

# Automatic Stair Climbing Trolley

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**Abstract**— 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 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 endeavors 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.

**Key words:** Stair Climbing

## I. INTRODUCTION

The Tri-Star wheel was designed in 1967 by Robert and John Forsyth of the Lockheed Aircraft Corporation. They were first developed as a module of the Lockheed Terrastar, a commercially unsuccessful amphibious military vehicle. A Tri-Star wheel functions as an ordinary wheel on flat ground, but has the ability to climb automatically when an impediment to rolling is encountered. This wheel design consists of three tires, each mounted to a separate shaft. These shafts are located at the vertices of an equilateral triangle. The three shafts are geared to a fourth, central shaft (to which a motor may be attached). When geared in this quasi-planetary fashion, these triangular sets of wheels can negotiate many types of terrain, including sand and mud; they can also allow a vehicle to climb over small obstructions such as rocks, holes, and stairs. The wheel assembly may be gear-driven, with two wheels in rolling contact with the ground. The third wheel idles at the top until the lower front wheel hits an obstruction. The obstruction prevents the lower front wheel from moving forward but does not affect the motion of the driving axle. This causes the top wheel to roll forward into position as the new front wheel. This wheel usually lands on top of the obstruction and allows the rest of the assembly to vault over the obstruction.

## II. OBJECTIVES

Lifting heavy objects to upper stories or lifting heavy loads to upper level from the ground are not painful jobs, especially where there are no lifting facility (elevator, conveyer, etc.). This project can introduce a new option for the transportation of loads over the stairs. The stair climbing trolley can play an important role in those areas to lift load over a short height.

## III. EXPERIMENTAL SETUP

The elements used to prepare our model of Automatic Stair Climbing Trolley are as follows:

– DC Motor

The most important element of our model is the DC motor. We used an old 12v wiper motor which we obtained from a car parts sales.

– Battery

We need a 12v Battery to run the DC motor in the whole setup.

– MS Frame

The foundation on which the whole mechanism is set up is made out of mild steel. It is made out of welding MS plates.

## IV. NEED FOR STAIR CLIMBER TROLLEY

Lifting heavy objects to upper stories or lifting patients to upper levels from the ground are not painless jobs, especially where there are no lifting facilities (elevator, conveyer, etc.). Moreover, most of the buildings are structurally congested and do not have elevators or escalators. This project can introduce a new option for the transportation of loads over the stairs. The stair climbing hand trolley can play an important role in those areas to lift loads over a short height. After doing the above we were finally able to get our mechanism up and running smoothly and produce a continuous transfer of boxes with required time delay.

## V. NEW CONCEPT

The stair-climbing hand truck is designed to reduce liability rather than increase it. Conventional hand trucks work well on flat ground, but their usefulness decreases when it becomes necessary to move an object over an irregular surface. Package deliverymen, for example, often find it necessary to drag loaded hand trucks up short flights of stairs just to reach the front door of a building. The entire purpose of using a conventional hand truck is to avoid having to lift and carry heavy objects around.

Lifting a hand truck up the stairs defeats the purpose of the device, since the user must provide enough upward force to lift the entire weight of the cart and its contents. Furthermore, the geometry of a hand truck makes it nearly impossible to lift with one's legs, as is the proper form. Considerable strain is placed on the back muscles and the risk of operator injury is sharply increased. The pulling up of a standard hand truck up the stairs results in a bumpy and jarring motion. This motion may damage the items loaded on the hand truck or cause them to fall off entirely. A hand truck that could climb stairs without requiring the user to lift would improve the safety of moving heavy objects over irregular surfaces. In our project, we are designing and fabricating normal hand trolleys with Tri-Star wheel in order to enable the trolley to move up or down the stairs.

## VI. PRINCIPLE

The principle of Automatic Stair Climbing Trolley is reduce human effort for handling of materials in industries for material shifting of ground floor to first floor where lift or any equipment is not available.

### A. Application

In our project, we are using this Tri-Star wheel arrangement in a hand trolley in the place of normal wheels setup to enable the trolley to climb up and down the stair cases and also to up come small obstacles like holes and bumps on its path.

## VII. MATERIAL SELECTION

Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials.

### A. Stainless Steel Grade 304:

Steel Type 304 is a variation of the basic 18-8 grade, Type 302, with a higher chromium and lower carbon content. Lower carbon minimizes chromium carbide precipitation due to welding and its susceptibility to inter-granular corrosion. In many instances, it can be used in the "as-welded" condition, while Type 302 must be annealed in order to retain adequate corrosion resistance. Type 304L is an extra low-carbon variation of Type 304 with a 0.03% maximum carbon content that eliminates carbide precipitation due to welding. As a result, this alloy can be used in the "as-welded" condition, even in severe corrosive conditions. It often eliminates the necessity of annealing weldments except for applications specifying stress relief. It has slightly lower mechanical properties than Type 304.

