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Hand Truck Capable of Climbing Stairs using Timing Belt Driven by Motor

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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 this devices usually fails 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. 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 continuous track which enable us to carry load up and down the stairs. It also eases the movement of trolleys in irregular surface like holes, bumps, etc.

KEYWORDS: forklift, staircase, continuous track wheels.

I. INTRODUCTION

The subject of MACHINE DESIGN deals with the art of designing machine of structure. A machine is a combination of resistance bodies with successfully constrained relative motions which is used for transforming other forms of energy into mechanical energy or transmitting and modifying available design is to create new and better machines or structures and improving the existing ones such that it will convert and control motions either with or without transmitting power.

II. OBJECTIVES

1. The device should be able to provide necessary upward and downward motion withease.
2. The device should be able to carry weight upto100Kg.
3. The cost of device should be comparable to that of conventional fork liftmachines.
4. To reduce man power as well as human efforts eventually leading to savetime.

III. LITERATURE REVIEW

Giuseppe Quaglia , Walter Franco, Riccardo Oderio stated that Wheelchair.q [1] stated that “A motorized wheelchair with stair climbing ability. A concept for a stair climbing wheelchair was presented. Thanks to its auto-adaptive locomotion units, it can move in structured and unstructured environments, climb over obstacles and go up and down stairs. The locomotion unit's mechanical design makes it possible to reduce the number of motors and thus the wheelchair's weight and size. In fact, only one motor is necessary for each locomotionunit.”

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Jean-Luc PAILLAT Philippe LUCIDARME Laurent HARDOUIN [2] stated that “Evolutionary stair climbing controller for Unmanned Ground Vehicles. This paper presents a way to climb staircases with classical VGTVs by using their ability to modify their geometry in order to adapt themselves to the ground. It consists in a neural network which computes the elevation of the robot’s front part in respect to its inclination and the distance between it and the next step. This controller could be used concurrently to classical UGVs staircase climbing algorithms which guaranty the steering during climbing and improve its efficiency.”

B. Strah, S. Rinderknecht et al [3] concluded that “Autonomous Stair Climbing of a Wheeled Double Inverted Pendulum. Some extensions and improvements should also be mentioned. A compensation of Coulomb friction could improve the real system and the model matching. The control task is then to induce stable limit cycles. The presented methods can be transferred to systems with hybrid nonlinear dynamics, unilateral constraint or under actuation.”

IV. DESIGN AND FABRICATION

The CAD model of the product was designed to determine the external dimensions of the stair climber. The general steps to be followed in designing the machine are as followed.

- i) Types of load and stresses caused by the load.
- ii) Motion of the parts and kinematics of machine. This deals with the type of motion i.e. reciprocation. Rotary and oscillatory.
- iii) Selection of material & factors like strength, durability, weight, corrosion resistant, weld ability, machine ability are considered.
- iv) Form and size of the components.
- v) Frictional resistances and ease of lubrication.
- vi) Convenience and economy in operation.
- vii) Use of standard parts.
- viii) Facilities available for manufacturing.
- ix) Cost of making the machine.
- x) Number of machine or product to be manufactured.

V. METHODOLOGY

A stair climbing hand truck is a type of trolley which can be pushed or pulled up or down steps or a stairway. Stair climbing hand truck can be manual or battery-powered, and are commonly found in wheel, track, and push arm or walker variants.

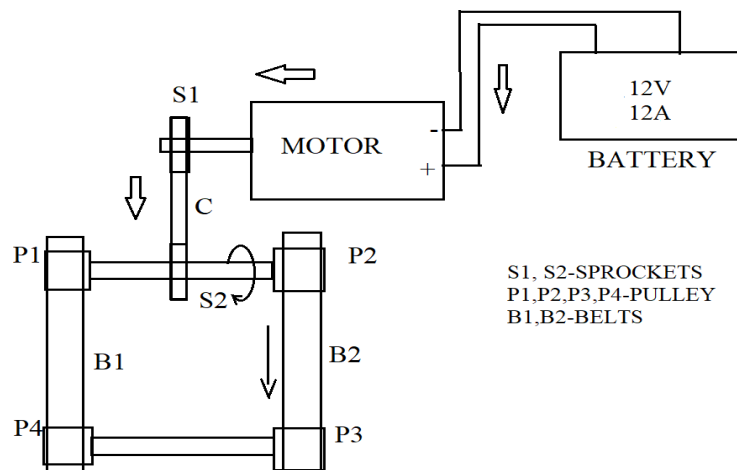


Fig.1.General Layout of Power Transmission

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GENERAL PROCEDURE IN MACHINE DESIGN

The general steps to be followed in designing the machine are as followed:-

1. Preparation of statement of the problem indicating the purpose of themachine.
2. Selection of groups of mechanism for the desire motion.
3. Calculation of the force and energy on each machine member.
4. Selection of material.
5. Determining the size of component drawing and sending for Manufacturing.
6. Preparation of component drawing and sending for manufacture.
7. Manufacturing and assembling the machine.
8. Testing of the machine and for functioning.

VI. DESIGN CALCULATION

It is very important to do force analysis for manufacturing any machine, so as per our purpose we are doing force analysis for load of 100Kg.

As per hand truck application it moves along plane surface in horizontal direction as well as it move upstairs and downstairs in incline direction.

