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Automatic Stair Climbing Machine

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***Abstract*—Simple mechanical devices like hand trolleys with single and dual wheel are finding their use in large number of industries as well as for household purposes. But their usage is limited to carry goods along the floors from one location to the other. Out of the formulated designs that are available in the market, no design fulfils the need of support in shifting the load over stairs. To eliminate this difficulty, stair wheels (combination of three wheels) are used as a substitute which will reduce the effort of lifting. The present paper focuses on the design and manufacturing of a tri-wheel stair climbing hand trolley to move along rough surfaces and to transport considerable loads over stairs with the improved wheel arrangement, with comparatively less human effort & manufacturing cost. The design concerns including steepness of the stairs, steadiness and speed of the trolley while climbing the stairs are discussed. Hybrid trolleys such as tri wheeled ones can be adopted to carry several items at various locations where mechanical elevators cannot be installed.**

***Index Terms*—Automatic stir climbing machine, automation, climbing system, robotic machine, material handling, industrial robots, stir climbing technology, mechanical engineering, automation in construction.**

I. INTRODUCTION

In the early 2000s, a research group has come up with a rover type of vehicle with rhombus configuration with one wheel mounted on a fork in the front, one wheel in the rear and two bogies attached on either side of it. Chang Hsueh-Er came up/suggested/proposed with a five-wheeler trolley which can be operated manually. Anastasios et al. and D. Helmick et al. has designed a robotic carrier with no wheel attached and was driven by belt. Serious research has been done to redesign such mechanisms to make them efficient, economical and affordable. Urbanization results in structurally congested buildings in the rural areas in many countries where availing elevator facility is difficult. Even in the small industries and construction sites the load is transferred by means of cranes which can lead to accidents/slips in some cases. Stair climbing trolleys acts as a replacement in locations where human labour seems to be the only alternative, thereby reducing human effort. They are designed to safely manoeuvre heavy items which may exceed 150 kg for instance refrigerators, washing machines, cupboards, water cans, books, small containers, food grains, toxic items etc., from ground floor to top floor and vice versa.
The objective here is to design and manufacture a multi functioned trolley that serves different purposes which includes moving on the floor and climbing the stairs. In the early designs, a single wheel or a set of wheels set on each side is merely capable of moving the vehicle on flat surfaces. Here the modelling is done in such a way that it has tri wheels on every facet that enables shifting the load over stairs. It comprises of two sets of three wheels attached to a frame at 1200, positioned at the bottom of the trolley which works as a single unit. Handles are provided to give support to the frame and apply the human effort either to push or pull the trolley. The size, shape, selection of the frame, position of the trolley changes as per the working load and requirement. With bearing support, the wheels are mounted on the shaft. Material selection is also a main consideration. In general, Stainless steel is used to carry heavy loads and mild steel is preferred for moderate loads. The movement of stair wheel trolley.

II. PROBLEM STATEMENT

Many individuals, such as delivery personnel, the elderly, or those with mobility impairments, struggle with transporting heavy or bulky items up and down stairs. Traditional trolleys are inefficient or unusable on stairs, increasing the risk of injury or product damage.

Key Problems:

1. Manual Effort: Carrying items upstairs is physically taxing, especially for heavy loads. Users, like delivery workers or older individuals, often experience fatigue or strain.
2. Safety Concerns: There is a high risk of items falling, or the user losing balance, potentially causing accidents and injuries.
3. Time-Consuming: Transporting items using conventional trolleys on stairs requires multiple trips, increasing delivery times or household chores.
4. Accessibility Issues: For people with disabilities or the elderly, stair-climbing with traditional tools is often impossible without assistance.
5. Durability on Stairs: Standard trolleys lack the necessary features to safely and efficiently maneuver stairs, leading to wear and tear.

III. LITERATURE SURVEY

Many researchers performed various experimental investigations on stair climbing vehicles such as trolley, trucks, chair for handicapped person, forks etc. it requires an in-depth study of maximum load acceptable for a cabin and how stress transferred to wheels alignment.

Pratik H. Rathod et al. [1] designed and fabricated a hand truck which climb stair with less effort which is useful for library, hospital, regular goods carrier etc. the main modification in this truck were made at wheels using plat surface roller plat attached instead of traditional wheel frame. The mechanism based on retched arrangement mechanism. The maximum bending moment was calculated. The inclination of 44 degrees plays a major role which covers more than 90% of all stairways within this limit. There is an optional maximum inclination warning alarm that alerts the operator of an inclination of more than 44 degrees. When truck operated with exceeding the limit there should be taken the necessary safety precautions.

