

A Review on Stair Climbing Trolley

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ABSTRACT

This paper provides the detail study of stair climber trollies for material handling. In this paper illustrates the various reviews about the stair climber material handling System for small scale industrial application considering the average requirement of small Indian organization where the lifts are not available. Therefore, in this paper, an attempt has been taken to summarize the past and current research in the material handling. The main objective of this paper is to present the review about the stair climber material handling System. After studying the previous concept of material handling system we try to make it automatically without damage the material.

Keywords: Material Handling System, Conventional Trolley

I. INTRODUCTION

In everyday life we may have to carry so many goods of various quantities through stairs specially in offices, schools, colleges, hotels, industries, apartments etc. where the lifts may not be available, may be full with the people or under repair. It is very tiresome to carry the various objects through stairs manually for higher floor for so many times. In most of building lifts are not installed so there only human labor is solution for caring material. Labor is becoming costly as well as time consuming, where growth rate is getting negative. This problem can be solved if a trolley can lift loads while traveling through stairs. The paper introduces a new option for the transportation of the loads over the stair. The vehicle is designed in such a

way that it has three wheels on each side. They are set in triangular pattern. This project focuses on the maximum ergonomically beneficial to human being. The present project related to load carrying equipment of a type that is automatically operated of moving upwardly and downwardly on flight of stairs. Load carrier is a wheeled mechanism device, is generally used to carry a loads. It reduces human efforts.

II. LITERATURE REVIEW

1. On the basis of Manual transmission

Bakakrishna et. al. [1] aims to develop a mechanism for easy transportation of heavy load over stairs. The need of such system have raised from day to day

requirement in our society. Local goods transportation generally depends on manual Trolleys which are used in warehouses, construction sites, malls, residential relocations etc. Mostly hand trolleys are manufactured with the main aim of transporting goods on flat surface or at ground level. However, when it comes to shifting the goods above the ground level there are limitations where a hand trolley cannot be brought to, such as rough surfaces or any up level from ground is not an easy job, especially where there are no lifting facilities (elevator, conveyer, etc). Therefore, limiting the aspect of transportations from lower ground to higher levels or vice versa. The hand trolley could be tried to handle through the staircase but there are higher chance of failure occurring during the lifting on staircase, such as falling of hand trolley when it gets out of control and causing accidents as well as injuries. Apart from that, smaller and circular objects have the highest tendency of falling as it doesn't fit the trolley area. In shifting and moving heavy load above ground, Human labors are considered to be the solitary This mechanism of stair climbing trolley allows for efficient stair climbing functionality. This functionality allows for easy movement of goods across stair cases. The project aims to develop a mechanism for easy transportation of heavy load over stairs. The need of such system have raised from day to day requirement in our society. Using of this vehicle the labor cost can be reduce as well as large amount of load can be transfer uniformly with less power consumption thus our project introduces the new alternative for transportation of load over the stairs. It has designed in such a way that it can be climb a stepped path with its modified wheel structure.

Agrawal et al. [2] presents the summary of various mechanism that could easily transport the loads over stairs is studied. The development of such a mechanism is essential for Industrial applications for the routine tasks. For easy transportation there is already conventional trolley available, however these

trolley can only transport the loads over flat surface/ground. Although these conventional trolley usually is not applicable for transportation of loads over staircases. There by its essential to develop a stair climbing trolley which can easily carry heavy loads up the stairs with less effort and less time as compared to the conventional trolley or carrying them manually. It also endeavors to study the commercial viability and importance of such a product. It's not 1st time but earlier also various designs were developed that would allow non-industrial conventional trolley to travel over stairs, curbs or uneven terrain surfaces which reduced the stress and strain on the user. This paper aim to design and develop a trolley with Tri-star wheel assembly which helps us to carry heavy loads upstairs as well as down stairs. This makes ease movement of trolley on holes, bumps or irregular surfaces.

Nayak and Singh [3] aims to create a way to easily move heavy loads on stairs. The need for such a plan arises from the daily needs of our society. Devices such as handcarts are used to relieve lifting stress while on flat ground; however, these devices often fail when it comes to carrying a load over short stairs. In light of this, the project is trying to design a hand-carriage ladder that can carry heavy ladders with minimal effort compared to manual handling. It also attempts to study the commercial performance and value of such a product. Several designs were developed that would allow the non industrial handcart to move up stairs, roads, or uneven terrain while minimizing stress to the user. In this paper, the trolley is fitted with Tri-Star wheels which enables us to carry the load up and down the stairs. It also reduces trolley movement in unfamiliar areas such as holes, bumps, etc.

