PNEUMATIC STAIR CLIMBING TROLLEY

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ABSTRACT

Every year, both at home and in the workplace, thousands of adults injure themselves while attempting to move heavy objects. Devices such as hand trucks are used to relieve the stress of lifting while on flat ground; however, these devices usually fail when it becomes necessary to negotiate a street curb or a short flight of stairs. The objective of this thesis was to design and test a consumer-grade hand truck capable of climbing stairs. Several designs were conceived that would allow a non-industrial hand truck to travel over stairs, curbs, or uneven terrain while putting minimal strain on the user. One strategy, referred to as the Blanco Stair-Climbing Wheel with pneumatic piston support for supporting the heavy loads, was selected for development; several solid models were created and a prototype was constructed. The finished prototype was tested with a payload of approximately 300 lbs, and it was determined that the hand truck design using the Blanco strategy is a viable option for a stair-climbing consumer product

Keyword: - *Flight of stairs, Wheel frame, Blanco strategy, Stair-Climbing, Step length.*

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1. INTRODUCTION

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 dolly, the hand trolley is often used by stock persons who arrange and restock Merchandise in retail stores and company. When used properly, trolleys can protect people from back injuries and other health problems that can result from lifting heavy loads. Stair climbing trolley is designed to lift the high weight with less human effort. Stair climbing trolley is designed to movement on uneven surfaces. In pedal powered stair climbing trolley is used to pedal the trolley in normal surfaces in order to push the trolley.

Lifting heavy loads like cabinet, fridge, washing machine. Up to 150 kg isn't clean job, especially where there are no lifting facilities (elevator). Furthermore, in maximum of the Homes inside the rural areas does now not have elevators or escalators? In this example human labours are considered to be the only solution. Labour is becoming highly-priced each day, wherein increase rate is decreasing. This problem may be solved if a trolley can raise hundreds whilst traveling through stairs. The task introduces a new hybrid for the transportation of the masses over the stair in vertical function and cargo on identical floor horizontally. Maximum of the homes of the agricultural areas are structurally congested and unavailability of elevator facility so it's miles difficult and onerous to rise up heavy loads from ground to floor. The stair mountaineering trolley can play vital position in those areas to raise loads over a stairs, like colleges, hospitals, and in family motive.

1.1 PROBLEM STATEMENT

The trolley consists of square frame or bar of cabin. But, analysis is to be carried when maximum load of weight applied on trolley. Fabrication must be consist of simple mechanism i.e. ratchet to climb each staring of steps with height 200mm and also perform structural analysis to find out stress and displacement on all components of trolley.

1.2 OBJECTIVES

1) To reduce the person energy and efforts for heavy home load shifting through stairs.
2) To make contributions this work to society.
3) To be used for stair mountain climbing in addition to hand trolley at the uneven ground.
4) To be intuitive and ergonomic to use.
5) To be able to provide most or all of the upward force necessary to ascend a flight of stairs.
6) To decrease the weight of model as compare to other conventional models.

2. LITERATURE REVIEW

For reducing human comfort for carrying the load on steep ways or stairs, for achieving this objective scope can be observed by following review of research papers.

1. Author- Gaurav Lodaya,1 Nagsen Ingle2,Akash Todkar3 [2020] Force analysis of Geneva wheel and face cam used in automat, the literature showed different stresses acting on the Geneva wheel. The stress analysis of the Geneva wheel was done using FEA (Finite Element Analysis). The use of FEA showed a complete view of the stress distribution around the Geneva wheel and Face Cam. The result showed that the deflection was small for the force acting on maximum and minimum position of Geneva wheel. The variation of displacement with the stresses acting on the Geneva for the maximum and minimum condition of the wheel and also face cam increased non-linearly.

2.Author- Pratik R. Baviskar, Aniket V. Naik, Ganesh B. Payghan[2017] Design of stair climbing hand truck, this project was also based on the three wheel system but since, the equipment was automated it was much more efficient. The equipment had the limitation of brakes. If the stair size change then controlling the equipment would be difficult.