Md. A. Hussain et al. [2] designed and manufactured a stair climbing vehicle using modified form of frame arrangement i.e a curved wheel frame which move on rough surface. To address several technical issues in designing this vehicle is stability and maintain high speed at vehicle wheel arrangement while climbing stairs. The frame arrangement consists of sun, planetary, idler wheel which are assembled to the shaft which reduces application of load. However, the steepness of the stairs is also the important concern of this study. The vehicle has four set of wheels arrangement to support its weight when it moves over the flat terrain. Each wheel frame consists of three sub-wheels attached with the sun wheel through three idler gears.

Ashish Singh et al. [3] worked on four-wheeled robot will have the capability of climbing the stairs of height equal to its diameter. It will possess maximum gripping capacity and stability during motion in rough terrain owing to the 4 differential driven wheel configurations. The maingoal of this investigation involved within this project such as the robot should be upgradeable with a variety of application sensors, e.g. cameras, thermal vision, or chemical sensors. To be usable in any search and rescue or security application, the robot has to be operational without changing batteries for at least two hours.

Raj Kishor Kumar et al. [4] investigated on stair climbing functionality is embedded in the design through its structure and mechanism. The product mainly consists of modules viz. seat, links and frame. Anthropometric measures are considered in the dimensioning of seat. Focus is laid on different parameters such as form, functionality, technology and architecture of the product. The design is validated by developing Digital Mockups of individual parts are generated in PRO-E Creo software and are assembled to form the final product. Necessary simulations of the product are generated in virtual environment of PRO E Creo software. The physical and focused prototype indicating the structure and functionality is developed using thermocol material. Here wheel carriers are made in RP (Fused Deposition Modelling) using ABS (Acrylo Butadiene Styrene) material. Wheelchair is embedded with some additional features like integrated commode facility, after gathering costumer requirements from different subjects.

P. Jey Praveen Raj et al. [5] designed device such as hand trolley 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 to 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 6 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 pinion-gear 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.

Roshan Alaspure et al. [6] designed AND fabricated a Stair Climbing Wheel Mechanism which can be considered as Alternate for lifting goods in such a way that it can be climb a stepped path with its modified wheel structure using manual metal arc welding (MMAW) or stick Welding. An electric current is used to strike an arc between the base material and consumable electrode rod or stick. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapors that serve as a shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination.

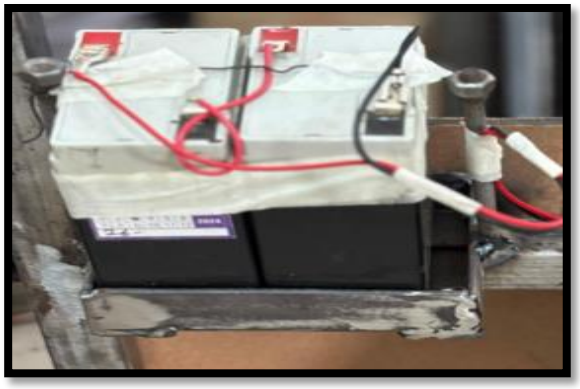
P. P. Gondole et al. [7] fabricated a stair climbing hand trolley with proper dimensions of Height 4 feet, Lower frame 38 X 38 cm, Length of each arm of trigonal wheel axial geometry 15 cm, Diameter of shaft 15 mm. The major components used to fabrication process are square bar cast iron pipe, Round bar shaft of SAE 1030, rubber rest, caster wheels (industrial rubber), iron plate, long guzzon pin. Mathematical calculations are made to this work to exhibits expected results and carried load across the stair very easily thus climbing across stairs transportation of goods very easily.

IV. METYHODOLOGY

1. Weight Capacity: Measurement of the maximum load the trolley can safely carry, often ranging from a few hundred pounds to over a thousand, depending on the design.

2. Dimensions: Overall size, including height, width, and depth, as well as the size of the wheels or tracks, which affect maneuverability and storage.

3. Power Specifications: Voltage and wattage of the motor, as well as battery life and charging time for electric models.



