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Hydraulic Scissors lift design, manufacturing & analysis

Varun jaiswal [1], Mr. Dilip Gehlot[2], Mr. Vikas Sharma [3]

Department of Mechanical Engineering (CAD/CAM) , MALWA INSTITUT OF TECHNOLOGY , INDORE (MADHYA PRADESH) – 452001

Email: varun.8007@gmail.com, varun.8007@hotmail.com

Abstract -*The following paper describes the design as well as analysis of a hydraulic scissor lift. The design value the conventional method of using rope, ladder, scaffold etc. conventionally a scissor lift or jack is used for lifting a vehicle to change a tier, to gain access to go the underside of the vehicle , to lift the body and many application the lift can be used for various purpose like maintenance and material handling operations. It also have a different types the design describe the lift can be operated by mechanical means by using pantograph so the cost of the lift will reduce. In this project a mobile scissor lift has been design that will be powered by hydraulic hand pump without consuming electric power. We decided to use the hydraulic hand pump and cylinder. These designs make the lift more compact and must suitable for medium scale work. Finally the analysis of scissor lift was done in ansys and all responsible parameter were analyzed.*

Keywords - *Hydraulic scissor lift , hand pump , vonmisses stresses , ansys.*

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 crisscross “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 by 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.

The name scissors-lift originated from the ability of the device to open (expand) and close (contract) just like a scissors. Considering the need for this kind of mechanism, estimating as well the cost of expanding energy more that result gotten as well the maintenance etc. it is better to adopt this design concept to the production of the machine.

The initial idea of design considered was the design of a single hydraulic ram for heavy duty vehicles and putting it underneath, but this has limitations as to the height and stability, and someone will be beneath controlling it. It was rather found out that; there is a possibility of the individual ascending/ descending, to be controlling the device himself. Therefore further research was made to see how to achieve this aim.

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.

Types of lifts can be classified as follows: -

Classification based on the type of energy used

1. Hydraulic lifts
2. Pneumatic lifts
3. Mechanical lifts

Classification based on their usage

1. Scissor lifts
2. Boom lifts
3. Vehicle lifts

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:

1. Scissors arms
2. Hydraulic cylinder
3. Top plat form
4. Base plat form
5. 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.

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:

1. Functionality of the design
2. Manufacturability
3. 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

1. Mass of top frame= 22.5 kg
2. Mass of each link:5kg(5*8)=40kg
3. Mass of links of cylinder mounting=4kg
4. 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= 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 scissor 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

Area=(3.14*632)/2

=3117.24mm2

Pressure =(Force/Area)

=(8580.316/3117.24*10-6)

=27.52bar

DESIGN OF LINK

Now Let Hy0 =Mass applied on the lift=800kg

B=Mass of the lit which the cylinder needs to lift=74.65kg

Hyi=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 X1 = XBi-1

For level 2 X 2= XBi

The angle of cylinder with horizontal is $\theta=20^{0.}$

Hyi=8580.316N

X2=Hyi*I (cot θ/2)

=8580.316*1*0.5*(cot20/2)

=11787.112N

Resultant of X 2 & HYi/4

R1 = √(11787.112)2+(8580.316/4)2

R1 = 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,

Xmi=(2i-1)*Hyo*(cot θ/2)+ (2i2-2i+1)*by* (cot θ/4)

=Hyo* cot θ/2 +(2i2-2i+1)*by* (cot θ/4)

= (7848 X 0.5 X cot 200)+(732.316 X 0.25 X cot20^0)