3. DESIGN OBJECTIVES

The functional requirements set forth for this stair-climbing hand truck are:

1) The device should be able to provide most or all of the upward force necessary to ascend a flight of stairs.
2) The device should be able to bear up to (mention your load)
3) The cost of the device should be comparable to that of a conventional consumer grade hand truck.
4) The product should be ergonomic and intuitive to use.
5) The weight of the product should be comparable to that of conventional models.
6) The appearance of the product should be similar to that of conventional models.

A hand truck with the ability to climb stairs would decrease the possibility of injury from having to lift a wheeled cart or its contents over an obstruction. If successful, this device should provide increased safety both in the home and in the workplace. Also, it is hoped that a simple stair-climbing device such as this one might increase public acceptance of other, more complex stair-climbing devices such as wheelchair

3.1 ANALYSIS OF BASIC STAIR ASCENSION

Before delving into the theory behind complex stair-climbing mechanisms, it should first be noted that it is possible to climb stairs using an ordinary wheel. As shown in Figure 3.1, a properly applied force F will allow a wheel to drive over a stair. In Figure 3.1, FM is the force of gravity acting on the machine, Fs is the horizontal force exerted on the wheel by the stair, N is the normal force, and d and h are the diameter of the wheel and height of the stair, respectively. Balancing the forces shown in Figure 3.1 yields

EM = 0 d _ (3.1) F (- h) - FM dh- h = 0

$$\Sigma M = 0$$

$$F(\frac{d}{2} - h) - F_M\sqrt{dh - h^2} = 0$$

By simplifying the force and moment balance equations (3.1) an expression for the force necessary to drive a wheel over a stair can be determined. This force is given by

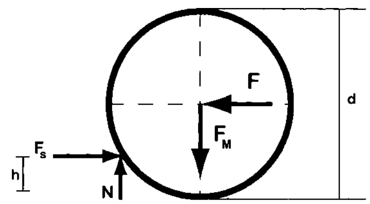

Fig -3.1 Force diagram of a wheel driving over a stair

$$F = F_M \frac{\sqrt{dh - h^2}}{\frac{d}{2} - h}$$

3.2 THE TRI-STAR WHEEL DESIGN

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 Tri-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. As shown in Figure 3-2a, the three shafts are geared to a fourth, central shaft to which a motor is attached.

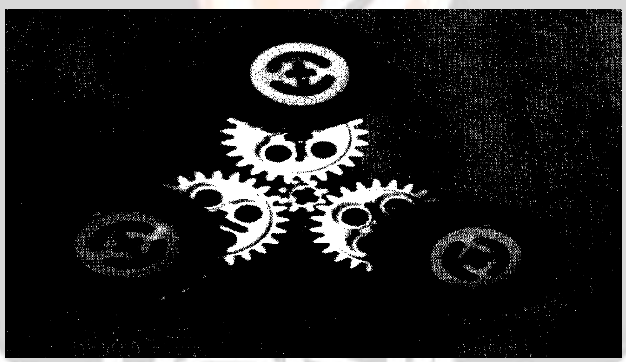

Fig -3.2a Tri-Star wheel sketch model

The tri-star wheel design allows relatively smooth ascension of stairs. The assembly functions in a similar fashion to a large wheel (as in Section 3.2b) with several chunks missing. The compliance of the tri-star is greater than that of an irregular wheel, however, because of the gearing of the tri-star. In most cases, the gearing allows the mechanism to interact only with the horizontal and vertical stair surfaces, avoiding the points and wrapping around each stair. Unfortunately, this gearing system is relatively complex and expensive for its size. Its weight and cost make the full tri-star system overkill for a simple consumer-grade product; however, tri-star wheels might still be a realistic option if lighter, simpler wheels were to be designed.

