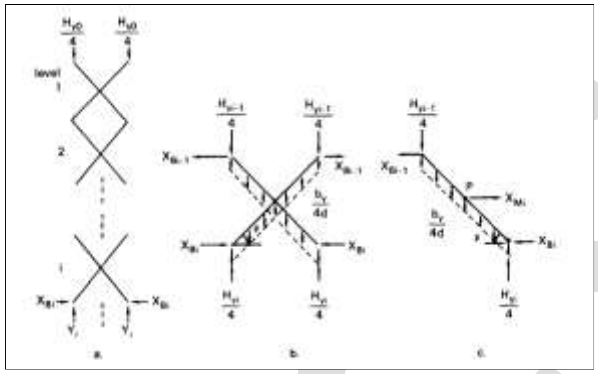


Fig No-1,Free body diagram for force applied in y direction

5.DESIGN FOR FABRICATION

For the link design it has been considered that, the entire load is acting on half of the link length.

Length of the entire link = 720mm.

Length of the link considered as the beam for the calculation purpose = 360mm.

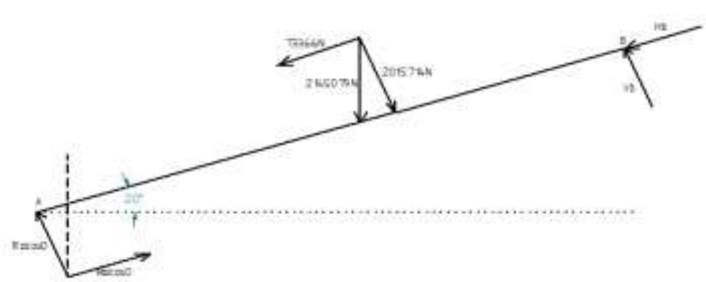
The load pattern on the top platform is considered to be U.D.L.

Hence, the load pattern on the link is uniformly varying load (U.V.L.) due to its inclination with horizontal.

The calculation is done for the link in shut height position, i.e. when the angle made by the links with horizontal is 20^0.

The length of the pin from the intermediate pin to the bottom roller is considered as a beam. The forces acting on the beam are-

- The reaction offered by the base to the roller, R_A resolved into 2 components.
- The reactions offered by the intermediate pin, H_B, V_B.
- The force due to (Payload + Platform weight) resolved into two components, along the length of the link and perpendicular to the length of the link.



W = force per unit length of the beam can be evaluated as follows,

As the load pattern of U.V.L. is a triangle, we can say,

W (total force perpendicular to the link) = (1/2)*base*w

H_{yi}=8580.316N

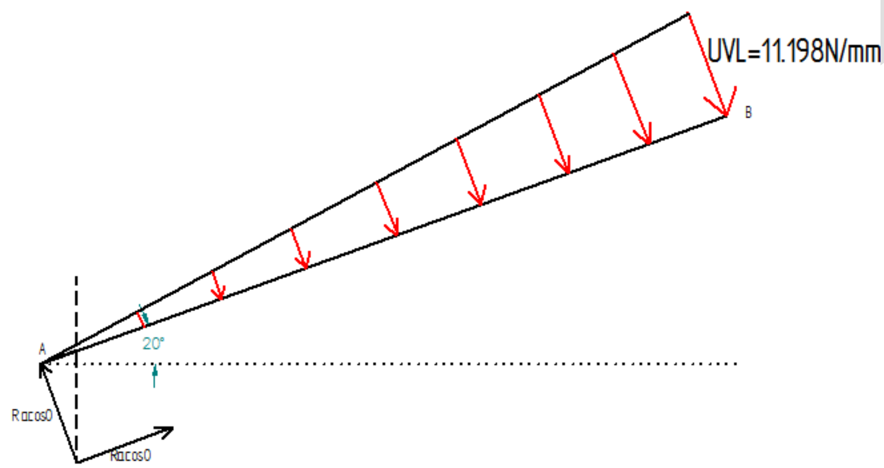
H_{yi}/4=(8580.316/4)=2145.079N

2145.079cos(20^0)=2015.714N

2145.079sin(20^0)=733.66N

Now 2015.714=(1/2)*360*W

W=11.918N/mm



Taking moment about point A,

VB * 360 – [(2015.714X*360 *$\frac{2}{3}$)]