=11512.48N

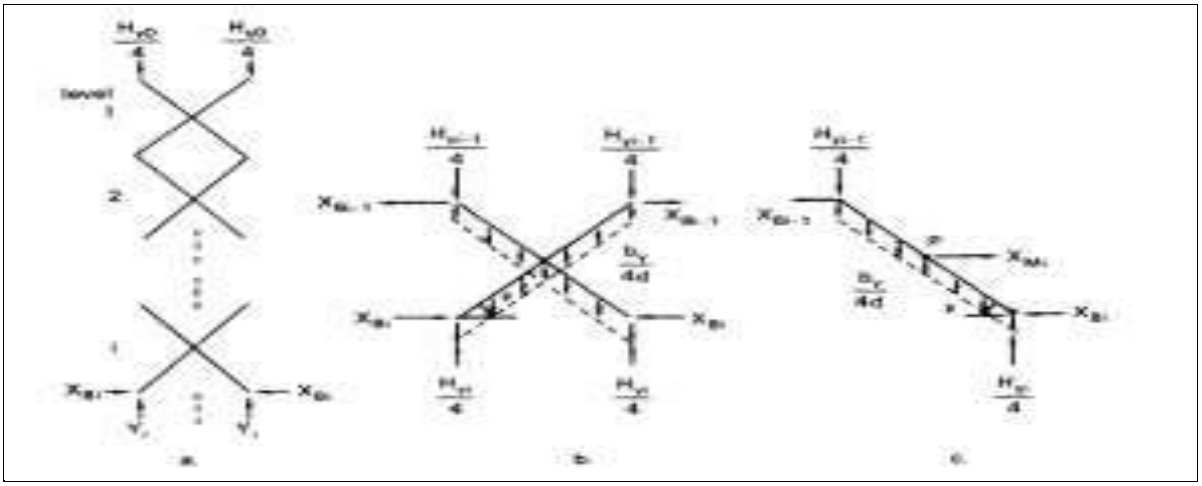


Fig No-1, free body diagram for force applied in y direction

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.

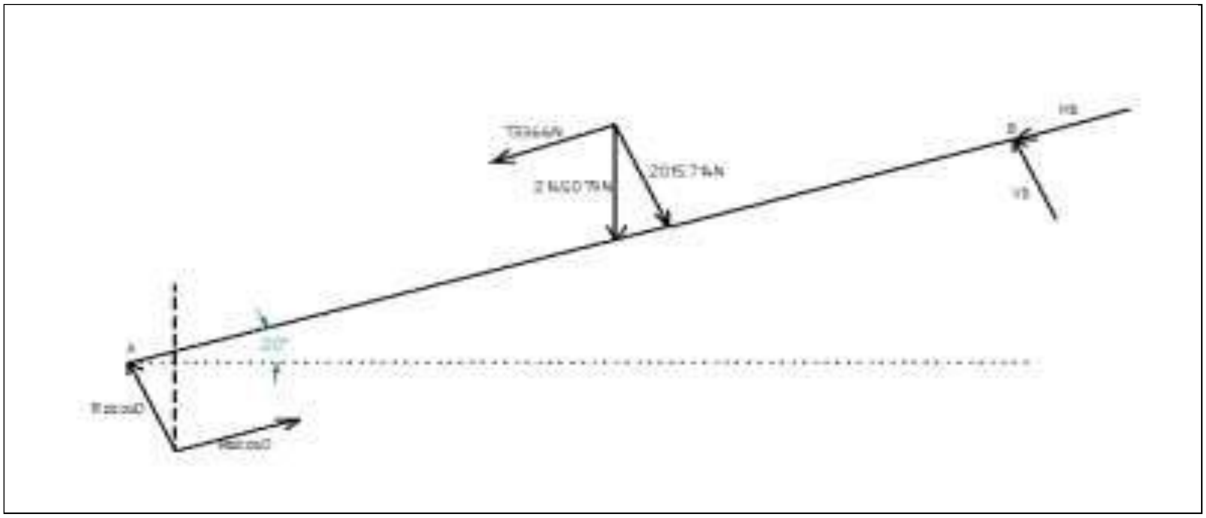
The calculation is done for the link in shut height position, i.e. when the angle made by the links with horizontal is 200.

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, RA resolved into 2 components.

The reactions offered by the intermediate pin, HB, VB.

