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Design, Analysis and Development of Multiutility home equipment using Scissor Lift Mechanism

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Abstract: *The conventional method of using rope, ladder lift getting person to a height encounter a lot of limitation (time and energy consumption, comfortability, amount of load that can be carried etc.) also there may be a risk of falling down in case of ladders hence hydraulic scissors lift is designed to overcome all these difficulties. The main aim of this paper is design and analysis and to construct a multiutility home equipment for senior citizens so that they can carry their daily activities efficiently. Also the equipment should be compact and cost effective. Lifting height achieved by scissor mechanism is of 1 m from bottom level. Buckling and bending failure analysis of scissor is also done in this paper.*

Keywords: Scissor Mechanism, Hydraulic, Multifunctional, Mild Steel(MS),3D design.

1. Introduction

With ceaseless development of science and technology, more and more new technologies are applied to lifting appliance design. This project aims at making equipment multifunctional, easy to use/operate, cost effective and portable so that it will be used conveniently at home and may be used in hospitals, hotels and other common places. Senior citizens face many problems to carry out their day to day activities, as this equipment is designed in such a way that (e.g. it is remote operated with battery) they can easily move in house and perform day to day activities. All safety considerations are taken into account while designing equipment. Scissor lifting mechanism is designed to lift person to desired height. A scissor lift mechanism is a device used to extend or retract a platform by hydraulic means. The extension or displacement motion is achieved by the application of force by hydraulic cylinder to one or more supports. This force results in an elongation of the cross pattern. Retraction through hydraulic cylinder is also achieved when lowering of platform is desired.

2. Material Selection

After thorough survey regarding the strength and economics of different materials, it was found out that mild steel (MS) is the most appropriate material for the construction of the unit. Also Stainless Steel (SS) can be used at top of platform for support and to have better look to the equipment. Also Aluminium sheet of 2 mm thickness is used at top as material for platform. Aluminium sheet of 2 mm thickness is used at base.

3. Design

3.1 Equipment design with Software

Many kinds of constructions exists for the scissors lift platform, but the main constituents of all lift platform are the upper platform, number of pairs of scissors and the bottom platform . In our design we have used wheels with motors attached to it at back for movement from one place to other. The numbers of the scissors pairs and the position of the hydraulic cylinders even have different positions, which lead to different lifting height of the platform. We achieve height of 1m for the upper platform from base. Upper platform dimension is about 750x500 mm^2 which is enough for carrying bigger rated loading capacity. There are three ways for the bottom platform to move as for dragging, automatic control through remote and force application at back. The bottom platform is designed so as to have pair of scissors mechanisms held symmetrically.

Figure 1(a): Platform at maximum extended position(3D design)

Figure 1(b): Platform at fully retracted position

Using the design software detailed design of components and their assembly and their simulation can be done. This analysis is then verified with the manual calculations considering geometry of platform. Also manual design calculations are done for bending and buckling failure analysis of rectangular pipe. Figure above shows the upper platform in maximum extended and fully retracted position. Circular pipes with platform at sides to hold objects are attached to upper platform so that person will not lose balance and can hold pipe while lifting.

Upper platform velocity can be controlled with the help of hydraulic cylinders. Cylinders extension and retraction velocities are different. Also special care has been taken so as not to cause jerk.

2D diagram of mechanism and force diagram for upper scissors are given below. These diagrams are used to calculate reactions at various joints.

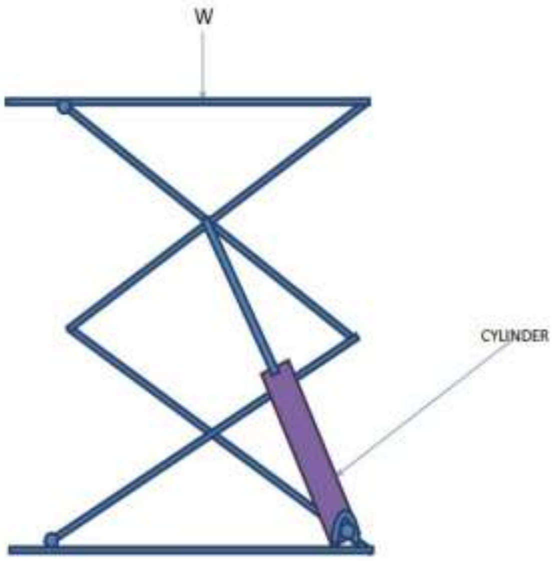

Figure 2: 2D diagram of scissor lift mechanism with cylinder

In Fig.2 we can see that one end of scissor mechanisms are locked with the help of hinge and other end carries rollers. Also cylinder is hinged to bottom platform and at middle of top scissor pair. Necessary force is applied to top scissor with the help of hydraulic cylinder which is then used to lift bottom scissor pair. Scissors are attached with help of pin joints.