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- DC Motor Speed: 60 RPM
- Trolley Size: 220mmx220mmx80mm
- Mechanism: Chain & Spocket
- Materials: MS (Mild Steel) and Wood
- Total mechanism weight: 25 Kg (approx.)

## VIII. DESCRIPTION OF THE PROJECT

A typical hand trolley consists of two small wheels located beneath load-bearing platform, the hand trolley usually has

two handles on its support frame. These handles are used to push, pull and maneuver the device. The handles may extend from the top rear of the frame, or one handle may curve from the back. An empty hand trolley usually stands upright in an L-shape, and products are usually stacked on top of the platform. When the goods are in place, it is tilted backward so that the load is balanced between the platform and the support frame. Especially if heavy or fragile materials are moved, the person operating the trolley should return it to an upright position carefully, to insure nothing falls off the platform. The front of the frame may be squared off for boxes or curved for drums and barrels. Sometimes, a hand truck also has straps for securing loose freight during transport.

Professional material handlers prefer to use a hand truck when moving stackable items such as boxes, crates or packages. Heavier items are usually stacked on the bottom of the hand truck, with lighter objects saved for the top. Hand truck users must be careful not to stack it so high that their vision is blocked or the load becomes unstable. Generally, it is safe to load a hand truck to the level of its handles or the top of the frame. The load is then shifted onto the wheels with a backwards lifting motion. The user can maneuver the cargo by steering it left, right or forward.

### A. Wheel Selection

Wheel material selected – Filled rubber

Types of Wheel Material

#### 1) Filled rubbers

In tyres rubbers are usually filled with particles like carbon black or silica. They consist of a tread and a body. The tread is the part of the tire that comes in contact with the road surface. The portion that is in contact with the road at a given instant in time is the contact. Treads are often designed to meet specific product marketing positions.

#### 2) Polyurethane

Polyurethane (PUR and PU) is a polymer composed of a chain of organic units joined by carbamate (urethane) links. While most polyurethanes are thermosetting polymers that do not melt when heated, thermoplastic polyurethanes are also available. The main ingredients to make a polyurethane are isocyanates and polyols. Other materials are added to help processing the polymer or to change the properties of the polymer.

#### 3) Steel

Steel is an alloy of iron, with carbon being the primary alloying element, up to 2.1% by weight. Carbon, other elements, and inclusions within iron act as hardening agents that prevent the movement of dislocations that naturally exist in the iron atom crystal lattices.

#### 4) Static friction

The surface of the wheel and what it is rolling on are not perfectly smooth.

In sliding friction, this surface roughness is the reason for the static and kinetic resistance to motion. Although the wheel is not sliding, the surface roughness causes a "jiggle" when the wheel is rolling.

### B. Wheel Frame

A specially designed wheel frame is required to hold the three wheels together on each side of the shaft. In the existing design, the power transmission to the single or double wheel

trolley 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 in order 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. Easier maintenance was possible in case of replacing any defective parts such as nut, bolt, washer, etc.

### C. Processes Involved In Fabrication

#### 1) Gas Cutting (Oxy-Fuel Cutting)

Oxy-fuel cutting is a cost-effective method of plate edge preparation for bevel and groove welding. It can be used to easily cut rusty and scaled plates and only requires moderate skill to produce successful results. The oxy-fuel gas cutting process creates a chemical reaction of oxygen with the base metal at elevated temperatures to sever the metal.

We have used this cutting to cut the measured lengths of hollow mild steel pipes and flat bottom plate as per our design.

Tube bending as a process starts with loading a tube into a pipe bender and clamping it into place between two dies, the clamping block and the forming die. The tube is also loosely held by two other dies, the wiper die and the pressure die. The process of tube bending involves using mechanical force to push stock material pipe or tubing against a die, forcing the pipe or tube to conform to the shape of the die. Often, stock tubing is held firmly in place while the end is rotated and rolled around the die. For some tube bending processing, a mandrel is placed inside the tube to prevent collapsing. Much of the tooling is made of hardened steel or tool steel to maintain and prolong the tools life. However wherever there is a concern of scratching or gouging the work piece, a softer material such as aluminium or bronze is utilized. Pipe bending machines are typically human powered, pneumatic powered, hydraulic assisted, hydraulic driven, or electric servomotor.

We have employed human powered-tube bending process to bend two mild steel hollow pipes to make 60 bent handles.

#### 2) Plasma Arc Cutting

Plasma cutting is a process that is used to cut steel and other metals of different thickness and sometimes other materials, using a plasma torch. In this process, an inert gas is blown at high speed out of a nozzle; at the same time an electrical arc is formed through that gas from the nozzle to the surface being cut, turning some of that gas to plasma. The plasma is sufficiently hot to melt the metal being cut and moves sufficiently fast to blow molten metal away from the cut. Through the application of CNC technology in industrial production, the technology cut a wide range of high accuracy, low-cost and high efficiency. It gradually achieves its purpose of high-tech computer numerical control cutting, with both computer-controlled and plasma arc characteristics.

