INTERNATIONAL JOURNAL OF ADVANCED INNOVATIVE TECHNOLOGY IN ENGINEERING

Published by Global Advanced Research Publication House Journal

Home page: www.ijaite.co.in

Design of Stair Climbing Trolley

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Article History

Received on: 25 April 2023

Revised on: 12 May 2023

Accepted on: 24 May 2023

Keywords: Stair Climber Trollies, Driving Shaft, Ergonomic Staircase

e-ISSN: 2455-6491

DOI:

Production and hosted by
www.garph.org

ABSTRACT

The following paper offers a thorough analysis of material-handling stair climber trollies. The numerous reviews of the stair climber material handling system for small-scale industrial applications are illustrated in this study, taking into account the typical needs of tiny Indian organisations where lifts are not provided. Therefore, a summary of both previous and present material handling research has been attempted in this study. This essay's primary goal is to provide a review of the stair climber's material handling system. We attempt to automate the material handling system after examining the prior approach without causing material damage.

1. INTRODUCTION

In our daily lives, we might have to carry a lot of different-sized items up and down stairs, especially in places like workplaces, schools, colleges, hotels, industries, residences, etc. where elevators might not be accessible, might be crowded with people, or might be undergoing maintenance. Manually carrying various items up stair to a higher floor repeatedly is highly exhausting. Since there are typically no lifts in buildings, the sole option for material maintenance is human labour. Labour has become more expensive and time-consuming, with a negative growth rate. If a tram can hoist loads while moving through steps, this difficulty can be handled. The paper presents a fresh method for moving loads up and down stairs.

The vehicle has three wheels on each side, according to the way it is built. They are arranged in triangle shapes. This research focuses on the most ergonomically advantageous designs for people. The current project concerned load-carrying machinery of the kind that moves up and down a flight of steps mechanically. A wheeled

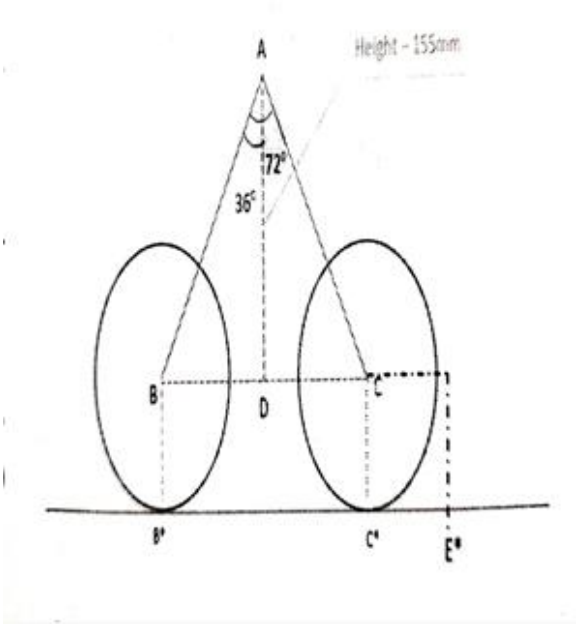
apparatus called a load carrier is typically used to transport loads. Human effort is decreasing.

2. PRELIMINARY DESIGN

A. *Calculating The Dimensions Of The Five Star (By Geometry)*

Known data:
Height of stairs=150mm
Breadth of stairs=290mm
Angle between the arms of the star=72(by symmetry)

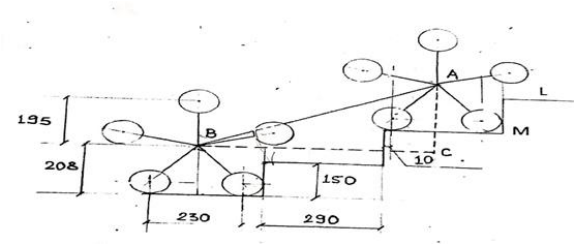
Step 1: To keep both wheels in contact on the breadth of the stairs
The distance from the end of of the wheel to the centre of other wheel on a single five star must be less tan 290(breadth of commercial stairs)



We assume the centre to centre distance as 230 mm.
Std. wheel size available in market=100mm (outer dia.)
As seen from the diagram.
We construct an isosceles triangle with base 230mm & <BAC =72 degree

The distance from the end of one wheel to the centre of the other wheel on a single five star i.e.

