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Design and Analysis of Hydraulic Ladder

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Abstract - *With everlasting development of science and technology, more and more new technologies are applied to lifting appliance design. In this paper scissor ladder powered by hydraulics has been introduced. The main aim to design and analysis and construct multi-utility equipment for workers so that can carry their activities efficiently. The ladder should compact and cost effective. We expect that our ladder carry load around 150-200kg with factor of safety equal to 2.5 and lifting to height of around 7 to 8 ft. It is used for school, colleges, malls, hospital and small scale industries. The beginning aim of our project is to make marketable product in the market. To get maximum possible acceptance in the market will be our objective.*

Key Words*: *Scissor Ladder, Hydraulic Cylinder, Multifunctional, compact, cost effective.

1. INTRODUCTION

Now days so many different types of ladders are available in market such as step ladder, fixed ladder, extension ladder, platform ladder, telescopic ladder, folding ladder. This projects aim at making equipment multifunctional ease to use or operate cost effective and portable so that it will be used in various places and other common places.

"The machine which is achieved desired height by the using of linkages, folding support in the scissor form is known as scissor mechanism." A scissor ladder mechanism is a device used to extend or react a platform by hydraulic means. The extension and or displacement motion is achieved by application of force by hydraulic cylinder to one or more support. This forces results is an elongation of the cross pattern. Retraction through hydraulic cylinder is also achieved when lowering of platform is desired.

Fig -1: Hydraulic scissor Ladder

1.1 Objective

This project is aimed at designing and constructing hydraulically powered mechanical scissor ladder to achieve desired height with worker and his working equipment with the ease and economical way. The ladder is expected to work minimum technical challenges and greater comfort due to wide range of application. The aim of this study is design

scissor ladder that can be used in the domestic and small scale industries. The design specifications are as follow:-

1. The ladder will have achieved maximum height up to 7 to 8 ft.
2. The ladder should be Light in weight.
3. With easy design reduce the design complication in the system.
4. The model should compact In size.
5. The ladder will be easily portable from one place to another place.

1.2 Material selection

After through survey regarding the strength and economics of different materials ,it was found that mild steel (MS) is most appropriate material for the construction of the unit.

Also stainless steel can be used as pulling rod. Also plywood sheet used at top platform. Plywood sheet of 18 mm thickness is used at Base.

2. Design Methodology

It includes selection of slandered component based on our system requirement the selection of the cylinders for the scissor ladder is carried out via following calculations.

2.1 Total Weight Of The System

An important aspect is determining the total weight of the system as this can not done accurately at present we make an estimated guess and check its validity. we approximate the weight of system with complete payload to about =150 kg

Assuming the factor of safety=2.5(as pe OSHA-USA Standards)

Number of cylinder = 1

Total payload = complete payload × Factor of Safety

= 150 kg × 2.5

= 385 kg

2.2 Selection of Hydraulic Cylinder

Determining The Stroke Of Hydraulic Cylinder

Moment due to weight of payload=opposing moment produced by the cylinder

∴Weight× gravitational force× distance from centre × FOS=2 × force × cylinder stroke

$$\therefore 385 \times 9.81 \times \frac{1.3}{2} \times 2.5 = 3000 \times 9.81 \times Stroke$$

$$\therefore Stroke = \frac{385 \times 9.81 \times \frac{1.3}{2} \times 2.5}{2 \times 3000 \times 9.81}$$

$$\therefore Stroke = 250.23mm$$

2.3 Minimum Area Of Horizontal Cylinder Rod

The horizontal cylinder rod will have shear stress .we have to make sure that the rod capable of handling the shear stress without failure.

Shear stress= $\tau = \frac{Force}{Area}$

$$\therefore \tau = \frac{29430}{(\frac{\pi d^2}{4})}$$

$$\therefore 108.1875 = \frac{29430}{(\frac{\pi d^2}{4})}$$

$$\therefore Area_{min} = 272.027mm^2$$

$$\therefore Diameter_{min} = 18.79mm = 1.88cm$$

2.4 Selection of Hydraulic Cylinder

Based on all above conditions, we select the following cylinder and check it for safety.

1. Bore Diameter = 60 mm
2. Rod Diameter =30 mm
3. Outer Diameter =70 mm
4. Cloased Length = 450 mm
5. Stroke = 250 mm
6. Weight = 13 kg

2.5 Calculations for the cylinder

According to the requirement, the cylinder must extend to full length in 30 seconds.

Velocity = $\frac{Distance\ Extended}{Time}$

$= \frac{0.250}{10}$

= 0.025 m/s

Area = $\frac{\pi}{4}(D^2 - d^2)$

$= \frac{\pi}{4}(0.06^2 - 0.03^2)$

$= 2.1206\times10^{-3}\ m^2$

Pressure = $\frac{Force}{Area}$

$= \frac{29430}{2.1206\times10^{-3}}$

$=13.8781\times10^{6}\ N/m^2$

=138.69 bar

This is less than 200 bar which is safety limit as given by manufactures.

Discharge = Area × Velocity

$= 2.1206 \times 10^{-3} \times 0.025$

$= 5.3015\times10^{-5}\ m^3/s$

= 0.53015 liter/s

= 3.1809 liter/min

Power = Pressure × $\frac{Discharge}{600}$

$= 138.69 \times \frac{3.1809}{600}$

= 0.7352 kW

Now checking that the rod dose not fail under compression.

Compressive stress = $\frac{29430}{(\frac{\pi d^2}{4})}$

$= \frac{29430}{(\frac{\pi\times30^2}{4})}$

$= 41.6349\ N/mm^2$

Hence it is safe under compressive force.

Based on our requirement, we have selected double acting hydraulic cylinder. We have carried out the necessary analysis and selected standard cylinder which is available in market.

2.6 Selection of oil

Base on Indian standards we selected URSA-Extra duty SAE-10 oil as fluid used in the system.

Theoretical volume of oil = Extra in Tank + Volume of Hydraulic Cylinder + Volume of Hydraulic Pipe

= (2×2.0106)+(4×0.7069)+(4×0.189

= 4.0212 + 2.8276 + 0.756

= 7.6048 liters

Actual Volume of Oil = 1.25 × Theoretical Volume

$= 9.974 \cong 10\ liters$

2.7 Selection Of Standard Power Pack

The selection of power pack is based on three main criteria, which are

1. Power capacity: the total power capacity required for hydraulic system is around 3kW.
2. Total volume of oil: (Tank Capacity): the required tank capacity as calculated is 10 litre.
3. Types of power supply: according to Indian standards we have selected 24v DC supply.

Table 1:- Specification

Types of supply	3-phase supply
Power Capacity	3.5kW
Flow Rate	3.189 lit/min
Maximum Pressure	140 Bar
Reservoir Size (Tank Capacity)	10 liters

3. CONCLUSION

This paper is focus on various aspects related to mechanism and its design. The hydraulic scissor ladder is functional and most likely reliable for its purpose. The hydraulic scissor ladder is designed for high load and allows user travel one

place to another. In this paper we carried out detailed design and analysis of hydraulic scissor ladder and members.

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BIOGRAPHIES

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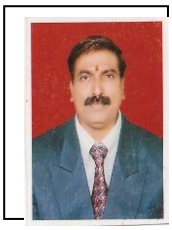

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