CONSTRUCTION OF A GOODS ELEVATOR WITH A MANUAL PULLEY SYSTEM

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Abstract

An elevator, commonly referred to as a lift, is a lifting device frequently used in multi-story buildings to transport people or goods. In the context of this design, the objective is to develop an elevator for a two-story building with a height of 4 meters. The background of this project is to provide a practical and efficient elevator system for buildings that do not require high-capacity or complex machinery. The purpose of this design is to create an affordable and reliable manual pulley-based elevator system suitable for low-rise buildings. The methodology includes observation of existing elevator systems, the application of established design standards, and a thorough literature review. Based on these inputs, the elevator utilizes a manual pulley system with a maximum load capacity of 540 kg. The cabin, which accommodates four people, is lifted using six ropes of type 8x19 with a diameter of 13 mm. The cabin is guided by T90 rails and is equipped with a wedge-type safety gear system for enhanced security. The results of the design show that the system meets the required specifications for load capacity and safety, while remaining cost-effective and efficient for the intended application. In conclusion, this manual pulley elevator system is a feasible and practical solution for small to medium-sized buildings, offering both reliability and safety within a modest budget.

Keywords: *Lift, Elevator, Manual Pulley System, Load Capacity, Safety Gear*

Abstrak

Lift, atau yang sering disebut sebagai elevator, merupakan alat angkut yang biasa digunakan pada bangunan bertingkat untuk mengangkut orang atau barang. Dalam perancangan ini, tujuan utamanya adalah untuk merancang sebuah lift yang digunakan pada gedung bertingkat dua dengan ketinggian 4 meter. Latar belakang dari proyek ini adalah untuk menyediakan sistem lift yang praktis dan efisien bagi bangunan dengan kapasitas atau mesin yang tidak terlalu besar. Tujuan dari perancangan ini adalah untuk menciptakan sistem lift berbasis katrol manual yang terjangkau dan dapat diandalkan, cocok untuk bangunan bertingkat rendah. Metode yang digunakan meliputi observasi terhadap sistem lift yang sudah ada, penerapan standar perancangan yang ada, serta tinjauan pustaka yang mendalam. Berdasarkan hal tersebut, lift ini menggunakan sistem katrol manual dengan kapasitas beban maksimal 540 kg. Sangkar yang mampu menampung empat orang ditarik menggunakan enam tali tipe 8x19 dengan diameter 13 mm. Sangkar tersebut dituntun oleh rel tipe T90 dan dilengkapi dengan sistem pengaman jenis wedge untuk meningkatkan keamanan. Hasil dari perancangan ini menunjukkan bahwa sistem ini memenuhi spesifikasi yang diperlukan terkait kapasitas beban dan keselamatan, serta tetap efisien dan terjangkau untuk aplikasi yang dimaksud. Kesimpulannya, sistem lift katrol manual ini merupakan solusi yang layak dan praktis untuk bangunan kecil hingga menengah, dengan menawarkan keandalan dan keamanan dalam anggaran yang terjangkau.

Kata Kunci: *Lift, Elevator, Sistem Katrol Manual, Kapasitas Beban, Sistem Pengaman*

1. BACKGROUND

In the era of technological advancements today, human needs have been increasing with the presence of innovative technologies that greatly enhance human behavior across various fields and sectors, ranging from small to large-scale industries. The presence of tools that make human work easier has led to a reduction in the need for human resources, as fewer people are required to operate and supervise the use of these tools. Lifting devices, such as cranes, forklifts, and others, are no exception to technological progress [1].

A forklift is a machine used to move or lift heavy objects. The lifting mechanisms on forklifts can be categorized into several types, such as hydraulic, chain, and winch (cable) systems. Forklift

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manufacturers generally use hydraulic and chain mechanisms designed to handle heavy lifting loads, resulting in high market prices for industrial forklifts. However, this high price can be a barrier for small to medium-sized industries that also need forklifts. Forklifts are widely used in warehouse operations, but there is also a demand for smaller forklifts with lower lifting capacities and more affordable prices [2], [3].