E*C* is 280
<ABC is 54
BD = 230/2
Tan (54) = AD/BD



Therefore

AD=158
AD*=AD+50=158+50=208mm

Hence the height from the ground level to centre of the shaft = 208mm

Now as we will see in the upcoming figures that the distance of the part of the largest component coming down from the centre of the shaft is 25mm Therefore, the clearance between the flight of stair and the components of the shaft is 208-25 150=33mm

Which is enough for smooth travelling of the device.

Calculating the length of each arm

Cos (54) =BD/AB
AB=BD\Cos (54)
AB=BD/Cos (54)
AB=195

The centre to centre distance between shaft and the centre of wheel is 195mm.

To provide strength to each arm after drilling is done for the hole we increase the length by 10mm. Now the length of each arm is 205mm

B. *Distance Between Driving And Driven Shaft*

Both the stars of the driven and driving shaft must pivot at the same time so that proper ascent can be made. Therefore, at rest position both wheels should be in contact with the edge of the stairs LM.

We can see that the distance between the two shafts is AB

AC=165=290+125=580mm

BC=382mm (analytically calculated)

$AB= (580^2 + 382^2)^{1/2}$

AB=695mm

3. LITERATURE REVIEW

In order to make it simple to transfer big loads up and down stairs, Bakakrishna et al. [1] set out to build a mechanism. The demand for such a system has increased as a daily necessity in our culture. Manual trolleys, which are used in warehouses, malls, construction sites, and other locations, are typically employed for local goods movement. The majority of hand trolleys are made primarily with the intention of moving on flat surfaces or at ground level. However, there are places where a hand trolley cannot be used while moving items beyond ground level, such as rough surfaces or any level above ground. This is especially true in places without lifting infrastructure (elevator, conveyer, etc.). As a result, transit from lower ground to higher levels or vice versa is limited. The hand trolley might be attempted to be handled through the staircase, but there is a higher likelihood that it will fail while being lifted on the staircase, such as collapsing when it loses control and causing accidents and injuries. Aside from that, smaller and rounder things tend to fall the most because they don't fit in the trolley's space. Human labour is regarded as the loneliest in lifting and hauling heavy loads above ground. This stair climbing trolley's technology enables effective stair climbing capabilities. This functionality makes it simple to transport items up and down stairs. The project's goal is to create a system for simple transportation of big loads up and down stairs. The demand for such a system has increased as a daily necessity in our culture. Our concept presents a new alternative for the transportation of cargo over the stairs by utilising this vehicle, which also allows for the reduction of labour costs and the uniform transfer of huge amounts of load while using less electricity. Its improved wheel construction allows it to traverse a graded path thanks to clever design.

Agrawal et al.'s description of numerous mechanisms that could readily move goods up and down stairs is shown in [2]. It is crucial to design such a system for industrial applications that involve repetitive tasks. There are currently standard trolleys available for simple transportation; however, these trolleys can only move items across level surfaces or ground. However, these traditional trolleys are typically not suitable for carrying items up or down stairs. As a result, it's imperative to create a stair-climbing trolley that can effortlessly transport large items up stair with less effort and in less time than a traditional cart or by carrying them manually. It also makes an effort to research the value and commercial viability of such a product. It's not the first time, since different concepts for non-industrial conventional trolleys to traverse stairs have been created in the past. curbs or surfaces with irregular topography that eased the user's stress and strain. The purpose of this thesis is to design and create a Tri-Star wheeled trolley that will enable us to transport large objects both up and down stairs. This makes moving the tram over cracks, ridges, or other uneven terrain easier.

The goal of Nayak and Singh's [3] invention is to make it simple to carry large objects up stairs. The daily necessities of our society drive the necessity for such a plan. On flat ground, tools like handcarts are employed to reduce lifting strain; nevertheless, these tools frequently fall short when it comes to hauling a load up small flights of stairs. As a result, the project is attempting to develop a hand-carriage ladder that can transport huge ladders with less effort than human handling. Additionally, it makes an effort to analyse the value and commercial performance of such a product. In order to carry the non-industrial handcart over stairs, roads, or uneven terrain with the least amount of user stress, several designs were created. Tri-Star wheels on the trolley in this paper allow us to move the weight up and down stairs with ease. Additionally, it lessens trolley movement on irregular surfaces like holes and bumps.