Ajay et al. [4] presents to develop a simple mechanism to transport such weights over stairs with ease. Trolleys helps to reduce the stresses a human being experiences while lifting loads from one place to another over flat surfaces. However, when stairs are considered, normal hand trolleys fail. To overcome

this, a staircase climbing trolley is developed which can carry heavy objects up the stairs with comparatively less effort than to carry them manually. Optimization of resources and reducing the cost at which it is manufactured is also taken into account. Several other designs have been proposed for this project but we intend to change the web structure for better stress distribution compared to other designs that would allow a trolley to travel over any uneven terrain, like stairs, bumpy pavements, etc. while reducing the physical strain experienced by the user. In this proposed design, the trolley is equipped with a set of Tri-Star wheels which is the most crucial part of the climbing mechanism that enabled the trolley to traverse along uneven surfaces. The proposed idea can be extended to Wheel Chairs, where the load acting on the structure is much greater. With little modifications in the design parameters, the concept could be expanded to a myriad of applications.

Tin and Win [5] presents in the research that, the design and performance test of stair climbing trolley. The aim of this project is 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. In this research, shaft diameter is calculated by using bending strength of the beam. Mild steel shaft is selected for design to obtain high strength. The length of shaft is 21 in and the calculated diameter of shaft is 0.75 in. Bearing No: 204 of single row angular contact ball bearing is selected. The design is based on the bearing that can be only efficient for 60 kg load with the speed of the normal human.

Kumar et al. [6] 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 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 endeavours 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. Additionally we are included a wheel setup to pedal it on the ground and while climbing stairs the rear wheel is lifted and locked by locking system.

Chambhare et al. [7] presented in the research to develop a mechanism for easy transportation of heavy load over stairs. The need of such system have raised from day to day requirement in our society. Using of this vehicle the labor cost can be reduce as well as large amount of load can be transfer uniformly with less power consumption thus our project introduces the new alternative for transportation of load over the stairs. It has designed in such a way that it can be climb a stepped path with its modified wheel structure.

Shubham S et al. [8] aims to develop a mechanism for straightforward transportation of masses over stairs. The requirement for such a system arises from regular necessities in our society. Devices like hand trolleys (single or double wheel trolley) square measure used to relieve the stress of lifting whereas on flat ground. However, these devices sometimes fail once it involves carrying the load over the steps. Keeping this concept in mind, the project tries to design a stair rising hand cart which may carry objects (up to 150kg) up the steps with less effort compared to carrying them manually by hand. It's conjointly a sincere plan to study the utility and importance of such a product. Many styles were envisioned that might enable a non industrial hand trolley to travel over stairs, curbs or uneven terrain whereas reducing the strain on the user.

More et al. [9] aims to develop a mechanism for easy transportation of heavy load over stairs. The need of such system have raised from day to day requirement in our society. Using of this vehicle the labor cost can be reduce as well as large amount of load can be transfer uniformly with less power consumption thus our project introduces the new alternative for transportation of load over the stairs. It has designed in such a way that it can be climb a stepped path with its modified wheel structure.

Nath in 2020 [10] research on a forklift is lifting off heavy objects and transporting them from one location to another. These criteria were considered while designing and fabricating the model. A modified forklift has been presented that is capable of climbing staircases and lifting a certain amount of load to a certain height simultaneously. The designed forklift uses a low speed motor, which is cost efficient, with a reduction gearbox and a pulley to lift the weight instead of using a hydraulic set up which is traditionally used in industrial forklifts. This increases the load capacity of the forklift in comparison to the industrial forklifts. Efforts have been made for coupled construction of the forklift and the climbing trolley. This has been achieved by introducing two tri-star-wheels at the rear of the forklift for enhancing the parametric evaluation of the newly proposed concept. Overall, the concept turned out to be usable for manoeuvrability and durability and also proves the usage of staircase climbing mechanism in a normal forklift

Akumalla Lukmanhakim et al [11] research in the field of production technology though there are many developments and advancements in Material handling, still there are difficulties to carry industrial loads over rough terrain surfaces, stairs or to elevated surfaces. Handling of finished goods at construction areas is a very important matter of concern. As goods need to be transported through all terrain conditions hence there exists a demand for a mobile user-friendly material handling device. We intend to produce a project a material handling device with a mechanism