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

Hyi=8580.316N

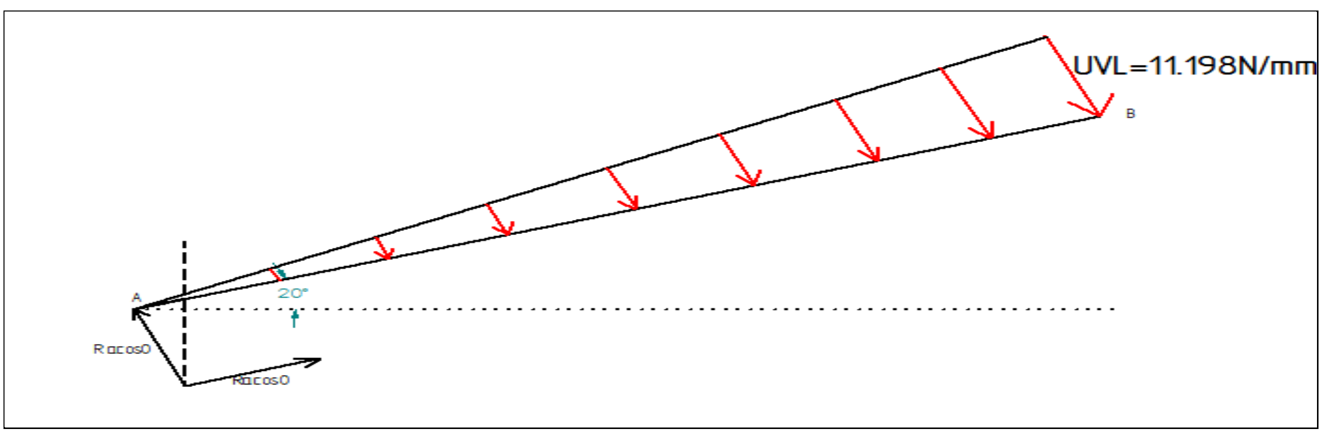
Hyi/4= (8580.316/4)=2145.079N

2145.079cos (200) =2015.714N

2145.079sin (200)=733.66N

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

W=11.918N/mm



Taking moment about point A,
VB * 360 – [(2015.714X*360 *)]
Therefore,
VB = 1343.089N

$\sum FY=0$ GIVEN

VB + RA cos (20) – 2015.714=0

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

1343.809+ RA cos (20) – 2015.714 = 0

Therefore RA = 715.026N

$\sum FY=0$ GIVEN

RA sin (20) = 244.55N

RA sin(20)+733.63=HB

Therefore, HB = 489.08N

Therefore, RA cos (20) = 671.904 N

M/I =σ/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

=sut / f.o.s.

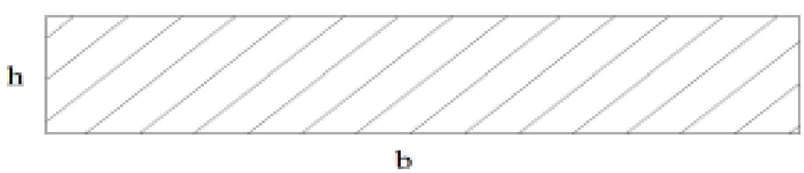
=250/4

= 62.5 MPa

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

$=bh^3/12$

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*l2)/(9√3)

Bmax=(11.198*3602)/(9√3)

=93098.423N.mm

Substituting in(M/I)=(σb/Y)

Assume Y=h/2 and b=4h

h=13.07

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

DESIGN OF MOVING END PIN

τ_{all}= 0.5*380/FOS

63.33Mpa

63.33= 4*F/3.14*D2*2

= 10.76mm

D = 12mm……………selecting standard value.