Ajay et al.'s [4] proposal outlines the development of an easy-to-use method for moving such weights up and down stairs. The strains associated with lifting objects from one place to another over flat surfaces are lessened by the use of trolleys. However, standard hand trolleys fall short when stairs are involved. A stair-climbing trolley has been created as a solution to this problem, allowing large goods to be carried up stairs with considerably less effort than if they were carried manually. It also takes into account resource optimisation and lowering the cost of production. In contrast to earlier ideas that would allow a tram to move over any obstacle, we propose changing the web structure for improved stress distribution in this project. any uneven surfaces, such as stairs, uneven pavement, etc., while minimising the user's physical effort. In the suggested design, the trolley has a set of Tri-Star wheels, which are the most

important component of the climbing mechanism and allow the trolley to move across uneven terrain. The suggested concept can be applied to wheelchairs, where there is a significantly greater load on the structure. The idea might be applied to a wide range of situations with only minor changes to the design specifications.

Tin and Win's [5] research on the stair climbing trolley's design and performance evaluation is presented. The goal of this project is to provide a system for the simple transportation of large goods up and down stairs. The necessity for such a system is brought on by daily needs in our society. In this study, the shaft diameter is determined using the beam's bending strength. For the design, a shaft made of mild steel was used for its high strength. The computed shaft diameter is 0.75 in, and the shaft's length is 21 in. The single-row angular contact ball bearing with bearing number 204 is chosen. The design is based on a bearing that can only be effective with a weight of 60 kg while moving at a normal human pace.

A method for the simple transportation of big loads up stairs is being developed by Kumar et al. [6]. The necessity for such a system is brought on by daily needs in our society. On flat ground, devices like hand trolleys are used to reduce the strain of lifting; however, these devices frequently fall short when it comes to transporting the burden up and down a short flight of stairs. As a result, the project aims to create a stair-climbing hand cart that can move large goods up stairs with less effort than manual lifting. It also makes an effort to research the value and commercial viability of such a product. There were several designs considered that would allow a non-industrial hand trolley to cross curbs, stairs, and other obstacles. or difficult terrain while minimising user effort. Tri-Star wheels on the trolley that we're using for this project allow us to transport loads both up and down stairs. Additionally, it makes it easier for the trolley to move across uneven terrain like holes, bumps, etc. The back wheel is raised and locked by a locking device while climbing stairs, and we have also added a wheel setup for pedalling it on the ground.

In their research, Chambhare et al. [7] established a technique for the easy transportation of big loads over stairs. The demand for such a system has increased as a daily necessity in our culture. Our concept presents a new alternative for the transportation of cargo over the stairs by utilising this vehicle, which also allows for the reduction of labour costs and the uniform transfer of huge amounts of load while using less electricity. Its improved wheel construction allows it to traverse a graded path thanks to clever design.

The goal of Shubham S. et al.'s research [8] is to provide a simple system for mass transit across stairs. The need for such a system results from common requirements in modern society. On level terrain, tools like hand trolleys (single or double wheel trolleys) are used to reduce the strain of lifting. However, when moving the burden up and down stairs, these devices occasionally malfunction. The project attempts to develop a stair-rising hand cart that can move objects (up to 150kg) up the stairs with less effort than physically hauling them by hand. It is also my real intention to research the value and significance of such a thing. There are many designs that could allow a non-industrial hand trolley to move over obstacles like stairs, curbs, or uneven ground while putting less pressure on the operator.

A method for the simple transportation of big loads up stairs is being developed by More et al. [9]. The demand for such a system has increased as a daily necessity in our culture. Our concept presents a new alternative for the transportation of cargo over the stairs by utilising this vehicle, which also allows for the reduction of labour costs and the uniform transfer of huge amounts of load while using less electricity. Its improved wheel construction allows it to traverse a graded path thanks to clever design.

Research on a forklift will take off big objects and move them from one place to another in 2020 [10]. When creating the model, these characteristics were taken into account. A forklift that has been adapted to be capable of both climbing stairs and lifting a specific quantity of weight to a specific height has been exhibited. Instead of employing a hydraulic setup, which is normally used in industrial forklifts, the proposed forklift uses a low-speed motor that is economical, along with a reduction gearbox and a pulley to lift the weight. Compared to industrial forklifts, this increases the forklift's load capacity. Forklift and climbing trolley construction have been attempted in tandem. This was accomplished by adding two tri-star wheels to the forklift's back to improve the parametric analysis of the recently suggested

design. Overall, the design proved to be practical for manoeuvrability and durability, and it also demonstrated how a standard forklift could use a staircase climbing mechanism.

