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Design and Development of Staircase Climbing Trolley in Multistory Building

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ABSTRACT:

It can be difficult to raise items and loads to storing above the ground, such as food grains, books and other items, or even to carry the patients from ground to the upper level when there are no lifting facilities available (conveyer, elevator, etc) If a vehicle is capable of lifting cargo while passing through steps, then this issue can be resolved. The staircase climbing truck can be very useful in places where lifting objects over a low height is required, such as hospitals, libraries, and construction sites. Stair climbing hand truck or similar is the name for the vehicle that can run on extremely uneven and rocky type surfaces or moves up or down on steps.

***Key Words-Stair climbing, hand truck, libraries, hospital, patients*.**

1. INTRODUCTION

Because of its design, this trolley may be used both on level surfaces and to ascend staircases. This trolley features tristar wheels, also known as spider wheels, which are linked to the tristar at a 120-degree angle. We can simply transmit the load from one location to another when draw force is supplied to the trolley at that moment due to wheel rotation.

Six wheels on the trolley allow for easier stair climbing with least effort from the user. For simple weight lifting, this has suspension attached to the wheel.

In places like hospitals, libraries, and construction sites where items must be lifted over short heights, stair climbing trolleys can be quite helpful. This trolley's primary purpose is to transport loads up stairs and onto table platforms. The labourer can effortlessly manoeuvre the cart on the staircase due to its suspension-equipped wheels, and it is also easy for him to handle heavy loads on the table platform. We are able to move the material in this cart both up or down stairs and on horizontal surfaces.

2. LITERATURE SURVEY

2.1 Smart Trolley in Mega Mall

Every time a consumer uses a trolley to gather products from rack to rack, he or she must calculate cost of those items and compare it to their personal budget. Following this process, the customer must wait in queue to be billed. Therefore, a new concept known as the "smart trolley in mega mall" was invented in order to minimise headaches like pushing a trolley, standing in queue for billing and worrying about money. In the present period, a microcontroller-based, fully automated trolley has been built for mall automation.

While the customer is making purchases, it follows them and keeps a safe distance from them. The product wrapper's barcode side only needs to be held in front of the barcode scanner by the customer. The relevant product data will then be shown on the display. With this trolley, customers can purchase a lot of goods quickly and with little effort. A computer can be readily interfaced at the billing counter for verification purposes, and a bill printout must be pulled.

Fig 1: Stair Climber Physically Challenged

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2.2 Automatic Stair Climber Using Chain Mechanism

A two-wheel stair climber is also utilised in this instance, but the stairs are ascended via a chain mechanism. Two tiny lifting forks are used on each side of the chain, for a total of four. To evenly distribute the weight of the part among the lifting forks, their position should be adjusted so that two of them reach the next step simultaneously. The climber would be able to move smoothly because these lifting forks would be passing through the chains.

The motor-gear mechanism will be in charge of the movement. Other lightweight motels could be used to lessen the weight of the tyres and other MS steel components. The climber would have been much more stable if the machining quality had been significantly higher. Ultimately, more features could be added to improve the comfort and smoothness of the climbing motion, such as automatic movement controllers and brakes.

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2.4 Fabrication of an Staircase Climbing Wheels Mechanism an Alternate for the lifting of goods

Information regarding the development of an mechanism for the simple transport of an heavy loads over the stairs is provided in this literature. These kinds of systems are becoming more and more necessary in our society on a daily basis. With the help of this vehicle, labour costs can be decreased and a significant amount of weight can be transferred evenly while using less energy, introducing a new option for load transportation over stairs in our project. It is modified with wheel structure will allows it to climb a stepped path thanks to its design.

2.5 Design and Development of six wheels Staircase trolley

This article in the literature focuses on the creation and construction of a tram that can traverse extremely uneven terrain and climb stairs. The speed and stability of the tram when climbing stairs are the technical design flaws in this device. But this study's other major concern is how steep the stairs are. The frequent lifting of items like books for libraries, medications for hospitals, mail for all institutions, or hazardous material transportation for industries are some uses for this special trolley. It also allows patients who are paralysed or retarded to move freely anywhere on a flat surface and up stairs. When a large number of loads are transported evenly and with a less power consumption, this vehicle can save labour costs.

3. Construction and working principle

Because of the way we designed it, this tram can be used both on level surfaces and to climb stairs. This trolley features tristar wheels, also known as spider wheels, which are attached to the tristar at a 120-degree angle. We can easily transmit the load from one point to another when pull force is applied to the trolley at that moment due to wheel rotation.

Lockheed Aircraft Corporation designers Robert and John Forsyth created the Tri-Star wheel in 1967. Originally, they were designed as a part of the Lockheed Terrastar, a military amphibious vehicle that was a commercial failure. On level terrain, a Tri-Star wheel operates like any other, but when it encounters an obstacle, it can automatically ascend.

There are three tyres on each of the three shafts in this wheel design. The vertices of an equilateral triangle are where these shafts are situated. A fourth, central shaft, to which a motor may be attached, is the destination of the three shafts' gearing. These triangle sets of wheels, when geared in this quasi-planetary manner, can manoeuvre over a variety of surfaces, including mud and sand, and they can also help a vehicle ascend over small obstacles like stairs, holes, and rocks.