3.2 Cylinder Calculations:

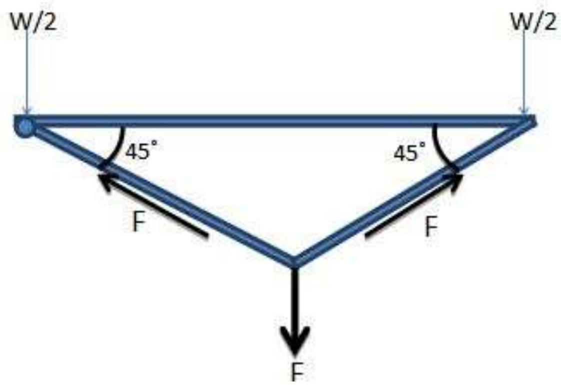

Figure 3: Force diagram

Let a weight of 100 kg be applied on the platform
$\Theta=45^0$

Resolving the load at both ends,
W/2= 490.5 N

From fig.
$490.5=f\sin 45^0$

$f= 693.67N$

Also,

$2f \cos 45^0=F$

$F=981N$

Force acting at the midpoint of the cross bar R= 2F= 1962N

But cylinder axis is inclined when fully extended

Therefore,

$F=R/\cos 45^0$

$F=2774.68N$

For selecting cylinder

Pressure P= F/A

P=20.58 bar

3.3 Analysis of rectangular cross-section pipe:

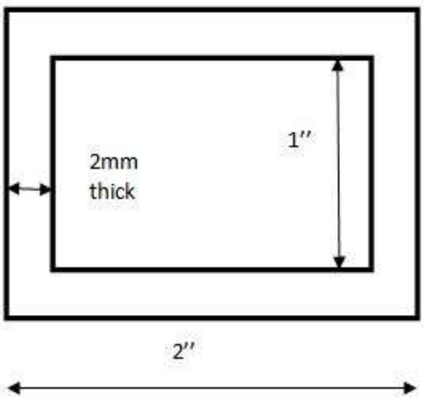

Figure 4(a) : Rectangular pipe

Maximum load acting on bottom platform = 130 kg

Minimum load acting on bottom platform = 30 kg

Factor of safety$=\frac{maximum\ stress}{working\ stress}$

$=\frac{130}{30}$

$= 4.333$

Analysis of rectangular cross-section pipe:

h=50.8mm

b=25.4mm

t=2mm

$A_1=bxh=1290.32x10^{-6}m^2$

$A_2=(b-t)(h-t)=1141.92x10^{-6}m^2$

$A=A_1-A_2=148.4x10^{-6}m^2$

Volume V $=89.04x10^{-6}m^3$

Density of mild steel $\rho= 7850kg/m^3$

Mass M= $\rho xV=0.698kg$

Mass of 1 tier= Mx4= 2.792kg

$W_b =2.792xg = 27.38N$

$M_P=100kg$

$W=M_pxg= 981N$

$\Theta=45^0$

$F= (W+W_b /2)/\tan\Theta$ (1)

$=994.70N$

$F_{overall}$=F x no. of tiers

$=1989.38N$

3.4 Design of members for buckling:

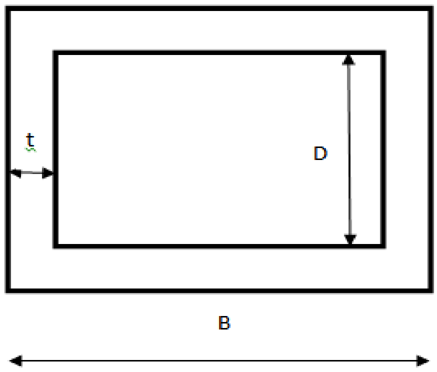

Figure 4(b) : Buckling analysis of pipe

B=50.8mm

D=25.4mm

t= 2mm

b= B-t= 48.8mm

d= D-t= 23.4mm

$I=\frac{BD^3-bd^3}{12}$ (1)

$=1.7266 x10^{-8}m^4$

Buckling load for members:

Modulus of elasticity for mild steel

$= 210GPa = 2.1x10^{11}N/m^2$

$P_E = \frac{\pi^2 EI}{L^2}$ (2)

$= 93000.85$ N

Actual $P_E = \frac{93000.85}{4.333}$ (3)

$= 21463.38$ N

Critical stress$= \frac{P_E}{A}$ (4)

$=144.63 \frac{MN}{m^2}$

Since critical stress is less than the yield strength of mild steel(300 MN/m^2).

Hence, the material is safe.

4. Conclusion:

This paper focuses on various aspects related to lifting mechanism and its design. The dimensional, dynamic and strength analysis reflects that the selected mechanism is functional and most likely reliable for its purpose. The portable work platform is operated by hydraulic cylinder which is operated by a motor. Also whole device is motorized and with help of control panel allows user to travel from one place to other. The scissor lift can be designed for high load also if a suitable high capacity hydraulic cylinder is used. The hydraulic scissor lift is simple in use and does not require routine maintenance. In this paper we carried out detailed analysis of scissor mechanism members against bending and buckling failure and also focused on various design aspects and working of scissor mechanism.

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