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3 Wheel Stair Climbing Trolley

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Abstract- This project aims at developing a mechanism for easy transportation of heavy loads over stairs. The need for such a system arises from day-to-day requirements in our society. Devices such as hand trucks are used to relieve the stress of lifting while on flat ground; however, these devices usually fail when it comes to carrying the load over short fleet of stairs. In the light of this, the project attempts to design a stair climbing hand cart which can carry heavy objects up the stairs with less effort compared to carrying them manually. It also endeavors to study the commercial viability and importance of such a product. Several designs were conceived that would allow a non-industrial hand truck to travel over stairs, curbs, or uneven terrain while reducing the strain on the user. In our project, the trolley is equipped with Tri-Star wheels which enable us to carry load up and down the stairs. It also eases the movement of trolley in irregular surfaces like holes, bumps, etc.Trolley is generally use for the carrying heavy weights with the help of less human effort. The manufacturing of the trolley deals with proper design, accurate fabrication and prescribed analysis using finite element software gives better motion which resist to high load by applying less effort this paper deals with manufacturing of such stair climbing trolley with simple mechanism ratchet mechanism) initially the model is sketched using solid works and imported into ANSYS software for structural analysis used to find von-mises stresses under load which deals to fabricate trolley with better performance under heavy duty with less.

I. INTRODUCTION

Hand trolleys, commonly referred to as hand trucks or dollies, are indispensable tools for transporting heavy loads efficiently and safely. These devices are extensively used across industries for tasks such as stock handling, merchandise arrangement, and material transport. Hand trolleys not only streamline operations but also minimize the risk of back injuries and health issues caused by manual lifting.The 3-wheel stair-climbing trolley incorporates an innovative wheel configuration that enables smooth movement on stairs. Its design ensures better weight distribution, making it

Ideal for transporting bulky or heavy items safely. This type of trolley is particularly beneficial in environments where manual lifting is impractical or unsafe, reducing the risk of physical injuries and increasing overall productivity.

With enhanced stability and ease of operation, the stair-climbing trolley represents a significant improvement in material handling technology, addressing a critical gap in transportation solutions for vertical and uneven terrains.

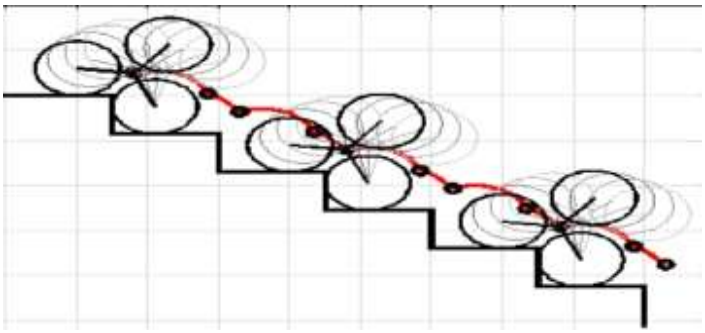

Fig.1.1 Kinamatic Analysis of Wheel Arrangement

Literature Review

The Tri-Star wheel was conceptualized in 1967 by Robert and John Forsyth of the Lockheed Aircraft Corporation. Initially developed as a component of the

Lockheed Tri-Star, an amphibious military vehicle, the wheel's design offers versatility in traversing challenging terrains. Despite the original vehicle's commercial failure, the Tri-Star wheel itself has proven to be a robust solution for uneven surfaces and stairs.

The concept of stair-climbing devices has been under development since the mid-20th century. Early designs focused on **manual stair climbers**, which relied heavily on human strength. Over time, advancements in wheel geometry, gear mechanisms, and materials science have led to more efficient designs, such as the **Tri-Star wheel** introduced in 1967 by Forsyth and Forsyth.

The introduction of the **Tri-Star wheel** marked a significant shift in design philosophy. By incorporating a triangular arrangement of three wheels per assembly, this design allowed for smoother navigation of stairs and obstacles without manual lifting. Such innovations laid the foundation for modern stair-climbing trolleys.