ANALYSIS OF THE LIFT IN ANSYS SOFTWARE

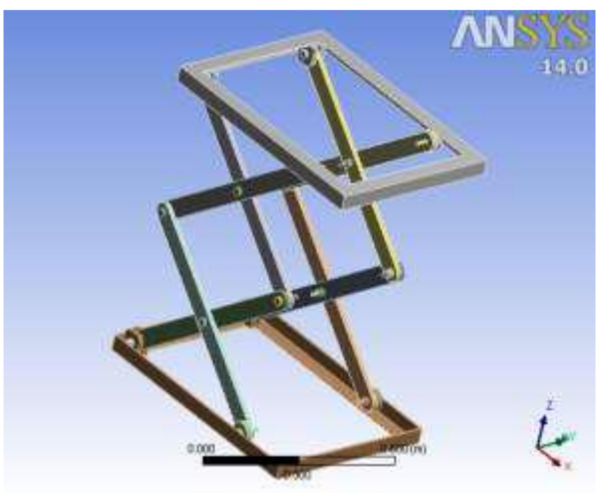


Fig No-2,ISO Assembly

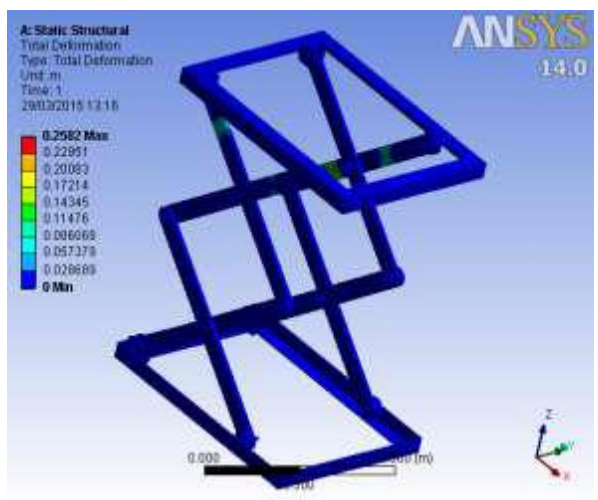
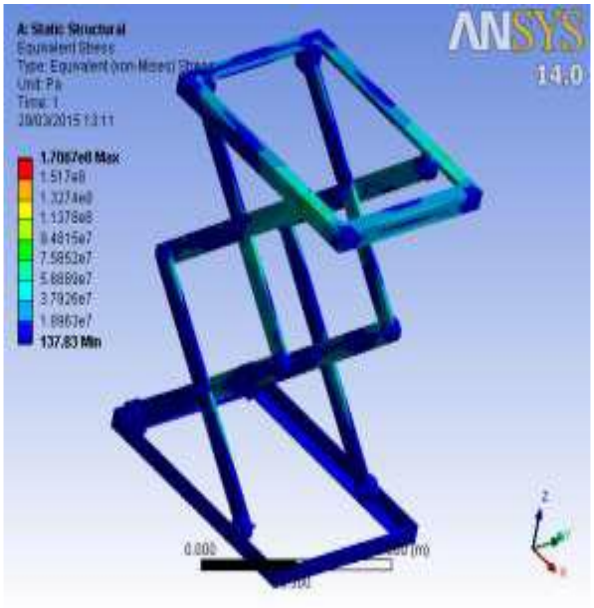


Fig No-3,Deformation Analysis



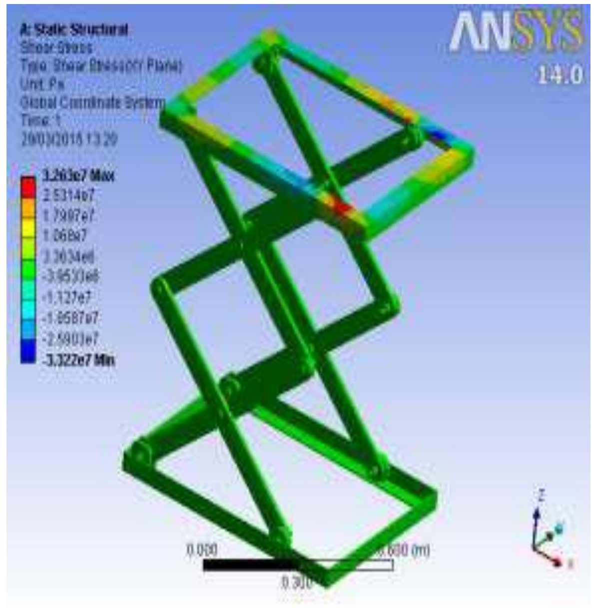


Fig No-3,Vonmises stress analysis

Fig No-4,Shear stress analysis

Analysis of results-

Type	MAXIMUM	MINIMUM
VONMISE STRESS	137.83 N/mm2	170.67N/mm2
DEFORMATION	0 MM	25 MM
SHEAR STRESS	-332.2N/mm2	326.3N/mm2

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.

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