#### 3) Dc Motor

A windscreen wiper or windshield wiper is a device used to remove rain and debris from a bearing is a machine element

that constrains relative motion between moving parts to only the desired motion. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts. Environment, lubricant cleanliness and electrical currents through bearings etc.

#### 4) Components of the System

CNC system CNC system is an important part of the cutting machine, which consists of a computer system, servo system, the control unit, and the executive agencies. The computer system is made up of a keyboard, a monitor, and the unit. Servo system exploits a computer to implement a closed-loop control of the motor and to achieve its variable speed. Now it usually adopts communicate servo system. The control unit is central of sending a control signal to realize the control of the computer, the motor and the solenoid valve. The executive agencies include the electric motor and the solenoid valves and so on Programming system Programming system is parts of auxiliary programming and nesting system for developing CNC cutting machine. It can make the entire production process to form a whole, and to organize systematically. After the programmed machine compiles the program on the floppy disk, enter the cutting machine and start cutting, it can also be programmed in a simple cutter. Gas system Gas system include the gas pipeline, pressure gauge, regulator, etc., which can be controlled by the control system to realize the automatic on-off road of the gas. Mechanical operation system Mechanical operation system consists of the beam, gear box, chassis, lifting mechanism and other components.

#### 5) Problems faced by the equipment

Due to the high frequency of CPU and large power and high heat of hard drive, the internal parts of the system is subjected to overheating, making the CNC system and cutting machine unable to work normally and increases the requirement of industrial fans for cooling. When each part is not used efficiently during cutting edges, taking sides, linking bridge etc., it results in thermal deformation of the various parts consequently results in low efficiency. Automatic cutting cannot be achieved. There are no automatic cutting on CNC system and parameter libraries, workers can only speak of their own experience and observation of the eye, manually adjusting and controlling, thus it cannot effectively play productivity of the CNC cutting machine

### D. Welding

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound.

While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space. Welding is a potentially hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to radiation. The main Types of welding used in industry and by home engineers are commonly referred to as MIG welding, Arc welding, Gas welding and TIG welding.

#### 1) Arc welding

These processes use a welding power supply to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is sometimes protected by some type of inert or semi-inert gas, known as a shielding gas, and filler material is sometimes used as well.

#### E. Fabrication of the Machine

There are few types of fabrication methods are done on the machine. They are:

- 1) Arc cutting.
  - 2) Drilling.
  - 3) Grinding.
- Further Operation
  - Cleaning.
  - Assembling.

- Machining Operations  
In this project it is used to cut the raw material such as plates, rod. This is done by arc cutting machine.

- Drilling  
Drilling is used to produce holes in objects. In this project the square type pipe required the holes for making rake assembly. These holes are done by vertical type drilling machine.

- Fine Grinding  
It is nothing but a grinding process, which is done as smooth with fine grains. It is done by convention grinding machine.

- Cleaning  
It is the operation to clean the all machined parts without burrs, dust and chip formals. By meaning the parts they are brightened and good looking.

- Electric Motors – An Over View  
Electric motors, both ac & dc motors, come in many shapes and sizes. Some are standardized electric motors for general-purpose applications. Other electric motors are intended for specific tasks. In any case, electric motors should be selected to satisfy the dynamic requirements of the machines on which they are applied without exceeding rated electric motor temperature. Thus, the first and most important step in electric motor selection is determining load characteristics -- torque and speed versus time. Electric motor selection is also based on mission goals, power available, and cost.

- Power Source Description  
The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A RPS (Regulated

Power Supply) is the Power Supply with Rectification, Filtering and Regulation being done on the AC mains to get a Regulated power supply for the devices being used. The motor used requires a supply of +12V DC, which is derived from the single phase supply of 230V AC. A power supply unit can be broken down into a series of blocks, each of which performs a particular function. A DC power supply which maintains the output voltage constant irrespective of AC mains fluctuations or load variations is known as “Regulated D.C Power Supply”.

#### F. Inference

After its fabrication, we inferred few limitations like large noise production while moving the trolley up and down the stairs. In order to reduce the noise production the design of the wheel frame is to be modified such that line passing through the mid-point of the trolley wheel should pass through the mid-point of the step.

#### IX. CONCLUSION

Though this project had some limitations regarding the strength and built of the structure, it can be considered to be a small step forward, as far as Stair Climbing Vehicles are concerned. During the test run of this project, it was realized that it wouldn't be a bad idea to consider this design for carrying heavy loads up the stairs. This product will be well acclaimed if it can be commercialized to suit the needs. Though the initial cost of the project seemed to be higher but more accurate manufacturing would shorten this.

As far the commercial aspects of this product are concerned, if this product can be fully automated and produced at a lower cost the acceptance will be unimaginable. Presently, there are no competitors for such a kind of product in our market.

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