Traditional hand trolleys, while effective on flat surfaces, are inefficient and hazardous on stairs. Studies (e.g., Smith et al., 2014) highlight the limitations of conventional designs, including:

- High physical strain on users.
- Increased risk of injury due to awkward lifting postures.
- Potential damage to cargo from uneven movement

New Concept

The design of a stair-climbing hand truck addresses the limitations of conventional hand trucks, which perform efficiently on flat surfaces but are less effective on irregular terrains such as stairs. Package delivery personnel, for instance, often encounter difficulties when transporting heavy objects over short flights of stairs, as conventional hand trucks require the operator to manually lift both the device and its load. This effort negates the purpose of the hand truck, which is to minimize physical strain and eliminate the need for heavy lifting.

To overcome these challenges, the stair-climbing trolley integrates a **Tri-Star wheel design** to facilitate seamless movement over stairs. Unlike traditional four-wheeled trolleys, this innovative design incorporates three wheels arranged in a triangular configuration.

This novel approach enhances the safety, efficiency, and usability of the hand trolley, making it an invaluable tool for navigating irregular surfaces and transporting loads over stairs. By reducing the physical demands on the operator and minimizing the potential for damage to the transported items, the stair-climbing trolley represents a significant advancement in material-handling equipment design.

Methodology

3.1. Design Overview:-The trolley integrates a Tri-Star wheel arrangement on each side of the axle. This configuration ensures continuous contact with the ground during climbing or descending stairs, thereby reducing the effort required

.**Material Selection**

- **Trolley Body:** Mild steel (density: 7850 kg/m³, Young's modulus: 210 GPa) was selected for its cost-effectiveness and mechanical properties.
- **Wheel Web:** Stainless steel grade 304 was chosen for its corrosion resistance and durability.

Wheels: Filled rubber was used due to its high coefficient of friction (0.85 on concrete) and impact resistance.Bearing Specification

The SKF 6006-2RS deep groove ball bearing (30x55x13 mm) was employed for its ability to handle high rotational speeds and combined radial-axial loads. It features pre-lubrication and rubber seals for maintenance-free operation.

3.4. Wheel Frame Design

A curved frame was developed to ensure optimal power transmission and stair-climbing efficiency. The design provides higher stability and allows for easier maintenance.

PerformanceAnalysis:-The Tri-Star wheel mechanism demonstrated excellent stair-climbing capabilities and smooth navigation over bumps and

holes. The filled rubber wheels provided optimal friction, ensuring stability during operation.

Discussion

After fabricating the Tri-Star wheel trolley, several limitations were observed during the testing phase. One major issue was the significant noise generated while moving the trolley up and down stairs. To mitigate this, a modification in the wheel frame design was proposed. This revised design ensures that the line passing through the midpoint of the trolley wheel aligns with the center of the stair tread. This adjustment is expected to improve the noise reduction and enhance the overall stability of the trolley during operation.After its fabrication, we inferred few limitations like large noise production while moving the troll up and down the stairs.In order to reduce the noise production design of the wheel frame to be modified such that line passing through the mid point of the trolley wheel should pass through the Trolley.

Fig.3.1 Model of Trolley

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Future Scope

9.1 Robotics Integration and Autonomous Navigation

Scope:
Future iterations of the 3-wheel stair-climbing trolley could leverage artificial intelligence (AI) and machine learning to enable fully autonomous navigation. Incorporating advanced sensors, cameras, and LIDAR (Light Detection and Ranging) technology would allow the trolley to detect and adapt to obstacles, stairs, and terrvarying

Fig. Arrangement of wheels

Conclusion

This project, despite its limitations regarding the structural strength and initial design flaws, marks a significant step toward the development of stair-climbing vehicles. The testing phase demonstrated the feasibility of using this design for transporting heavy loads up and down stairs. With commercialization, this product could address several challenges in material handling across various industries.

Although the initial cost of production was relatively high, refinements in manufacturing processes could reduce this cost, making the product more viable for large-scale use. The absence of competitors in the market for similar products offers a substantial opportunity for innovation and market penetration.

Further enhancements, such as automation and cost optimization, could lead to widespread acceptance and revolutionize material handling solutions.

The Following material is required for the fabrication of stairs climbing trolley.

Sr.No	Component	Material Used	Quantity
1	Shaft	Mild Steel	1
2	Bearing	Mild Steel	2
3	Circular Pipe	Mild Steel	1
4	Nut and Bolt	Cast Iron	6/6
5	Rubber Wheel	Thermosetting Plastic	6
6	Bushes	Steel	6
7	Sheet Metal Plate	Aluminium	6

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