(rocker bogie mechanism) which can enable the device to move on all terrain surfaces like rough constructional areas, stairs etc consuming less effort, energy and portable in nature. Our project also aims at developing a project which facilitates a user-friendly mode of waste collection at domestic level. Our project "Waste Collection Stair Climbing Material Handling Equipment" incorporates a mechanism which can enable the garbage trolley to climb stairs during waste collection in society buildings. An additional modification of making the trolley completely foldable can also be incorporated in order to achieve optimum space utilization and to make it portable. A special modification was done of making the trolley power driven so that it reduces human effort and provides more flexibility in operation by using DC motors and power supply. Hence after static and dynamic testing and analysis on SOLIDWORKS and ANSYS with formulative design calculations "Waste Collection Stair Climbing Material Handling Equipment" was intended to be made.

Norain & Yew [12] studied on a buildings with no lift and escalator facilities make it difficult for users to lift heavy loads from the ground floor to the upper floor. Human labor is the solution. There is a need to develop a mechanism that can lift loads while traveling through stairs to reduce the ergonomic constraint that may lead to the risk of developing musculoskeletal disorders (MSD). This work presents the tri-wheels stair climbing trolley for this purpose. The triwheels stair climbing trolley consists of two pairs of quasi-planetary wheel frames to hold three wheels at both sides, a frame, a movable base, and a manual hand winch. The trolley frame is made from malleable hollow steel, and mild steel is used for the wheel frames due to its high strength and toughness. Physical testing was done on the designed trolley, and it was found that it can carry the maximum load, which is 20kg, and tri-wheels design can climb the stair up and down smoothly without causing damage to the trolley and stair.

Z. Hussaini et al. [13] focuses on design modification and simulation of a new type of trolley with multifunctional ties. The device was redesigned to have three wheels in a triangular pattern that can be switched into three different working positions to aid in moving of heavy load through a desired vertical height. The project utilized concept generation and selection matrix to generate 30 possible design concepts. These concepts were pruned using concept scoring matrix to three (3) designs. Weighted Scoring Matrix was deployed to screen and rank three best designs. The project design was done using AutoCAD, SolidWorks and Ansys for load/stress analysis of each component. SolidWorks (SimXpress) was deployed for static analysis of the trolley components. Simulation result revealed a weight reduction from 200 kg to 15.3 kg and maximum stress of $7.13 \times 10^8 \text{ N/m}^2$ with a 1.5 factor of safety. The trolley design modification shows

trolley as a viable option for stair-climbing with lesser physical energy, higher workload capacity and better efficiency.

Rajkumar et al. [14] designed a trolley carrier considering the problem of lugging about handling and maneuvering. Situation becomes more difficult for elderly and women. Keeping in mind all these problems and requirements of different generation, Features added in such a way that it make one's journey comfortable and headache free. Universal trolley carrier is easy to carry on stair as well as on ground. Even with holes and bumps on road, one can easily handle this. There is folding chair attached with this for self-dependence and helpful during rush. There are some other features power bank etc. The emphasis is on the clear and minimalistic design, as well as the optimized details.

Table 1 : Review of Manual Powered Stair Climbing Trolley

Title	Year	Type of Study	Transmission Powered	No. of Wheel
Stair climbing trolley	2022	Fabrication	Manual	2
Development & fabrication of stair climbing trolley	2021	Fabrication	Manual	6
Design and Fabrication of Stair Climber Trolley	2021	Fabrication	Manual	6
Design and Development of Light Weight Mechanical Staircase Climbing Trolley with Better Stress Distribution	2017	Fabrication	Manual	6
Design and Fabrication of Stair Climbing Trolley	2019	Fabrication	Manual	6
Design & Fabrication of Tri-Wheel Stair Case Climbing Hand Trolley	2019	Fabrication	Manual	6
Design and Fabrication of Pedal Powered Stair Climbing Trolley	2018	Fabrication	Manual	7
Design and Fabrication of Easy Handling Trolley	2018	Fabrication	Manual	6
Design and manufacturing of stair climbing trolley	2019	Fabrication	Manual	6

