Design and Manufacturing of Ladder Roof Lift for Material Lifting

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Abstract - At construction site for material handling labours are used but this process is time consuming and due to which there will be possibility of accidents and thus for a multi storied building it is not economical. In this project we design and manufacture a ladder roof lift for material handling. For the operation of lift, we can use roller mechanism, chain drive or rack and pinion. For carrying different materials multiple containers will be placed on the lift. This process is economical and there is no chance of accidents and material wastage is also avoided. This design is compact and cost efficient.

Key Words: Aluminium Alloys, Chain Sprocket, Shaft, Conveyor Bucket.

1. INTRODUCTION

Material Handling equipment’s are used in movement of bulk, packaged, & individual products within the limits of place of business. The different types of handling equipment can be classified into four major categories transport equipment, positioning equipment, unit load formation equipment, and storage equipment. Material handling equipment’s used for following purpose:

- To increase efficiency of material flow
- To reduce material handling cost
- To improve facilities utilization
- To improve safety & working conditions
- To facilitate construction processes
- To increase productivity

All Material handling equipment are classified in main types, i.e

1) CONVEYORS

![Conveyor](image)

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another in fixed path. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries.

2) CRANE & HOISTS:

Cranes & Hoists is a tower or derrick that is equipped with cables and pulleys that are used to lift and lower material. They are commonly used in the construction industry. Cranes for construction are normally temporary structures, either fixed to the ground or mounted on a custom built vehicle or ship. They can either be controlled from an operator in a cab that travels along with the crane, by a push button pendant control station, or by radio type controls.

2. PROBLEM STATEMENT

At a construction site for lifting a material labor is required. If the building is multistoried it becomes difficult to transfer the material. Thus by this traditional system accident occurs and the process is very time consuming. Due to which costing for labours also increases. Also due to improper handling of material there is wastage of material.

So to overcome the problems arise in the existing method of material handling. We design a lift which carries the material at particular height of building from ground level. This lift can be made using roller mechanism, chain mechanism or rack and pinion. And for carrying the material multiple containers will be placed on the lift. For the operation of lift, we use motor.
3. **OBJECTIVE**

a) The main objective of the devices used for lifting purposes is to make material handling easy.

b) Ladder roof lift is used to raise or lower, convey and or transfer material between two or more elevations.

c) This ladder roof lift used for material handling process can transfer large quantity of material to the desirable height without its wastage.

4. **Methodology**

**PHASE 1**

a. Market survey
During this period detail market survey has been done to learn available parking systems and their utility also their literatures of different types of parking systems and its difference between have been observed.

b. Problems in existing systems
The problems regarding the existing system have been found such as, Complicated programming, High budgets, Unfeasible design, high end robots, etc.

c. Conceptual Design.
Taking problem statement from above and studying the fundamental engineering concepts various concepts regarding modern parking system are prepared and amongst those best concepts design has been selected for further phases.

**PHASE 2**

a. Modeling in CATIA
Putting the ideas on the modeling software for visualization of the prototype and making it more and more compatible so that there will be less complexity in designing

b. Material Selection and Procurement
In this phase material selection is done and also its procurement as per need the dimensions are taken from CATIA model.

c. Fabrication
This phase includes fabrication of prototype in the workshop from the procured material and preparing the Prototype model from the software model.

d. Assembly & Testing
This phase includes Assembly of all the sub parts, also the arrangement of the motor and its wiring is done, all finishing operations like grinding, trimming, painting is done here.

4. **WORKING MODEL**

For making lift which is used for the application at construction site we need to consider all the parameters. We need to design a lift which will be able to reach a height of around 25 ft. Main advantage of the ladder roof lift is that it is portable thus it can be used at maximum places. For the movement of the ladder roof lift we can use chain drive or rope drive. Instead of using a single container for transferring material it is convenient to use multiple containers as large amount of material will be transferred in lesser time. For transferring the lift to different places it should be of lesser weight. Thus we use aluminum composite material for manufacturing of ladder roof lift.

![Working Model Image]

**Calculations**

**Design of Chain Drive**

Torque acting on the motor is $T = 0.8 \text{ kg} = 7.848 \text{ N.m}$.

RPM = 100rpm

Let, Number of teeth $= Z1 = 21$ (sprocket)

The number of teeth for the both sprockets are same because we will have to transmit same power to another axis.

Tooth correction factor $(K)$ for the both sprocket

$K2 = 1.26$

$k1=1$

For smooth chain & DC motor

$Ks=1.0$

We required power transmitted for the further calculations

$P = \frac{2\pi n T}{60}$
P = \frac{200+100+7484}{40 \cdot 1+2} = 82.18W

KW Rating of Chain

\text{Power rating} = \frac{\left(\text{power to be transmitted}\right) \cdot \text{K}}{\text{K} + \frac{\text{K} - \text{K}}{2}}

\text{Smaller value for 100 rpm in table 14.2 is 0.25}

For 100 rpm & Power 0.065KW

Power rating of simple roller chain

The Power rating at 06 B is 100rpm & 0.25 KW power

Therefore, chain number 06B is selected.