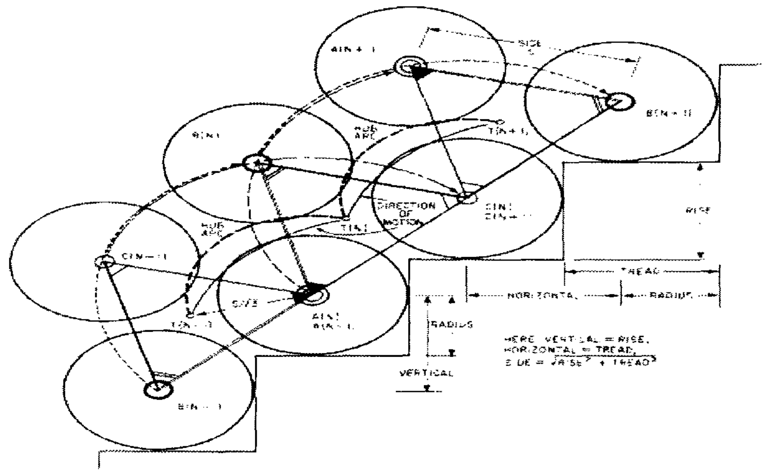

Fig -3.2b Stair climbing Motion of a try star wheel assembly

4. CONSTRUCTION

4.1 COMPONENTS

1. Tri star
2. Shaft
3. Frame
4. Wheel frame
5. wheel Hub
6. Bearing
7. Cycle wheel

6. CALCULATIONS

Tri-Star Wheel Design Deriving the Tri-Star wheel parameters depends on the position of Tri-Star wheel on stairs. It depends on two parameters, the distance between the edge of wheel on lower stair and the face of the next stair(L1), and the distance between the edge of wheel on topper stair and the face of next stair (L2), as shown in Fig.

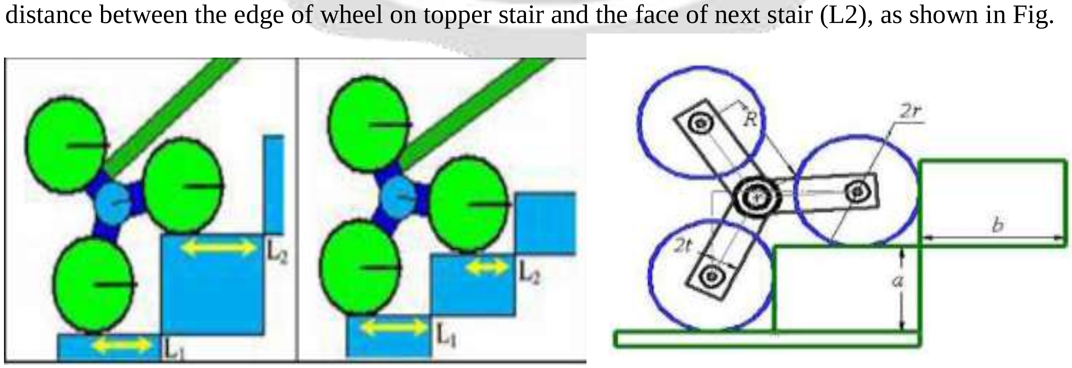

Fig -6.1 Stair climbing Motion of a try star wheel assembly

By comparing these parameters, three states may occur as follow:1. L1 < L22. L1 >L23. L1 = L2
Fig 6.1
Based on these states, the third states (L1 = L2) will be used as the reference of project to design the Tri-Star wheel. In this case, the L1 and L2 don’t change and remain constant while climbing stairs.
Therefore the case (1) and case (2) are not suitable since the robot will encounter the problems while climbing stairs, but the case (3) is suitable for climbing robot smoothly It should be noted that the value of L1 and L2 for derivation of the parameters maybe any values but equal. L1 and L2 are assumed equal to the radius of angular wheel (L1=L2=r)In the design of Tri-Star wheel, six parameters are important which are:

1) heights of the stairs (a),
2) width of stairs (b),
3) radius of regular wheel (r),
4) radius of Tri-Star wheel,
5) the distance between the centre of Tri-Star wheel and the centre of its wheel (R)
6) and the thickness of holders that fix the wheel on its place on Tri-Star wheel (2t), as shown in Figure (b)