This need has driven the development of small-scale forklift designs. These include manual hand forklifts and electric hand forklifts. Manual hand forklifts are operated using a hand crank to raise and lower the forks manually, requiring human effort to lift the forks with a lifting time of 1.5 meters in 15 seconds for a 100 kg load. This makes manual hand forklifts less efficient in small industries, as they take relatively long times to operate. In contrast, electric hand forklifts use an electric hoist to lift and lower the forks, which is more efficient and effective than manual hand forklifts, although they are priced higher[4], [5].

Based on this situation, the author intends to design a goods lift with a manual pulley system to lift and transport goods from a warehouse to a truck for a delivery business. This lift, being smaller in size, provides better visibility for operators when lifting goods and is ideal for narrow spaces. The design for this lift includes a maximum load capacity of 250 kg and a maximum lift height of 400 cm. This research encompasses a specific scope to maintain focus and clarity. The lift will be designed to carry a load of approximately 300 kg. The area allocated for the lift system will be around 1 m², making it suitable for compact spaces. Additionally, the lift will have a maximum height of approximately 320 cm, which is ideal for environments with limited vertical space. These limitations ensure that the study remains relevant to practical applications in small to medium-sized industries.The primary objective of this study is to design a material and goods lifting device capable of reaching a height of approximately 400 cm. Additionally, the design will focus on creating a transport device that can be effectively operated in narrow spaces, with a work area of approximately 1 m². The benefits of this design include providing an affordable and efficient solution for lifting goods in confined spaces, which is particularly beneficial for small to medium-sized industries. Moreover, it aims to enhance productivity by offering a quicker and more cost-effective alternative to conventional forklifts, making it a valuable tool for businesses with limited resources or space.

2. METHODOLOGY

The methodology for designing a manual pulley-based goods lift includes the following steps:

1) Observation: Identifying user needs for an efficient transport device suitable for a two-story building with limited space.
2) Literature Study: Referring to lift design standards, safety regulations, and mechanical engineering theories.
3) Technical Design:
   a) Determining technical specifications, such as load capacity (maximum 540 kg) and equipment dimensions.
   b) Selecting materials (hollow steel and UNP steel) based on strength and market availability.
4) Prototype and Testing: Designing and testing a prototype to ensure performance aligns with the technical specifications.
5) Evaluation and Modification: Adjusting the design based on test results to achieve efficiency and safety.

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3. RESULTS AND DISCUSSIONS

3.1 Design Results

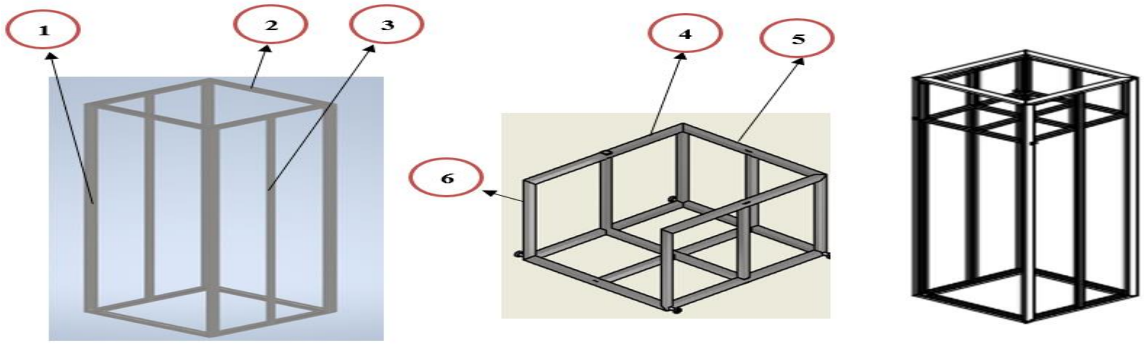

Figure 1. Goods Lift Design

Description of the Figure:

1) Height of the vertical frame: 400 cm
2) Width of the top and bottom vertical frame: 100 cm
3) Height of the hollow steel safety system for the vertical frame: 400 cm
4) Height of the movable frame: 70 cm
5) Length of the movable frame: 100 cm
6) Width of the movable frame: 90 cm

3.1.1 Dimensions to Achieve

Lift work area: 1 m²
Maximum lifting height: ±3.5 m
Maximum load capacity: ±250 kg
Weight of the movable frame: ±30 kg

3.2 Process Map

3.2.1 Fixed Frame

The fixed frame of the goods lift is the main structure that supports all components of the lift, including the cabin, drive mechanism, steel cables, and control system. This frame is typically made of steel or other strong metals designed to withstand heavy loads and ensure stability and safety during lift operation.