For chain number 06B

\text{Pitch (P)} = 9.525 \text{ mm}

\text{Roller diameter (d1)} = 6.35 \text{ mm (max.)}

\text{Width (b1)} = 5.72 \text{ mm}

\text{Transverse Pitch (Pt)} = 5.72 \text{ mm}

\text{Breaking load}

\begin{align*}
\text{Simple} &= 8900 \text{ N} \\
\text{Duplex} &= 16900 \text{ N} \\
\text{Triplex} &= 24900 \text{ N}
\end{align*}

\text{Pitch Circle diameter of driving & driven shaft (PCD)}

\begin{align*}
\text{D1} &= \frac{P}{\sin(\frac{180}{2})} = \frac{9.525}{\sin(\frac{180}{2})} = 64 \text{ mm} \\
\text{D2} &= 64 \text{ mm}
\end{align*}

\text{Number of chain link (Ln)}

\text{The central distance between sprocket wheels should be between 30P to 50P}

\text{By taking the minimum value}

\text{Approximate central distance (a)}

\begin{align*}
\text{a} &= 790 \text{ mm} \\
\text{No of links are} &= 187
\end{align*}

\text{Correct central distance}

\begin{align*}
\text{a} &= \frac{P}{4} \left( \frac{\text{Ln} - \left( \frac{21+22}{2} \right)}{2} \right) + \sqrt{\left( \frac{\text{Ln} - \left( \frac{21+22}{2} \right)}{2} \right)^2 - 8 \left( \frac{22-21}{2} \right)^2} \\
\text{a} &= \frac{9.525}{4} \left( 166 + \sqrt{166^2} \right) \\
\text{a} &= 790.575 \text{ mm}
\end{align*}

\text{To provide small sag, for allowing the chain links to take the best position on the sprocket teeth, the centre distance is reduced by (0.002a). Therefore, the correct centre distance is given by}

\begin{align*}
\text{a} &= 0.998 \times 790.575 \\
\text{a} &= 788.99 \text{ mm}
\end{align*}

\text{To calculate tension in chain}

\text{The chain velocity is given by}

\begin{align*}
V &= \frac{2 \times 1000}{60 \times 10^2} \\
V &= 0.3334 \text{ m/s}
\end{align*}

\text{The chain tension is given by}

\begin{align*}
T_1 &= \frac{1000 \times KW}{1000 \times 0.25} \\
T_1 &= 749.95 \text{ N}
\end{align*}

\text{Factor of safety}

FS = 11.86

\text{Design Of Shaft}

\text{Material of shaft is C45Cr75.}

\text{Table. Shaft Material Properties}

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield strength</td>
<td>247MPa, N/mm²</td>
</tr>
<tr>
<td>Ultimate tensile</td>
<td>841 MPa, N/mm²</td>
</tr>
<tr>
<td>strength</td>
<td></td>
</tr>
<tr>
<td>Factor of safety</td>
<td>2</td>
</tr>
<tr>
<td>Poisons ratio</td>
<td>0.303</td>
</tr>
<tr>
<td>θ</td>
<td>180°</td>
</tr>
</tbody>
</table>
For chain drive max tension  
\[ T_1 = 749.85N = 0.749KN \]

Permissible shear stress  
\[ \tau = 0.18 \times S_u \]
\[ \tau = 0.18 \times 841 \]
\[ \tau = 151.38 \text{N/mm}^2 \]

Torsion moment  
\[ T_1 = 0.746 \text{KN} \]
\[ \frac{T_1}{T_2} = e^{u\beta} \]
\[ \frac{T_1}{T_2} = e^{0.303 \times \pi} \]
\[ T_2 = 289.11N \]

Torque supplied to the shaft is given by
\[ M_{t1} = (T_1 - T_2) \times 64/2 \]
\[ = (749 - 289.11) \times 64/2 \]
\[ = 14716.48 \text{ N.mm} \]

Bending moment  
Also, \( M_{t2} = 1038.11 \times 10^2 \)
\[ = 105887.22 \text{ N-mm} \]

Shaft diameter,
\[ D = \frac{16}{13.6} \sqrt{(105887.22)^2 + (14716.48)^2} \]
\[ D = 15.32 \text{ mm} \]

Taking safe value diameter of shaft is 16 mm.

**Bucket Analysis**

**Total deformation**

**Maximum principal stress**

**Directional deformation**
Equivalent stress

Maximum shear stress

Advantages

1. Easy and convenient material handling.
2. Accidents will be avoided as no labour is required.
3. Due to lesser weight ladder roof lift is portable.
4. Due to multiple numbers of containers larger amount of material is transferred in lesser time.

Disadvantages

1. Initial cost is high.
2. Maintenance is required.

CONCLUSION

In our project we are getting more effective results and effective work than previous system so this project is cost effective and work efficient

REFERENCES