According to the project requirements, the value of (a)and (b)are determined as
s a= 15 cm,
b = 29 cm,
r = 3.5cm
R=√a2+b23=√152+2923= 18.85cm
The minimum value radius of regular wheel (rmin) to prevent collision of the holders the stair is derived as
rmin=6Rt+a(3b+√3a)(3−√3)a+(3+√3)b=
6∗18.484+15(3∗29+√3∗15)(3−√3)15+(3+√3)29= 8.43 cm
The maximum value radius of the regular wheels (rmax) to prevent the collision of the wheels together is
rmax= √a2+b22= √152+2922= 23.08cm
The maximum value of the thickness of holders to avoid collision between the holders and stairs is derived by
t1max= ar(3−√3)+br(3+√3)+a(√3a−√3b)6
R= 15∗4(3−√3)+29∗4(3+√3)+15(√3∗15−√3∗29)6∗18.85= 5.17cm
For, knowing the amount of r and R, we can derive the maximum height of stairs that the robot can pass through it
a1max= √a2+b2−r2= √152+292−42= 32.4037cm
For traversing the stairs with the maximum height, the half thickness of the holder must be in the following range.
.t2max= r(r+√3(a2+b2−r2))2√a2+b2= 4(4+√3(152+292−42))2√15+292= 3.68cm

7. RESULTS & ANALYSIS

The vehicle was moving well over the stair. It can move on flat surface uniformly at 20 rpm without any fluctuation and there was no variation of speed over steps. It was observed that there was very low noise and vibration over flat surface or stair. It was observed that the vehicle was disturbed when it faced the stair of different step sizes. This was because of the shape and size of the wheel frame.
Therefore for a range of stairs size can be considered for this vehicle. Although, different sizes step are not usually available in building design. It showed good performance when the step size was uniform. Here in this project separate frame can be used to move over the stair of different size and shape, which made its use over wide range of size of stairs. From the test run of the vehicle it was seen that the maximum height the vehicle could climb the stair whose inclined angle was 44° maximum.
If the inclination is more than 44° it would fail to climb the stair. In building construction, very few stairs are generally available having inclination more than that i.e.44°. The smooth ramp angle (θs) was not listed for the vehicle. But it can be easily predicted that stair inclined angle (θ) is less than that of ramp (θs).
This is shown in fig.

Fig -7.1 maximum Climbing angle θ, θs

The velocity of the vehicle during climbing the stair was higher than that on the flat surface as the wheel frame (higher radius) was used to climb stair. However; the speed of the vehicle running on ramp was not measured. This speed should not be higher or equal to the speed on the horizontal surface. From the above discussion, it could be summarized that considering some of the limitations, the vehicle was an effective alternative to transport loads using stairs. Some limitations could not be avoided because of the lacking in technological availability. This pioneer project, with a little further improvement, was hoped to be succeed to meet up the demand of carrying loads over the stair.

7. CONCLUSION

The design of the trolley is compact and hence is able to move about in almost all the stairs that we find at institutions, offices, industries and also at some homes. The design is made very safe and there is no chance of failure of the frame and wheels under normal condition. According to the tests conducted, the stair climbing trolley has a capacity of carrying a load of 100kgs on flat surface. It has the ability to ascend a flight of stairs of 45-degree elevation carrying a weight of approximately 40kgs.The main benefit of the project is stair climbing mechanism for load carrier with decreasing effort. Doing better work with lesser effort has been the main objectives of human beings in any field. This project as platform we present motorized stair case climbing trolley with reducing effort.

The future enhancement of our project is we have to rectify the problems that we have encountered during descending of the trolley in stairs. We had a smooth travel while ascending but while coming down from the steps, we found some vibration problem and to overcome this we have planned to install springs and braking system, so that trolley will be in a good control while descending also.

REFERENCES

1. C. A. McLaurin and P. Axelson," Wheelchair standards: an overview. Journal of Rehabilitation Research and Development (Clinical Supplement)" , 27(2):100-103, 1990.
2. T. K. K. Koo, A. F. T. Mak and Y. L. Lee, "Evaluation of an active seating system for pressure relief. Assistive Technology", 7(2): 119-128, 1995.
3. People Weekly and Tom Houston , "Real stand-up guy- vertical wheel chair", 32: 91-2, August 28, 1989.
4. IMEX Riser Wheelchair, Product Literature, Imex Medical Inc., San Jose, CA. Stand-up Wheelchairs. Product Literature, Levo Inc. Switzerland.
5. H. F. M. Van der Loos , S. J. Michalowski and L. J. Leifer, "Development of an omni-directional mobile vocational assistant robot" , In Proceedings of the 3rd International Conference of the Association of Advanced Rehabilitation Technology, Montreal, P. Q., Canada, June 1988.
6. R. Walli, " Transrovr --Omnidirectional wheelchair", DOE News Brief, October 10, 1996.