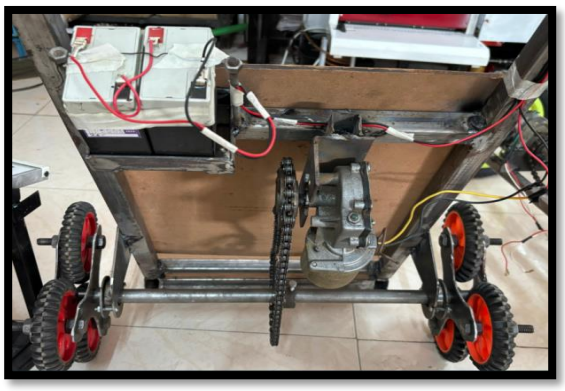
4. Speed: Rate at which the trolley can ascend or descend stairs, typically measured in feet per minute.

5. Angle of Incline: The maximum angle of stairs the trolley can navigate safely, usually expressed in degrees

6. Durability Ratings: Material strength and wear resistance, often tested through standard protocols to ensure long-term use.

7. Safety Features: Measurements related to braking force, stability, and emergency stop functions.

8. Design Methodology**:** The tri star wheel trolley presented here is designed using the version CATIA P3 V5 R11. CATIA is a multi-platform mechanical design suite. It is a characteristic aided supported, parametric solid modelling design tool. Conceptualization, design, engineering, manufacturing and PLM are multiple phases supported by CATIA. It is easy to transform 2D sketches into 3D parts in CATIA as it has user-friendly graphical interface. By means of using automatic or user described relations to confine design objective complete 3-D replica are generated with or without constraints. To perform operations like add, remove, rotate, sweep and cut the material while modelling, the different features used are Pad, Pocket, Revolve, Rib, Slot, Loft etc. for this design



9. Designed Parts: After calculating the basic design dimensions of the Stair climber, each part is designed with the help of dimensions.

10. Body: The body is designed for a height of about 106.60cm and is later fabricated with Mild Steel. The handle is attached to the extreme rails of the trolley body on either sides at an angle of 200 (with vertical). The base of the trolley is welded and it is made up of Mild Steel material. Accurate metrology ensures that the trolley meets safety standards and performance expectations for its intended use.

V. WORKING OF STAIR CLIMBING TROLLEY

Purpose of this trolley is to reduce human effort while carrying load over stairs. It has two sets of three wheels each on both sides of trolley. When first wheel come across a vertical side of step its motion will resisted and whole set of Tri-Star wheel will tilt and another wheel will fall on next step of stair and this process will repeated and with less effort load will be transported over stairs. It has adjustable handle. Whenever height or position of handle is not suitable for a person carrying, he may feel back pain or stress will act on his back. To reduce this problem person can adjust the handle of trolley as per his need just by unbolting nut-bolt and entering bolt in suitable hole of handle. It has weight calculating electronic machine which will display weight of load applied over it.

It has provision to adjust distance between three wheels of Tri-Star wheel from one another so that whenever size of step will change, we can change distance between wheels so that it will not create problem while climbing stairs.

VI. EXPECTED OUTCOMES

- Easy Vertical Transportation.
- Ergonomically suitable for the peoples with different height.
- Can measure the weight applied over it.
- Efficient Goods/Material Transport in Buildings.
- Less maintenance and cost.
- Can easily move on stairs as well as flat surfaces.

VII. RESULTS & DISCUSSION

Load Capacity: State the maximum load tested (e.g., 15 kg) and performance at different loads. Discuss any issues encountered with higher weights.

Speed: Present data on ascent and descent speeds under different loads.

Unloaded: 1 stair per second

Loaded (15 kg): 0.7 stair per second

Energy Efficiency: Provide data on battery usage, such as: Distance or number of stairs climbed per full charge. Battery consumption rates under varying loads.

Stability: Discuss the trolley's performance on different stair types. Include observations on any tipping or stability issues during testing.

VIII. 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 10 kgs on flat surface. It has the ability to ascend a flight of stairs of 45-degree elevation carrying a weight of 10-15 kgs. 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.

The primary objective of bearing heavy load like 10-15 kg is achieved during testing. The performance is slightly complicated when the straight frame was tested for varying step sizes. But when tested with Quasi-static frame, the vehicle exhibited greater performance even for stairs with different dimensions. Static structural analysis demonstrates that it is capable of moving heavy loads with less deformation and without any fracture. To operate with ease a motor can be arranged to the vehicle. Usually, its minor shortcoming is its noise. But it is very ergonomic to operate on stairs, inclines and uneven surfaces. It is efficient, economical and easy to assemble. It is proposed for material handling. Several advantages with this machine are effortless transportation of Heavy luggage, furniture from one floor to other. Bricks of different models and sizes can be easily carried in construction sites. The overall performance of the vehicle is observed as high with uniform steps

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