Design and Parametric Evaluation of a Staircase Climbing Forklift	2020	Fabrication	Manual	6
Design of Prototype based on Rocker Bogie Mechanism for Stair Climbing Material Handling Equipment	2020	Fabrication	Manual	6
Tri-wheels stair climbing trolley	2021	Fabrication and Simulation	Manual	6
Design modification and simulation of a stair climbing trolley	2022	Simulation	Manual	8
Design and analysis of universal trolley carrier with stair climbing mechanism	2018	Simulation	Manual	6

1- On the basis of Electric motor transmission

Olodu et al. [15] concentrated on designing and building an electric-powered staircase climbing trolley from locally sourced materials. Everyday needs in our society drive the necessity for such a system. This robotic trolley is also employed to reduce the strain associated with lifting while on level ground and over a staircase. Given this, the project aims to design, build, and test the functionality of an electric-powered stair climbing trolley that can transport items up and down the stairs as well as on flat surfaces and even rugged terrain. The trolley uses a triple interlink wheel configuration that makes it simple to move things. When comparing the designed and constructed motorized trolley machine established in this work to the hand trolley, whose performance efficiency ranges from 50% to 60% as explored in previous literature, the motorized trolley machine performed 87% more efficiently. Moving products up and down a staircase can potentially be solved with the help of a motorized trolley that was designed and manufactured specifically for this purpose

Meng [16] with the quick development of express industry, the courier needs to safely and quickly send things to customer house. As for customers living in the high building without elevators, it is very dangerous for courier carry large-scale things such as refrigerator, TV sets to upstairs and downstairs, which

has risk of destroying things, delaying delivery speed and threatening personal security etc. Therefore, designing auxiliary tools with stair climbing functions has important meanings to solve problems of difficult to carry things upstairs and downstairs in high buildings. Semi-automatic loading mope with stair climbing with new structure, safety and stability, low cost, strong practicability, convenient application, so it has universal development prospect

Raj et al. [17] study of development of lift simplifies the effort of carrying heavy loads over stairs, it is not possible to use lift in all places like schools, college's constructional areas. This project aims at developing a mechanism for easy transportation of heavy loads over stairs. The need for such arises from day to day requirements in our society. Devices such as hand trolleys are used to relieve the stresses of lifting while on flat ground. However these devices usually fail when it comes to carrying the load over short fleet of stairs . Our project attempts to design a stair climbing trolley which can carry heavy objects up the stairs with less effort compared to carrying them manually. The main objective of the project is to find an efficient and user friendly method of carrying various objects through stairs using minimum effort from the user and to also provide a smooth movement while climbing the stair. Under this project we have manufactured a stair climber with tri lobed wheel frames at both sides of the climber and three wheels on each sides are used in the tri lobed frame. The

wheel assembly is rotated by a gear- motor mechanism where a DC gear motor is used to provide the necessary power for rotation and a piniongear mesh is used for reducing the rotating speed of the wheel. The motor is connected to a lead acid battery of similar ratings and they are in turn connected to DPDT switch.

Gangadia et al. [18] presents in the paper to describes the research and analysis of stair climbing trolley. Hand trolley is used to move heavy load from one place to another place. It is very common device used in large number of industry to move the physical product. Such kind of trolley does not move on stairs. To transfer heavy load or some object from bottom floor to the top floor is very difficult by using single wheel. In the industry the load is transfer by means of crane, lifting machine etc. But in civil construction site and also in home such kind of instrument is not used. So to transfer load to top floor is difficult. Such difficulty is eliminated by using stair wheels. The single wheel is replaced by means of stair wheels. Stair wheel is the combination of more than two wheels which works as single unit. Using such kind of stair wheels the load can be easily transferred from bottom floor to top floor by means of climbing the stairs or ladder step

Kumar et al. [6] studied on the rapid changes in the way the things are being manufactured, we are still used to the age of techniques of manufacturing. The reasons are multifold ranging from inertia, rejection of the new technologies, lack of engineering aptitude, lack of skill & technical know-how and most importantly fear of losing employment opportunities. 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 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. In present project, the trolley is equipped with Tri-Star wheels which enable us to carry load up and down the stairs and also eases the movement of trolley in irregular surfaces like holes and bumps.