Despite several breakthroughs and improvements in material handling, according to study by Akumalla Lukmanhakim et al. [11] in the field of production technology, it is still challenging to transport industrial loads up stairs, over rugged terrain, or to elevated surfaces. The handling of finished items in construction zones is a major source of worry. A mobile, user-friendly material handling equipment is needed since commodities must be transported through all types of terrain. A material handling device with a mechanism (rocker bogie mechanism) that enables the device to move on any surface, such as rough construction areas, stairs, etc. while using less work, energy, and being portable is what we plan to create. Our research also intends to create a system that makes it easy to collect waste at the household level. The garbage trolley in our "Waste Collection Stair Climbing Material Handling Equipment" idea has a mechanism that allows it to climb stairs while being collected in societal buildings. To ensure optimum space utilisation and to make the trolley portable, a further modification that makes it totally foldable can also be added. Using DC motors and a power supply, a unique alteration was made to the trolley to make it power-driven, reducing human effort and increasing operational flexibility. Consequently, following static and dynamic testing, analysis, and formulation design calculations on SOLIDWORKS and ANSYS.

It was intended to make "Waste Collection Stair Climbing Material Handling Equipment".

According to a study by Norain and Yew [12], users find it challenging to lift large loads from the lower floor to the upper floor of a structure without a lift or an escalator. The answer is to use human labour. To lessen the ergonomic limitation that could increase the risk of developing musculoskeletal diseases (MSD), a device that can lift loads while climbing stairs must be developed. For this reason, the tri-wheel stair climbing trolley is shown in this work. The tri-wheels stair climbing trolley is made up of a frame, a mobile base, a pair of quasi-planetary wheel frames holding three wheels at each side and a manual hand winch. Due to its great strength and hardness, mild steel is used for the wheel frames, whereas malleable hollow steel is used for the trolley's frame. The designed trolley underwent physical testing, and it was discovered that it can support the maximum load, which is 20 kg, and that the tri-wheel design allows it to ascend and descend stairs smoothly without endangering the trolley or stairway.

With regard to a new kind of trolley with multifunctional ties, Z. Hussaini et al. [13] concentrate on design modification and simulation. To assist in moving a large load via a desired vertical height, the apparatus was rebuilt to feature three wheels arranged in a triangle pattern that can be converted into three distinct working positions. 30 potential design concepts were generated for the project using a concept generation and selection matrix. Using a concept score matrix, these concepts were reduced to three (3) designs. Three of the finest designs were screened and ranked using a weighted scoring matrix. Utilising AutoCAD, SolidWorks, and Ansys for the load/stress analysis of each component, the project design was completed. The trolley's parts underwent static analysis using SolidWorks (SimXpress). The weight reduction from 200 kg to 15.3 kg and maximum stress of 7.13 x 108 N/m2 with a 1.5 factor of safety were shown by the simulation results. The trolley's improved design makes it a practical choice for stair climbing because it requires less physical effort and is more efficient.

A tram carrier was created by Rajkumar et al. [14] with the issues of dragging, handling, and manoeuvring in mind. The situation gets more challenging for women and the elderly. Features were implemented with all of these issues and the needs of various generations in mind, making for comfortable and stress-free travel. Carrying a universal trolley carrier is simple on both the ground and stairs. One can manage this even with the road's holes and bumps. This is attached to a folding chair for independence and convenience in a hurry. Other features include a power bank, etc. The straightforward and simple design, as well as the optimised details, are highlighted.

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

4. CHALLENGES AND FUTURE SCOPE

Olodu et al.'s [15] primary focus was on developing a locally sourced electric-powered stair climbing trolley. The requirement for such a system is driven by daily necessities in contemporary society. The use of this robotic trolley also lessens the tension that comes with lifting while standing on level ground or going up a staircase. In light of this, the project's objective is to design, construct, and test the operation of an electric-powered stair climbing trolley that can move objects up and down stairs as well as on flat areas and even rough terrain. The trolley's triple-interlink wheel design makes it easy to move anything. The hand trolley, whose performance efficiency ranged from 50% to 60% as studied in prior research, operated 87% less efficiently when compared to the developed and built motorised trolley machine established in this work. A motorised cart that was made particularly for the purpose of moving things up and down a staircase could potentially alleviate this problem.

