Motorised Stair Case Climbing Trolley

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Abstract- *This project aims at making headway for developing a mechanism for transportation of considerable loads over stairs. The requirement for such a trolley emerges from everyday prerequisites in our general public. Hand trolleys are used to lessen the stress of lifting while moving it on flat ground; however, these hand trolley usually fail when it comes to shifting the load over stairs. This project endeavors to design a stair climbing trolley which helps anyone to carry heavy objects up the stairs with less struggle compared to carrying them physically. Several designs were formulated that would allow a non-industrial hand trolley to travel over stairs which reduce the struggle on the user. In this project, the trolley is equipped with Tri-Star wheels which entitle us to convey load up and down the stairs.*

Keywords- Tri-Star wheels, Wheel Frame, Motors, Transportation, Stairs.

I. INTRODUCTION

The project aim is to design and manufacture a trolley that has multifunction. The trolley is modelled in such a manner that it has tri wheels on every facet that enables shifting the load over stairs. They are set in a triangular shape. This theory concentrates on the maximum intense ergonomically useful to man or woman. The existing challenge related to load wearing equipment of a type that is operated by the hand of shifting upwardly and downwardly on a flight of stairs. Load service is a wheeled mechanism device, is commonly used to hold loads. Its miles are to reduce human efforts.

II. MATERIAL SELECTION

a) Tri-Star Wheel: -

A Tri-Star wheel capability as an ordinary wheel on the flat ground, but has the potential to climb robotically whilst an impediment to rolling is encountered. This wheel configuration contains three tires, every established to a separate shaft. These shafts are positioned at the vertices of an equilateral triangle. While geared on this quasi-planetary style, these triangular sets of wheels can negotiate many kinds of terrain. They can also permit a vehicle to climb over small obstructions inclusive of rocks, holes and stairs.

Fig.1. Tri-Star Wheel

b) Trolley body:-

Mild steel is the most well-known type due to the fact its price is tremendously low even as it affords material properties that are best for plenty applications, greater so than iron. Low-carbon metallic includes approximately 0.0503 percentage carbon making it malleable and ductile. Mild steel has a relatively quite low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing.

c) Tri-Star wheel web:-

Stainless Steel Grade is material with a higher chromium and lower carbon content. Lower carbon minimizes precipitation due to welding and its susceptibility to intergranular corrosion. Therefore, this combination can be utilized as a part of the as-welded condition, even in corrosive conditions. It regularly gets rid of the necessity of annealing weldments besides for applications specifying strain remedy.

d) Bearing:-

The most common material used to produce bearing is Chrome Steel. A ball bearing is a sort of rolling-detail bearing that makes use of balls to hold the separation among the bearing races. The reason of a ball bearing is to lessen rotational friction and aid radial and axial loads.

e) Stepper Motor:-

Stepper motor is a special type of electric motor that moves in precisely defined increments of rotor position (Steps). The size of the increment is measured in degrees and can vary depending on the application. Due to precise control, stepper motors are commonly used in medical, satellites, robotic and control applications. There are several features common to all stepper motors that make them ideally suited for these types of applications. They are as under High accuracy: Operate under open loop Reliability: Stepper motors are brushless. Load independent: Stepper motors rotate at a set speed under different load provided the rated torque is maintained. Holding torque: For each and every step, the motor holds its position without brakes. Stepper motor requires sequencers and driver to operate. Sequencer generates sequence for switching which determines the direction of rotation and mode of operation. Driver is required to change the flux direction in the phase windings.

f) Battery:-

The batteries in which a reversible reaction is responsible for the generation of electricity such that they can be reverted to the original reactant state fall under the category of secondary batteries. Recharging is effected by passing electric current through the battery. The oldest form of rechargeable battery is the Lead-Acid battery. Lead Acid battery market is dominating primarily because of the unavailability of any able competitive solution in the market and that they offer lowest cost per watt-hour despite of their low specific energy. The desire to make these batteries maintenance free, the flooded battery type evolved into two variants: Sealed Lead Acid or Gel cells and valve regulated lead acid (VRLA) Batteries.