Dileepan et al. [19] studied on the staircase climbing robot are important for conducting scientific analysis of objectives. Current mobility designs are complex, using many wheels or legs. An eight wheeled rover capable of traversing rough terrain using an efficient high degree of mobility suspension system. The primary mechanical feature of the stair case climbing mechanism design is its simplicity. Which is accomplish by using only two motors for mobility. In the modern world though there are many developments in the field of engineering. Still there are difficulties to carry heavy loads over stairs. Development of lift simplifies the effort of carrying heavy loads over stairs, it is not possible to use lift in all places like schools, college's constructional areas. This project aims at developing a mechanism for easy transportation of heavy loads over stairs. The need for such arises from day to day requirements in our society. Devices such as hand trolleys are used to relieve the stresses of lifting while on flat ground. However, these devices usually fail when it comes to carrying the load over short fleet of stairs. Our project attempts to design a stair climbing trolley which can carry heavy objects up the stairs with less effort compared to carrying them manually.

Yadav et al. [20] works on the issues associated are the design for proper application with better capacity to handle the load. The trolleys are capable for moving the heavy material with least efforts. These are also useful in shifting of household material specially in shifting of the house. We have identified the need of special design which can be used for moving the material with staircase. The design of the trolley for staircase is discussed in this paper in detail. This design is suitable mainly for multistory buildings where we can move the material with ease. Tri-Star

wheels are used to up and down lift the load with fewer efforts.

Swamy et al. [21] works on the basic problems of Load Carriers is overcoming architectural barriers (kerbs, stairs etc.) on its way. The commercially available Load carriers do not have functionality for climbing Stair case. Even though many research studies have been reported in different fields to increase the mobility of load carriers, the question of overcoming obstacles by load carriers always remains as topic of discussion for many researchers. In our project a motor operated stair climbing wheelchair concept which can overcome the architectural barriers to a considerable extent has been developed. This paper involves the design and analysis of an ergonomically designed battery powered load carriers for multipurpose use. Stair climbing functionality is embedded in the design through its structure and mechanism. All the design parameters of load carriers were based on the standard design of the stairs in India. Major part of this paper focuses on the proposed design concept and concludes by discussing upon the physical working model developed for the proposed design solution. In this paper five different dimensions for square hollow section used in the chassis are analyzed and best of these is taken for our

proposed model and all other components are selected based on the calculations obtained. Final assembled model is designed and analyzed using CATIA and ANSYS softwares. The final model is found safe on plane surface and on stairs.

Chaudhari et al. [22] aims at developing a mechanism for easy transportation of heavy loads over stairs. 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 fleet of stairs. Hence the need for using staircase climbing trolley has been greatly felt to ease the effort required to carry the heavy loads manually. The main objective of the project is to find an effective and user friendly method of carrying loads through stairs using minimum efforts from the user and to provide a smooth movement. A few issues of vibrations, speed control, and so forth greatly affect the working of the trolley. Hence this project involves the design of an ergonomic staircase climbing trolley for a variety of staircase types. The model is an application of the E-Bike Chain-Drive Transmission system. The frames and wheels are designed and developed according to the statistical data of dimensions of staircases in Indian buildings.

Table 2 : Review of Electric Powered Stair Climbing Trolley

Title	Year	Type of Study	Transmission Powered	No. of Wheel
The design and construction of a locally sourced electric powered stair climbing trolley	2023	Fabrication	Electric	6
Design and Fabrication of Motorised Stair Case Climbing Trolley	2018	Fabrication	Electric	6
Design and Fabrication of Stair Climbing Trolley	2016	Fabrication and Simulation	Electric	6
Design and modeling of stair climbing trolley	2015	Fabrication and Simulation	Electric	6
Application of E-Bike Chain-Drive Transmission in Stair Climbing Trolley	2020	Fabrication and	Electric	6

		Simulation		
Design and Fabrication of IOT based Stair Climbing Robot	2019	Simulation	Electric	6
Design and fabrication of staircase climbing trolley	2020	Simulation	Electric	6
Design and Analysis of Motor Operated Load Carrying Stair Climber	2021	Simulation	Electric	4
One Kind of Semi-automatic Loading Mope by Stair Climbing	2016	Fabrication	Semi automatic	4

III.CONCLUSION

In this paper we implement the material handling with less human efforts in minimum time without damaging the material while transportation. In this concept we find out the automatic trolley and it operate automatically. concept of stair climber material handling system which provide the service to reduce the human efforts in many fields like offices, colleges and industries for handling material on stair case. It provides service to replace man in dangerous environment to transfer material on stairs and flat surface, like underground storage go down where oxygen is in less amount.

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