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Design and Development of Staircase 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 trolleys 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 flight of stairs. In 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 trolley 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.

KEYWORDS: trolley. Stair climbing mechanism, three star wheel, easy transportation

I. INTRODUCTION

Hand Trolley

A hand trolley is a small transport device used to move heavy loads from one place to another. It is a very common tool used by a large number of industries that transport physical products. Also called a hand truck or a dolly, the hand trolley is often used by stock persons who arrange and restock merchandise in retail stores. When used properly, trolleys can protect people from back injuries and other health problems that can result from lifting heavy loads.

Relevance

A typical hand trolley consists of two small wheels located beneath a load-bearing platform, the hand trolley usually has two handles on its support frame. These handles are used to push, pull and maneuver the device. The handles may extend from the top rear of the frame, or one handle may curve from the back. An empty hand trolley usually stands upright in an L-shape, and products are usually stacked on top of the platform. When the goods are in place, it is tilted backward so that the load is balanced between the platform and the support frame. Especially if heavy or fragile materials are moved, the person operating the trolley should return it to an upright position carefully, to insure nothing falls off the platform. The front of the frame may be squared off for boxes or curved for drums and barrels. Sometimes, a handtruck also has straps for securing loose freight during transport.

Professional material handlers prefer to use a hand truck when moving stackable items such as boxes, crates or packages. Heavier items are usually stacked on the bottom of the hand truck, with lighter objects saved for the top. Hand truck users must be careful not to stack it so high that their vision is blocked or the load becomes unstable. Generally, it is safe to load a hand truck to the level of its handles or the top of the frame. The load is then shifted onto the wheels with a backwards lifting motion. The user can maneuver the cargo by steering it left, right or forward.

II. LITERATURE REVIEW

RohitSalunkhe [1] this article point is fostering a component for the simple transportation of weighty burdens over a lopsided landscape. The requirement for such a framework emerges from everyday necessities in our general public. Gadgets, for example, hand streetcars are utilized to ease the pressure of lifting while on a level ground; notwithstanding, these gadgets normally bomb with regards to conveying the heap over a short tallness. A few plans were considered that would permit a non-modern hand streetcar to go over steps, controls, or lopsided territory while lessening the strain on the client. In our task, the streetcar is comprising the tri-wheel or tri-wheeled



instrument that facilitates the development of the streetcar in unpredictable surfaces like openings, knocks, and so forth.

Kyle A. Johnson et al [2] additionally Portrayed Tumbling Mode, When more shaky obstructions (steps, flotsam and jetsam, free landscape, and so on) are experienced, Tumbling Mode gives a fueled means to keep a robot moving. In Tumbling Mode, a slowing down component is locked in to follow up on the equipping framework with the end goal that it powers the three wheels to pivot around the middle hub of the Tri-Wheel gathering and walk like a Whigs robot over deterrents. This tri-talked revolution purposefully happens in a similar bearing as individual wheel turn, assisting with pulling along the robot. The system instigating Tumbling Mode could be locked in inactively, through administrator order, or independently utilizing input from sensors showing a slow downstate, possible slippage, or a specific separation from the snag to be survived. The slowing down component on this vehicle is a little cam-worked drum brake, which is activated through administrator order. Tri-Wheel in Tumbling Mode rising steps. Due to its double capacity to roll and climb, the Tri-Wheel pivots about its focal hub to move toward a stage and afterward moves along the progression surface until it arrives at an ideal situation to flip over itself indeed and proceed with the climbing system.

Mohammad A. Hosain et al. [3], expressed that in the underlying plan, each wheel contained an edge, a sun wheel, and three planetary wheels. The planetary wheel was associated with the sun wheel through an idler. The reason for utilizing the idler was to turn the planetary wheels in a similar bearing as the sun wheel. Each planetary wheel was adjusted in an orderly fashion with the idler and sun wheel. The straight wheel outline takes more push to shift the wheel edge to draw in the following planetary wheel. The length of each arm is high and hence makes vibration and the vehicle would be shaky. In the current plan, the wheel outline was made bend so the front surface of the arm couldn't crash into the edge of the step.

PrajanPradipGandole et al. [4] have presumed that the step climbing hand truck is intended to lessen risk instead of expanding it. Traditional hand trucks function admirably on level ground, yet their convenience diminishes when it becomes important to move an article over an unpredictable surface. Bundle deliverymen, for instance, regularly track down it important to drag stacked hand trucks up short stairwells just to arrive at the front entryway of a structure. The whole motivation behind utilizing an ordinary hand truck is to try not to need to lift and haul weighty items around.

Ravi Mishra [5] Adjusted In the main plan, the power transmission to the single or twofold wheel streetcar is futile to climb the steps because of the tallness component of steps making tremendous hindrances on the method of the vehicle. Additionally, the plan of the straight wheel outline turned out to be more confounded and was should have been altered with its bend round shape to give appropriate drive, which makes more frictional power. Consequently, three wheel sets on each side of the vehicle appended with the edge were acquainted with giving smooth power transmission to climb steps without obstructions. Outline course of action is appropriate to send precise speed proportion moreover. It furnished higher effectiveness and minimized format with solid help.