Two of the wheels on the wheel assembly may roll in contact with the ground when it is gear-driven. Up until the lower front wheel runs into something, the third wheel idles at the top. The driving axle is unaffected by the obstruction, but it does stop the lower front wheel from an moving forward. As a result, the top wheel rolls forward to take the place of the front wheel. Usually, this wheel lands on the top of obstacle, allowing the assembly to continue vaulting over it. The moving Tri-Star wheel is depicted in figure

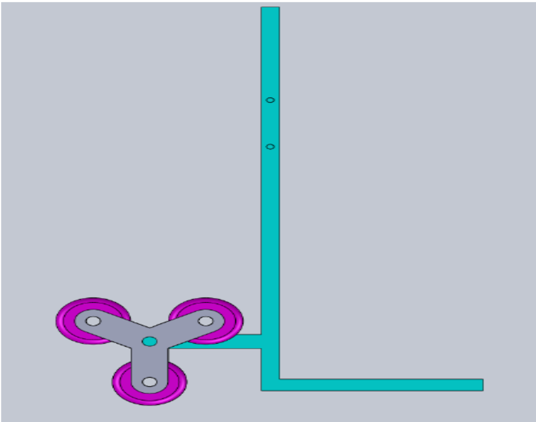


Fig - System of stair climbing mechanism.

4. DESIGN CALCULATIONS

4.1 Design of drive shaft

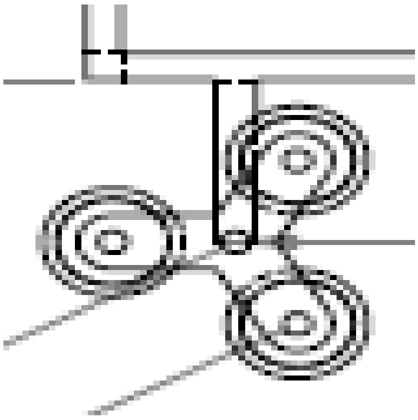


Fig- Wheel drive arrangement

The load in question is 150N/15 kg.

Hence, Maximum Torque T = Effort x Wheel Radius

100 mm is the wheel's diameter.

T= 150 x 50 = 7500N mm, where P is the load and T is the maximum torque produced by the sprocket wheel.

= 3000 N/mm

Reactions of support (RA).

Speed of motor N = 30 rpm

Shaft material is chosen in accordance with Design Data Book. Molybdenum steel C40

C40, yield = 435 N/mm^2, Sut = 580 N/mm^2, and σ = 145 N/mm^2

according to ASME code

Whichever is smaller, 0.3 X yield strength N/ mm^{2}or 0.18 X ultimate strength N/ mm^2.

99 N/ mm^2= 0.3 x 330 ——(a)

104 N/ mm^2= 0.18 x 580 ---(b)

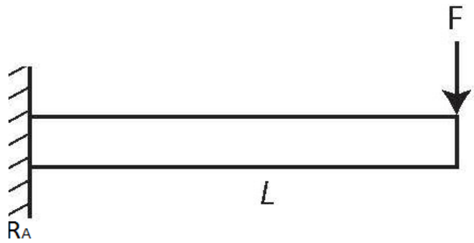
The allowed stress value is determined by equations (a) and (b). It is 99 N/ mm^2.

If the shaft is equipped with key ways, then τ = 99 x 0.75 = 74.25 N/ mm^2.

The formula for the maximum torsional moment is

where T is equivalent to 7500 N-mm.

Using the equation above, drive shaft dia (d) = 8.02 mm can be found.



We know that,

Max bending moment equation is given by

we know,

$$M = \frac{\pi}{32} d^3 \sigma$$

P = 150 N

$$\sum F_Y = 0$$

Based on the load and farm conditions, the total load on wheel is evaluated as RA = 100.Me

The distance that we have taken into account is 50 mm for component fitment L.

Bending moment calculation at loading point P, BM at M = 100 x 50 = 5000 N-mm we know,

$$M = \frac{\pi}{32} d^3 \sigma$$

σ = 145 N/ mm^2 with a F.O.S. of 4.

By applying the aforementioned formula, drive shaft dia (d) = 5.25 mm.

We chose the shaft diameter of 8 mm based on equations A and B, taking extra jerk into account and ensuring a safe design.

According to maximum shear stress theory

Equivalent Torque :-

$$T_e = \sqrt{(K_b M_A)^2 + (K_t T)^2}$$

From design data book service factor K_b & K_t = 1.

Equivalent bending moment

$$Me = \frac{1}{2}\left[M + \sqrt{(K_b M_A)^2 + (K_t T)^2}\right]$$

We have verified the allowable shear stress and allowable bending stress using the above equation, and both values are found to be within the limit, indicating that the design is safe.

5. Applications

1. It can be used to move luggage up and down stairs in shopping centres from one floor to another.
2. It can be applied to newly constructed buildings.
3. It is applicable to train stations and airports.

6. Conclusions

In this project, we designed a new type of stair case climbing trolley that can handle stairs, obstacles and flat or inclined terrain thanks to its compact structure. All of the wheelchair's components were modelled using the software packages Intor and Rhino, and simulation analysis was performed to ensure that the framework, gear shaft, and folding desk were all strong. The findings are

Create the walking mechanism and gearbox system for our stair-climbing trolley based on the structural calculations, and then model every component of the trolley.

The planetary wheel system's optimisation modifies the torsion acting on the gear train's box rather than the gear itself, preserving the gear's security and longevity.

To ensure that the trolley is safe, check the locking mechanism and the desk's strength in Autodesk Inventor.

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