g) Wheel Frame:-

A specially designed wheel frame is required to hold the motors together on each side of the shaft. In the existing design, the power transmission to the single or double wheel is useless to climb the stairs due to height factor of stairs. The design of the straight wheel frame became more complicated and was needed to be modified with its curved- spherical shape to give proper drive, which creates more frictional force. For these reason, three wheel set on each side of vehicle attached with frame was introduced to provide smooth power transmission to climb stairs without much difficulty. Frame arrangement is suitable to transmit exact velocity ratio also. It provided higher efficiency and compact layout with reliable service. The wheel frame is shown in fig.2.

Fig.2. Wheel frame

III. OBJECTIVES OF RESEARCH

- To design all parts of trolley i.e. frames, wheels, bearing, and assembling them with modelling software AUTOCAD software according to specific dimensions.
- Fabrication of trolley based on above analysis with accurate measurements to withstand maximum load.
- To reduce the man power and efforts for heavy domestic load shifting through stairs.
- Trolley that can be used for stair climbing as well as hand trolley on the same floor.

IV. WORKING PRINCIPLE

The climbing motion is made possible by the Tri-Star wheels alone. In the proposed model, the Tri-Star wheels are made of a set of three individually rotating wheels, with each individual wheel's center equidistant from the center of the web. It is basically a three-socked wheel, with individual wheels attached at each end. While moving along a flat surface, two of the three wheels will be in contact with the ground surface and will roll along the ground, just as a normal wheel would. The mechanism comes into action when a stair case is encountered. One of the two wheels on the ground will come in contact with the riser of the first stair. At this point of time, this wheel will not be able to rotate along its own axis. Since, continuous force is being applied by the user as it is being pulled up the stairs; the trolley tends to move along the direction of application of force. Here, the Tri-Star setup rotates, along the axis of the main hollow shaft and allows the second individual wheel, to touch the tread of the first stair.

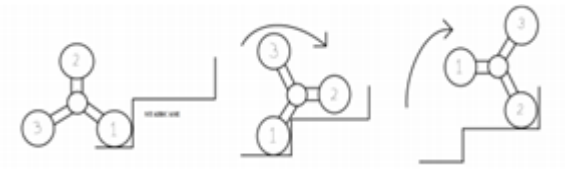

Fig.3. Working diagram of stair climbing trolley

At this moment, the orientation of the Tri-Star with respect to the observer would have changed. Thus, the Tri-Star wheel swivels about the main shaft. Since there is continuous force application, the riser will exert and equal and opposite force on the first individual wheel. This enables the Tri-Star wheel to rotate and the entire trolley moves up the first step. This process will keep repeating for the entirety of the staircase and will enable the trolley to climb it. A similar process occurs when the trolley moves down the stairs as well but in this scenario, the Tri-Star wheels need not rotate completely along its axis while moving down the stairs.

Fig.4. Actual Working Model

V. DESIGN CALCULATIONS

Stair climbing trolley is design to lift a load of 100kg. The hollow shaft connecting the two Tri-Star wheels is made of Mild Steel and the diameter is designed in such a way that the shaft overcomes the bending stresses acting on it. So it will act as a simply supported beam

Total Weight F = 100kg = 981 N
Design of Axle,

Under equilibrium condition sum of all vertical forces is zero, Calculation of end reaction at support.

RA–490.5–490.5 + RB = 0
RA + RB = 981 N

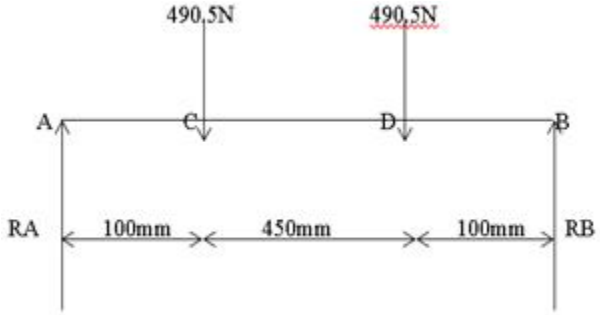

Fig.5. Loading diagram

Taking moment about A

$$\Sigma mA = 0$$

(490.5 * 100) + (490.5 * 550) – (RB * 650) = 0
RA = 490.5 N
RB = 490.5 N
Where, Shear Force Calculation