III. METHODOLOGY

3.1 Problem Statement

There is variety of trolleys available in market for carrying material and transport it from one place to another. However, most of these are relevant to the plane surfaces. In order to transportation through stair case, very limited sources are available.

3.2 Objectives

Fabrication of Tri Star Wheel Mechanism.

Fabrication of Stair Climbing Trolley for transportation purposes.

Fabrication of trolley based on above analysis with accurate measurements to withstand maximum load.

3.3 Methodology

Methodology deals with the process followed to perform the study. In context of this project, following steps are followed,

Problem Identification

Objectives

Design of System

Validation of System
Implementation
Performance analysis.

IV. EXPERIMENTAL SETUP

New Concept:

The stair-climbing hand truck is designed to reduce liability rather than increase it. Conventional hand trucks work well on flat ground, but their usefulness decreases when it becomes necessary to move an object over an irregular surface. Package delivery men, for example, often find it necessary to drag loaded hand trucks up short flights of stairs just to reach the front door of a building. The entire purpose of using a conventional hand truck is to avoid having to lift and carry heavy objects around.

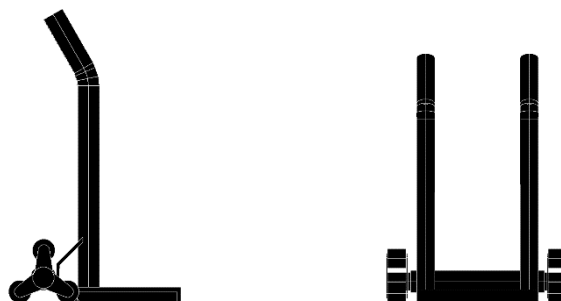
Lifting a hand truck up the stairs defeats the purpose of the device, since the user must provide enough upward force to lift the entire weight of the cart and its contents. Furthermore, the geometry of a hand truck makes it nearly impossible to lift with one's legs, as is the proper form. Considerable strain is placed on the back muscles and the risk of operator injury is sharply increased. The pulling up of a standard hand truck up the stairs results in a bumpy and jarring motion. This motion may damage the items loaded on the hand truck or cause them to fall off entirely. A hand truck that could climb stairs without requiring the user to lift would improve the safety of moving heavy objects over irregular surfaces.

4.2 Tri-Star Wheel Design:

Figure 1: Tri Star Wheel Mechanism

The Tri-Star wheel was designed in 1967 by Robert and John Forsyth of the Lockheed Aircraft Corporation. They were first developed as a module of the Lockheed Terra star, a commercially unsuccessful amphibious military vehicle. A Tri-Star wheel functions as an ordinary wheel on flat ground, but has the ability to climb automatically when an impediment to rolling is encountered. This wheel design consists of three tires, each mounted to a separate shaft. These shafts are located at the vertices of an equilateral triangle. The three shafts are geared to a fourth, central shaft (to which a motor may be attached). When geared in this quasi-planetary fashion, these triangular sets of wheels can negotiate many types of terrain, including sand and mud; they can also allow a vehicle to climb over small obstructions such as rocks, holes, and stairs. The wheel assembly may be gear-driven, with two wheels in rolling contact with the ground. The third wheel idles at the top until the lower front wheel hits an obstruction. The obstruction prevents the lower front wheel from moving forward but does not affect the motion of the driving axle. This causes the top wheel to roll forward into position as the new front wheel. This wheel usually lands on top of the obstruction and allows the rest of the assembly to vault over the obstruction.

CAD Design of Model:



Design Procedure:

Load Calculations:

Length of the axle = 0.44m Distance between welds = 0.40m

Load applied/ carried = 30 kg (distributed equally by the welds to the axle)

= 15 kg through each weld = 147.15N

Weight of the trolley = 20kg (uniformly distributed throughout the axle)

=196.2 N

Neglect the overhang beyond welded points since the wheel provides only negligible reaction

From equilibrium equation $\Sigma F = 0$

And $\Sigma M = 0$

Find reaction at the supports, $R_1 = 190.314\text{N}$; $R_2 = 190.314\text{N}$

Calculate the maximum bending moment for the beam, $M(\text{max}) = 6.7155\text{ N-m}$

Considering FOS = 1.5, $M(\text{max}) = 10.07\text{ N-m}$

Bending equation,

$$M/I = \sigma/y = E/R$$

Substituting $M(\text{max}) = 10.07\text{ N-m}$

$$I = \pi r^4/4$$

$$Y = D/2$$

$$\sigma = 3.8\text{ N/mm}^2$$

Bending stress for the given material can be assumed to be 0.66×yield strength Thus, the allowable bending stress for the given material is 165 N/mm^2

The calculated bending stress for the material is within the allowable bending stress for the material, Thus the design is safe.

V. CONCLUSION

Though this project had some limitations regarding the strength and built of the structure, it can be considered to be a small step forward, as far as Stair Climbing Vehicles are concerned. During the test run of this project, it was realized that it wouldn't be a bad idea to consider this design for carrying heavy loads up the stairs. This product will be well acclaimed if it can be commercialized to suit the needs. Though the initial cost of the project seemed to be higher but more accurate manufacturing would shorten this.

As far as the commercial aspects of this product are concerned, if this product can be fully automated and produced at a lower cost the acceptance will be unimaginable. Presently, there are no competitors for such a kind of product in our market.

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