Therefore,

VB = 1343.089N

$\sum Fy = 0$,gives

VB + R_A cos (20) – 2015.714=0

Putting value of VB from equation (1) in equation (2), we get,

1343.809+ R_A cos (20) – 2015.714 = 0

Therefore R_A = 715.026N

Therefore, R_A cos (20) = 671.904 N

$R_A \sin(20) = 244.55N$

$\sum Fx = 0$ gives

$R_A\sin(20)+733.63=H_B$

Therefore, $H_B = 489.08N$

$$\frac{M}{I} = \frac{\sigma}{Y}$$

Where, M = Maximum Bending moment on the link considered as beam.

Y = distance of the neutral axis from the farthest fiber = h/2.

σ_B = allowable bending stress

$$= \frac{Sut}{f.o.s.}$$

$$= \frac{250}{4}$$

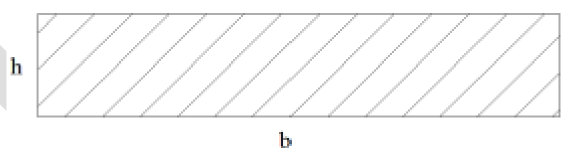
= 62.5 MPa

I = Moment of Inertia of the link c/s about the X-X (horizontal) axis

$$= \frac{bh^3}{12}$$

Where, b = width of the link

h = thickness of the link



Now the maximum bending moment is at the point of zero shear force.