Fig.6. Shear Force diagram

Shear Force at A= 1962 N
Shear Force at C=0 N
Shear Force at D= -1962 N
Shear Force at B= 0 N
Bending moment Calculation –
Bending moment at A =0 Nmm
Bending moment at B =0 Nmm
Bending moment at C = 490.5 * 100 = 49050 Nmm
Bending moment at D = 490.5 * 100 = 49050 Nmm
Considering the maximum bending moment ,
M= π/32 *d3 * σb (considering F.S. =2)

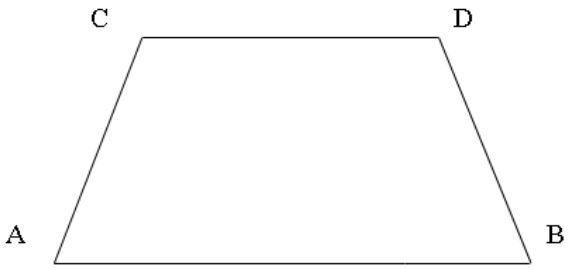

Fig.7. Bending moment diagram

Where, σb = σyt / factor of safety

Yield Stress σyt = 350 N/mm2 (from data book)

Therefore, σb = 350 / 2 = 175 N/m2

49050 = π/32 *d3 * 175

D = 14.18 mm

D = 15 mm

Design of stair wheel

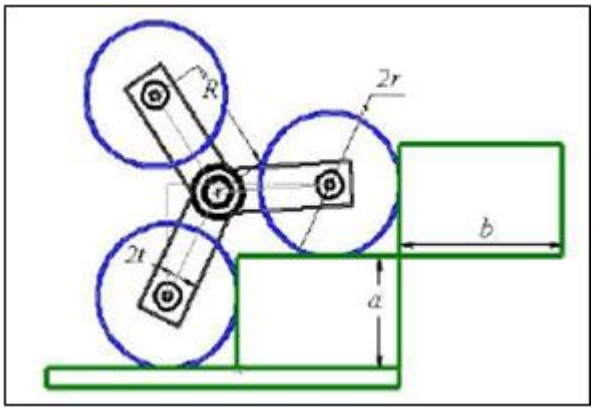

Fig.8. Stair and wheel measurement diagram

R =√a2+b22

= √162+3122

R = 20.14 cm

R = 201.4 mm

Minimum radius of regular wheel

R min = 6Rt + a (3b −√ 3*a*)(3−√ 3) *a* + (3+√ 3)*b*

= 6 ∗ 201.4 ∗ 20 + 160 (3∗310 − √3 ∗ 160)(3−√ 3) 160 + (3+√ 3)310

= 24168+101459.49 202.87+1466.93

R min = 77.03 mm

Maximum radius of regular wheel

R =√a2+b22

= √1602+31022

R = 174.42 mm

Mean Radius = R mean + R min 2

= 251.45 2

R mean = 125.28 mm R= 125 mm D= 250mm

Diameter of the wheel = 25cm

VI. MATERIALS

The following material is required for the fabrication of stair climbing trolley.

Table 1: List of components

Sr. No	Components	Material Used	Quantity
1.	Shaft	Mild steel	1
2.	Bearing	Mild steel	6
3.	Plywood Plate	wood	1
4.	Square pipes	Mild steel	5
5.	Nut And Bolt	Cast Iron	8
6.	Wheels (Tyre)	Thermosetting Plastic	6
7.	Stud And Axle	Mild Steel	6
8.	Sheet Metal Plate	Aluminium	1

Knowledge of Welding, turning, grinding, Sheet metal working was used to assemble the various components.

VII. 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 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.

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