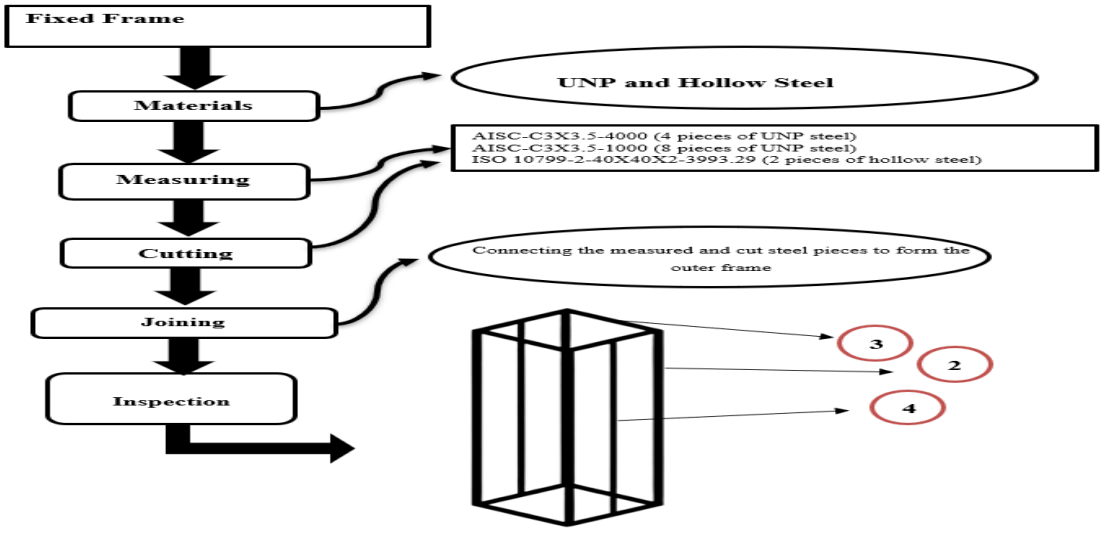

Figure 2. Fixed Frame

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3.2.2 Movable Frame (Drive System)

The movable frame of the freight elevator is a crucial part of the drive system and structure, functioning to lift and lower heavy loads.