Meng [16] Due to the express industry's rapid development, the courier must deliver packages to customers' homes swiftly and safely. It is extremely risky for couriers to transport huge items like refrigerators and TV sets to customers who reside in high buildings without lifts because doing so runs the risk of damaging the items, delaying delivery, endangering human safety, etc. Therefore, inventing auxiliary tools with stair-climbing capabilities is crucial to resolving the issue of carrying heavy objects upstairs and downstairs in tall buildings. The semi-automatic loading mope with stair climbing has a new structure, safety and stability, affordability, high practicability, and ease of application; therefore, it has broad development potential.

Although Raj et al.'s [17] study on the development of lifts makes it easier to transport big items up stairs, not all locations, such as schools and college construction zones, can employ lifts. The goal of this project is to create a method for carrying large objects easily up and down stairs. Daily necessities in our culture create the necessity for such Hand trolleys and other tools are used to reduce the strain of lifting when standing on level ground. However, when it comes to moving the load up and down a short flight of stairs, these technologies typically fail. Our project aims to create a stair-climbing trolley that can more easily move heavy

goods up stairs than hauling them manually. The major goal of the project is to develop a practical and user-friendly way for moving heavy goods up and down stairs while requiring the user to exert the least amount of effort possible. As part of this project, we created a stair climber with trilobed wheel frames on both sides. Each side of the climber has three wheels in the trilobed frame. A DC gear motor is used to provide the necessary power for rotation of the wheel assembly, and a pinion gear mesh is used to lower the speed at which the wheel rotates.

The investigation and analysis of the stair-ascending tram are presented by Gangadia et al. in their publication [17]. To transport big loads from one location to another, use a hand trolley. It is a very popular tool used in numerous industries to transport physical goods. Such a tram won't move up or down stairs. Using a single wheel to move a large weight or object from the lowest floor to the top floor is quite challenging. In the workplace, loads are moved using cranes, lifting equipment, etc. However, such a tool is not employed in homes or on civil building sites. So it is challenging to move loads to the upper floor. Using stair wheels eliminates this obstacle. Stair wheels are used in place of the single wheel. A stair wheel is a collection of more than two wheels that function as one. With the aid of such stair wheels, it is simple to move a load from a lower floor to a higher one by ascending stairs or ladder steps.

We are still accustomed to the production procedures used in the past, according to research by Kumar et al. [18] on the rapid changes in how things are made. The causes are numerous and include a variety of factors such as inertia, rejection of new technologies, a lack of engineering aptitude, a lack of competence and technical knowledge, and most crucially, fear of losing job possibilities. The goal of this project is to create a method for carrying large objects easily up and down stairs. The necessity for such a system is brought on by daily needs in our society. Hand trolleys and other tools are used to reduce the strain of lifting when standing on level ground. But when it comes to moving the burden up and down a small flight of steps, these gadgets typically fall short. In light of this, the project aims to create a hand cart that can climb stairs and transport large goods with less effort than hauling them manually. The trolley in the current project has Tri-Star wheels, which make it easier to operate the trolley across uneven terrain like holes and hills as well as up and down stairs.

The research by Dileepan et al. [19] on the robot that climbs stairs is crucial for undertaking objective-based scientific analysis. Many wheels or legs are used in the complicated mobility designs of today. a rover with eight wheels that can go across tough terrain with the help of a very effective suspension system. The simplicity of the staircase climbing mechanism design is its main mechanical characteristic. It can be done with just two motors for mobility. However, engineering has seen significant advancements in the modern world. It is still challenging to carry large things up stairs. Although the development of lifts made it easier to transport large objects up stair, not all locations, such as schools and college construction zones, allow the use of lifts. The goal of this project is to create a method for carrying large objects easily up and down stairs. Daily necessities in our culture create the necessity for such Hand trolleys and other tools are used to reduce the strain of lifting when standing on level ground. But when it comes to moving the burden up and down a small flight of steps, these gadgets typically fall short. In our project, we try to create a stair-climbing trolley that can lift heavy goods up the stairs more easily than lifting them by hand.