And Maximum bending moment is given by$(w*l^2)/(9\sqrt{3})$

$B_{max}=(11.198*360^2)/(9\sqrt{3})$

=93098.423N.mm

Substituting in$(M/I)=(\sigma_b/Y)$

Assume Y=h/2 and b=4h

h=13.07

rounding the value to available dimensions h=15mm and b=60mm

6.DESIGN OF MOVING END PIN

τ_{all} = 0.5*380/FOS

= 63.33Mpa

63.33= $4*F/3.14*D^2*2$

= 10.76mm

D = 12mm……………selecting standard value

7.ANALYSIS OF THE LIFT IN ANSYS SOFTWARE

Fig No-2,ISO Assembly

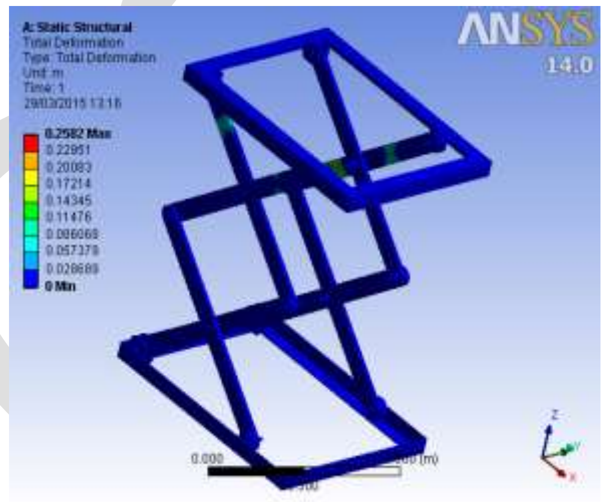


Fig No-3,Deformation Analysis

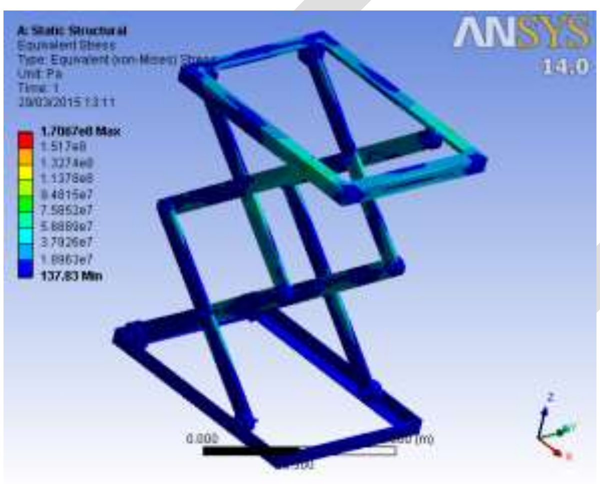


Fig No-3,Vonmises stress analysis

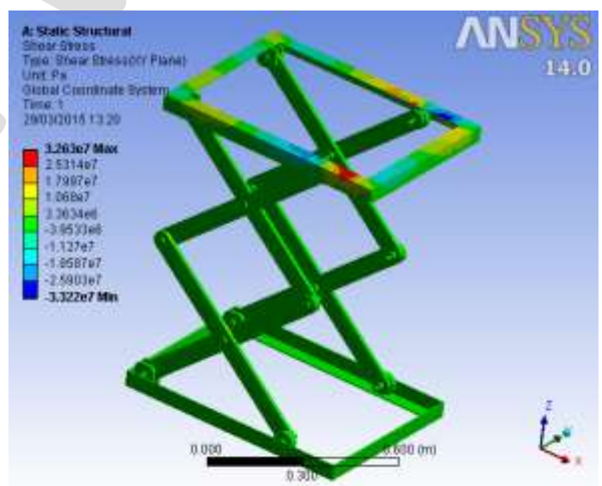


Fig No-4,Shear stress analysis

Analysis of results-

TYPE	MINIMUM	MAXIMUM
VONMISES STRESS	137.83 N/mm^2	170.67N/mm^2

DEFORMATION	0mm	25mm
SHEAR STRESS	-332.2N/mm^2	326.3N/mm^2

8.CONCLUSION

The design and fabrication of a portable work platform elevated by a hydraulic cylinder was carried out meeting the required design standards. The portable work platform is operated by hydraulic cylinder which is operated by a handpump ergonomics of a person or an operator working in the company premises is a responsibility of an organization. It is an important thing to give some comfort to the operator. Hence, by making this hydraulic lifter we improved the comfort level of the operator working on the cold forging machine.

Ergonomics, material handling and providing comfort to the operator was our main motive behind developing this lifter This was considered as a radical improvement in the productivity by the company.

The scissor lift can be design for high load also if a suitable high capacity hydraulic cylinder is used. The hydraulic scissor lift is simple in use and does not required routine maintenance. It can also lift heavier loads. The main constraint of this device is its high initial cost, but has a low operating cost. The shearing tool should be heat treated to have high strength. Savings resulting from the use of this device will make it pay for itself with in short period of time and it can be a great companion in any engineering industry dealing with rusted and unused metals.

REFERENCES:

1. Industrial Hydraulics Manual, Vickers 935100-B.
   Esposito, Fluid Power with application, prentice hall.
2. Hydroteck Engineering Company Series Heavy Duty NFPA Tie Rod Cylinders Catalogue.
3. Indian Standard DIMENSIONS FOR HOT ROLLED STEEL BEAM, COLUMN, CHANNEL AND ANGLE SECTIONS (Third Revision) IS 808:1989.
4. Mathematical analysis of Actuator forces in a scissor lift, Technical document 2643, May 1994 by H. Spackman. AD-A283 906
5. Mathematical analysis of Actuator forces in a scissor lift, Technical document 1550, May 1989 by H. Spackman AD-A225 220
6. Vector Mechanics for Engineers, Ferdinand Bear and E Russel Johnston, TATA McGraw Hill Publication