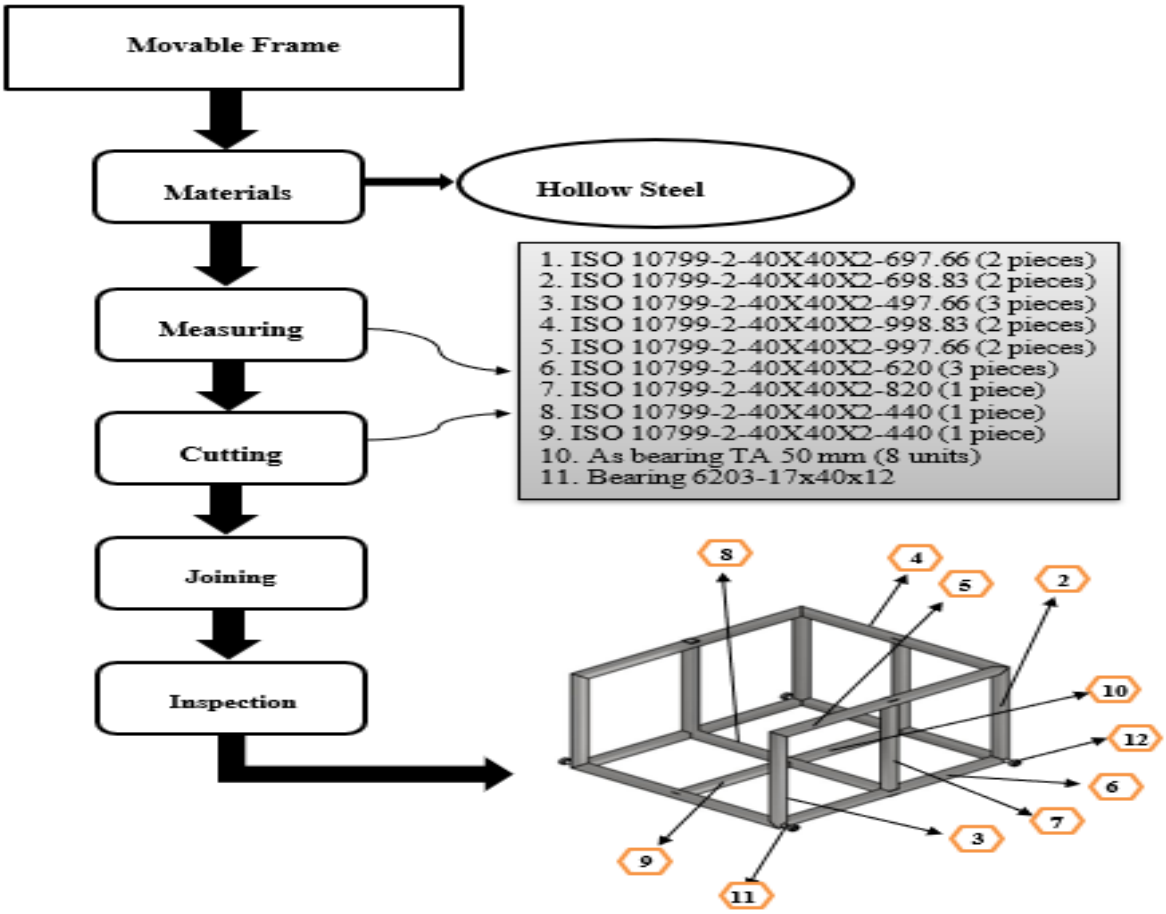

Figure 3. Movable Frame

3.3. Outer Frame Design

The design of the lift's outer frame is a critical component of the system, ensuring a sturdy, secure structure that supports the lift's optimal functionality. The outer frame, often referred to as the shaft or hoist way, provides the space or structure through which the lift moves up and down. Designing the outer frame must consider technical and safety factors to ensure smooth operation and passenger safety.

3.3.1 Key Components of the Outer Frame

1) Frame Structure:
   a) Built from strong materials like steel or reinforced concrete to support the lift's weight and maintain stability.
   b) The outer frame should be designed to withstand vertical and lateral forces caused by lift movement and additional loads like wind (for exterior lifts).

2) Guide Rails:
   a) Installed along the hoistway to ensure the lift cabin moves stably and controlled along the vertical track.
   b) These rails must be precisely installed to prevent the lift cabin from vibrating or shifting during operation.

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3) Counterweight Track:
A track for the counterweight, which moves opposite the lift to help reduce motor workload and improve energy efficiency. The counterweight typically moves on the opposite side of the guide rails.

4) Outer Frame Covering:
The hoist way's exterior can be made from materials like reinforced concrete or glass (for outdoor lifts), considering the building's aesthetics. This covering protects the lift mechanism from external factors and ensures safety around the lift.

3.3.2 Steps for Designing the Outer Frame

1) Material Selection:
   a) Steel: Commonly used due to its strength, lightweight, and ease of installation. Steel structures also provide good flexibility to withstand lateral forces.
   b) Reinforced Concrete: Used for lifts requiring very strong structures, such as in high-rise buildings. Reinforced concrete also offers better fire resistance and environmental durability.

2) Frame Geometry and Dimension Design:
   a) Determine the shaft dimensions based on the size of the lift cabin and the space required for the guide system, cables, and counterweight.
   b) Ensure sufficient space for installing and maintaining the lift's mechanical systems, including the motor, rails, and cables.