Yadav et al.'s [20] research focuses on the problems with designing for proper application and better load handling. The trolleys can move large items with the least amount of effort. These are also helpful when moving household items, particularly when moving a house. We have determined that a unique design that can be employed for material movement up and down stairs is necessary. In this study, the trolley's design for a staircase is thoroughly explained. This style is primarily appropriate for multistory structures where we have easy access to the material. Tri-Star wheels are used to more easily lift the weight up and down.

According to Swamy et al. [21], the fundamental issue with load carriers is overcoming architectural obstacles (such as kerbs, stairs, etc.) in their path. The functionality for climbing stairs is not included in commercially marketed load carriers. Even though numerous research studies have been published in various disciplines to boost the mobility of load carriers, the issue of load carriers being able to overcome barriers continues to be a hot topic of debate for many scholars. In our project, a motorised stair-climbing wheelchair concept that can substantially overcome architectural limitations has been created. This essay examines the design and study of ergonomic battery-powered load carriers for various applications. The design incorporates stair-climbing capabilities into its structure and mechanism. The standard design of the stairs in India served as the foundation for all load carrier design requirements. This article spends most of its time covering the suggested design concept before wrapping up with a discussion of the physical working model created for the suggested

design solution. In this study, the best of five potential dimensions for the square hollow section utilised in the chassis is chosen for our suggested model, and all other components are chosen based on the results of the calculations. ANSYS and CATIA software are used to develop and analyse the final assembled model. The finished model can be used safely on stairs and flat surfaces.

Chaudhari et al. [22] aim 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 flights of stairs. Hence, the need for using a 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 effort from the user and to provide smooth movement. The trolley's operation is significantly impacted by a few problems with vibrations, speed regulation, and other factors. Due to the variety of staircase types, this project requires designing an ergonomic staircase climbing trolley. The E-Bike chain-drive transmission mechanism is applied to the model. According to statistical information on stairway dimensions in Indian buildings, frames and wheels were developed.

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 Simulation	Electric	6
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

CONCLUSION

In this study, we execute material handling with fewer human efforts in the shortest amount of time without causing material damage during transit. This concept introduces an autonomous tram that runs on its own. concept of a stair climber material handling system, which offers the service of reducing human efforts in numerous domains, such as offices, colleges, and industries, for handling material on stairs. It offers the ability to carry materials safely on flat surfaces and up staircases, such as in underground storage facilities where there is a dearth of oxygen.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FUNDING SUPPORT

The author declares that they have no funding support for this study.

REFERENCES

[1] B. Bakakrishna, K. Raju, B. Venkateswara, and G. Manikanta, "STAIR CLIMBING TROLLEY," J. Interdiscipl. Cycle Res., vol. XIV, no. Vii, pp. 984–989, 2022.

[2] A. Agrawal, K. Bhi, K. Tapre, S. Dubey, and S. S. Pawar, "Development and Fabrication of Stair Climbing Trolley," Int. J. Innov. Eng. Sci., vol. 6, no. 6, pp. 27–28, 2021, doi: 10.46335/ijies.2021.6.6.7.

[3] S. Nayak and S. P. Singh, "Design and Fabrication of Stair Climbing Trolley," Int. J. Adv. Eng. Manag., vol. 8, no. 4, pp. 165–173, 2021, doi: 10.37896/sr8.4/022.

[4] A. G. Ajay, K. L. Harikrishana, S. Bharatharajan, and M. K. Avinashilingan, "Design and Development of Light Weight Mechanical Staircase Climbing Trolley with Better Stress Distribution," J. Chem. Pharm. Sci., no. 7, pp. 192–194, 2017, [Online]. Available: www.jchps.com

[5] N. W. E. N. I. Tun and H. H. Win, "Design and Fabrication of Stair Climbing Trolley," ICONIC Res. Eng. JOURNALS, vol. 8, no. 4, pp. 133–138, 2021, doi: 10.37896/sr8.4/022.

[6] P. V. S. Kumar, A. H. Kumar, and P. Varaprasad, "Design and Fabrication of Pedal Powered Stair Climbing Trolley," Int. J. Recent Trends Eng. Res., vol. 4, no. 3, pp. 479–483, 2018, doi: 10.23883/ijrter.2018.4153.afiwg.