3) Guide Rail System:
The design and positioning of the guide rails are essential to ensure smooth cabin movement. The rails must be installed with strict tolerances to prevent vibrations or deviations during the journey.

3.4. Inner Frame Design

The design of the lift's inner frame is a crucial component that serves as the internal structure to support the cabin and its driving mechanism. This frame must be designed considering strength, stability, safety, and user comfort, adhering to applicable technical and safety standards.

3.4.1 Key Components of the Inner Frame

1) Lift Cabin (Lift Car):
   a) The lift cabin is the space where passengers or goods are placed during operation. Its frame must be strong enough to support the weight of passengers and goods while resisting vibrations and shocks.
   b) The cabin is usually made from lightweight steel, aluminum, or other strong and lightweight materials.
   c) The cabin should be ergonomically designed, ensuring user comfort with efficient space layout, handrails, good lighting, and adequate ventilation.

2) Cabin Frame (Car Frame):
   a) The cabin frame supports the lift cabin and connects it to the driving mechanism, such as slings, guide shoes, and rollers.
   b) It must be strong enough to support the entire cabin weight and the load inside, ensuring stable movement within the shaft.
   c) The frame also houses safety devices like emergency brakes and vibration dampers.

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3) Cabin Sling:
   a) The sling connects the lift cabin to the driving mechanism and the pulling cable.
   b) Usually made of steel, the sling must be designed to support the cabin's weight and maintain stability during upward and downward movements.

4) Safety Devices:
   a) Governor System: A safety system preventing the lift from moving too fast, stopping the cabin if it exceeds the safe speed limit.
   b) Buffer: Installed at the base of the hoist way to absorb energy if the lift reaches the lower limit too quickly, functioning as a shock absorber.
   c) Overspeed Governor: A speed sensor monitoring cabin speed and triggering emergency braking if the cabin moves too quickly.

5) Guide Shoes and Rollers:
   a) Installed on the cabin frame, these components ensure the cabin moves stably along the guide rails.
   b) They are designed to minimize friction and reduce vibrations during cabin movement.

6) Cable and Pulley System:
   a) The inner frame must also support the pulling cable and pulley mechanism that moves the lift cabin up and down.
   b) The cables must be designed to resist wear, tension, and dynamic loads.

3.4.2 Steps for Designing the Inner Frame

1) Material Selection:
   a) Steel or aluminum is commonly used for the inner frame due to its strength and lightness, ensuring operational efficiency.
   b) Materials must withstand pressure and strain while being durable in environments with varying humidity or temperatures.

2) Ergonomic Cabin Design:
   a) Cabin design should prioritize passenger comfort and safety, with a layout allowing free movement inside, handrails, ventilation, and sufficient lighting.
   b) Consider anti-vibration and soundproof designs to enhance user experience.

3) Stability and Balance:
   a) Ensure the inner frame is designed to maintain cabin balance during movement, preventing swaying or deviation from the track.
   b) The roller and guide shoe system must be precisely installed to ensure smooth movement along the guide rails.

3.5 DISCUSSION

1) Reliability and Safety:
   a) The wedge-type safety system provides protection against mechanical failures.
   b) T90 guide rails ensure stable vertical movement, minimizing operational failure risks.
2) Design Efficiency:
   a) Leveraging available materials and manual operation, the design minimizes production and operational costs.
   b) The manual system is suitable for small to medium-scale industries as it does not require electricity.
3) Limitations:
   a) Lifting capacity is limited to 540 kg.
   b) The manual system requires human effort, making it less efficient for repetitive lifting.

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4) Development Potential:
   a) Integrating an electric motor system to improve efficiency.
   b) Utilizing composite materials to reduce the overall weight of the equipment.

4. CONCLUSION

1) The manual pulley-based goods lift design successfully addresses the needs of small to medium-scale industries for an economical and efficient transport tool.
2) The design complies with safety standards and specified technical requirements.
3) This project demonstrates that a simple approach can result in a reliable and purpose-fit tool.
4) For future development, exploring the use of electric drive systems and lightweight materials is recommended to enhance operational efficiency.

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