[7] S. Chambhare, M. Mandhre, G. Yogesh, and Y. Joshi, "Fabrication of Stair Climbing Wheel Mechanism: Alternate for lifting goods," Int. Res. J. Eng. Technol., vol. 3, no. May, p. 4, 2016.

[8] S. Z. Shubham S, Sagar P, "Design and Fabrication of Easy Handling Trolley," Int. Res. J. Eng. Technol., vol. 5, no. 5, pp. 1690–1694, 2018.

[9] P. More, S. More, Y. Bhamare, A. Bhakte, and Y. Ingulkar, "Designing and Manufacturing of Stair Climbing Trolley," Int. Res. J. Eng. Technol., vol. 6, no. Feb, pp. 4373–4375, 2019.

[10] R. Nath, "Design and Parametric Evaluation of a Staircase Climbing Forklift," Int. Res. J. Eng. Technol., vol. 7, no. July, pp. 2832–2839, 2020.

[11] A. L. A, K. S. A, S. A. I, and T. E. A, "Design of Prototype based on Rocker Bogie Mechanism for Stair Climbing Material Handling Equipment," Int. Res. J. Eng. Rechn., vol. 7, no. May, pp. 7975–7981, 2020.

[12] Muhammad Syafiq Norain and B. S. Yew, "Tri-Wheels Stair Climbing Trolley," J. Eng. Sci. Res., vol. 5, no. 3, pp. 1–6, 2021, doi: 10.26666/rmp.jesr.2021.3.1.

[13] Aliyu, Z. Hussaini, T. B. Ephraim, and J. M. Misali, "DESIGN MODIFICATION AND SIMULATION OF A STAIR CLIMBING TROLLEY," FUDMA J. Sci., vol. 33, no. 1, pp. 1–12, 2022.

[14] Rajkumar, K. Vivek, and R. M. Subba, "Design and Analysis of Universal Trolley Carrier with Stair Climbing Mechanism," Int. J. Adv. Trends Eng. Technol., no. January, pp. 128–131, 2018.

[15] D. D. OLODU, M. ABRAHAM, J. JESUOROBO, and O. O. AKIAKEME, "the Design and Construction of a Locally Sourced Electric Powered Stair Climbing Trolley," Black Sea J. Eng. Sci., no. 2022, pp. 25–31, 2022, doi: 10.34248/bsengineering.1187210.

[16] K. Meng, "One Kind of Semi-automatic Loading Mope by Stair Climbing," 2nd Int. Conf. Adv. Mech. Eng. Ind. Informatics (AMEII 2016) One, no. Ameii, pp. 1249–1254, 2016, doi: 10.2991/ameii-16.2016.235.

[17] P. J. P. Raj, P. M. M. Fuge, R. P. Caleb, and G. Natarajan, "Design and Fabrication of Stair Climbing Trolley," Int. J. Adv. Eng. Technol. Manag. Appl. Sci., vol. 8, no. 4, pp. 89–102, 2021, doi: 10.37896/sr8.4/022.

[18] H. Gangadia, H. Shukla, S. Patel, and M. Jani, "DESIGN AND MODELING OF STAIR CLIMBING TROLLEY," Sarjan, vol. 4, pp. 62–69, 2015.

[19] N. Dileepan, M. Kumaresan, M. Mohanraj, M. Naveenraj, and V. Krishnaprasanth, "Design and Fabrication of IOT based Stair Climbing Robot," Int. J. Eng. Res. Technol., vol. 7, no. 06, pp. 3–6, 2019.

[20] R. Yadav, R. Dundale, S. Phadtare, and A. Yenare, "Design and Manufacturing of Staircase Climbing Trolley," Int. J. Res. Appl. Sci. Eng. Technol., vol. 8, no. 7, pp. 1326–1332, 2020, doi: 10.22214/ijraset.2020.30487.

[21] T. V. Swamy, A. Khurshid, and M. Nagendrappa, "Design and Analysis of Motor Operated Load Carrying Stair Climber," Int. J. Technol. Emerg. Sci., vol. 01, no. 01, pp. 16–22, 2022.

[22] E. N. Chaudhari, H. B. Pawar, A. S. Oak, and K. P. Patil, "Application of E-Bike Chain-Drive Transmission in Stair Climbing Trolley," Int. Res. J. Eng. Technol., vol. 7, no. July, pp. 2610–2619, 2020.