Case 1]: when hand truck in incline position

On incline position it's driven by external power (motor)

ASSUMPTION:

Mass (m) = 100kg

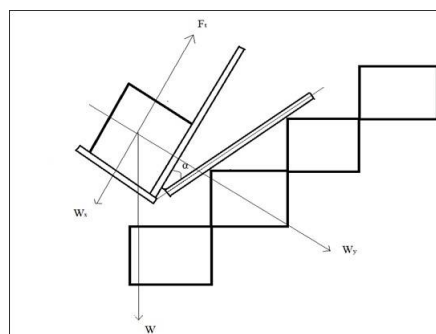


Fig.2 FBD for Inclined Position

- 1) Weight of Trolley
 $W = \text{Mass} \times \text{Gravity} = m \times g = 100 \times 9.81 = 981 \text{ N}$.
- 2) Reaction of the incline surface
 $R = W \times \cos(30) = 981 \times \cos(30) = 849.57 \text{ N}$
 $\approx 850 \text{ N}$.
- 3) Weight in the direction of movement

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$$W_x = W \cdot \sin(30) = 981 \cdot \sin(30) = 490.5$$

$$W_x \approx 491 \text{ N.}$$

$$4) \text{ Propulsion force} = F = 491 \text{ N.}$$

Material = C 45 (mildsteel)

Take fos 2

$$\sigma_t = \sigma_b = 540 / \text{fos} = 270 \text{ N/mm}^2$$

$$\sigma_s = 0.5 \sigma_t = 0.5 \times 270$$

$$\tau = 135 \text{ N/mm}^2$$

$$(135 \cdot 2) / D = (85283.705 \cdot 32) / (\pi \cdot D^4)$$

$$D = 14.76 \text{ mm}$$

$$D \sim 17 \text{ mm}$$

Diameter of shaft = 17mm

DESIGN OF KEY FOS=3

$$\sigma_c = S_{yt} / \text{FOS} = 460 / 3 = 153.33 \text{ MPa}$$

$$\tau_s = S_{yt} / (2 \cdot \text{FOS})$$

$$460 / (2 \cdot 3) = 76.66 \text{ MPa}$$

$$T = 29430 \text{ Nmm}$$

$$D = 17 \text{ mm}$$

Rectangular key

$$W = D / 4 = 17 / 4 = 4.25 \text{ mm}$$

$$W \sim 5 \text{ mm}$$

$$H = 2W / 3 = 3.33 \text{ mm}$$

$$H \sim 6 \text{ mm}$$

$$W = 5 \text{ mm, } H = 6 \text{ mm, } L = 70 \text{ mm,}$$

$$\sigma_c = (4T) / (DHL) = (4 \cdot 29430) / (17 \cdot 6 \cdot 70) = 16.487 \text{ MPa}$$

$$16.487 < 153.33 \text{ MPa } \tau_s = (2T) / (DHL) = (2 \cdot 29430) / (17 \cdot 6 \cdot 70) = 8.243 \text{ MPa } 8.243 < 76.66 \text{ MPa}$$

Hence, design is safe.

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VI. PART & ASSEMBLYDRAWING



Fig 3. Assembled Product

Parts:

1. DOLLY: It is an L-shaped box-moving [handcart](#) with handles at one end, [wheels](#) at the base, with a small ledge to set objects on, flat against the floor when the hand-truck is upright.



Fig 4. Dolly

2. WHEELS:

A caster wheel is a [wheel](#) equipped with [counterbalance steering](#), which allows it to rotate itself in the direction it is being propelled. Caster wheels exist in two basic types: rigid or swivel.

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Fig 5. Wheels

3. TIMINGBELT:

Continuous track, also called tank tread or caterpillar track is a system of [vehicle propulsion](#) in which a continuous band of treads or track plates is driven by two or more wheels.



Fig 6. Timing Belt

4. MOTOR & BATTERY: This motor Gives input to the caterpillar wheel to drive the belt. Battery gives input.



Fig 7. Motor

5. LATCHES AND BRACKETS:

A latch or catch (called sneck in Northern England and Scotland) is a type of mechanical [fastener](#) that joins two (or more) objects or surfaces while allowing for their regular separation.



Fig 8. Bracket

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VII. RESULT

The hand truck can climb the stairs carrying load with minimum human efforts. We calculated and got the following specifications:

Sr. No.	Part	Parameter	Value
1	Motor	Power Speed	90 W 50 rpm
2	Battery	Power Voltage Current	144 W 12 V 12A
3	Shaft	Equivalent Torque Diameter	85.283 Nm 17 mm
4	Pulley	Rotation	50 rpm

Table 1. Result Table

VIII. CONCLUSION

While manufacturing the staircase climbing hand truck we take the following process parameters and study parameters into consideration:

1. Application and actual use
2. Material and cost required for manufacturing
 - a) Buying of standard components easily available in the market
 - b) Components needed to be manufactured
 - c) Selection of material type for manufacturing above components by comparing different properties of different metal (mildsteel)
3. Calculation and Design
 - a) Calculation for parts and assemblies
 - b) Design done by using CAD CAM software
4. Manufacturing
 - a) Fabrication
Lathe, CO2 gas welding, drilling, cutting, grinding, powder coating, etc.
 - b) Customization according to the standard components.
5. Assembly done using manufactured components and brought up products.
6. Testing for power, torque, weight carrying capacity, etc.

Thus, the above steps give the clarity towards required study and general parameters.

During Manufacturing we understand actual process needed and respective machining technique and machine's working.

Hunting for components, specially standardized components, served us with a wide idea regarding the market, rarity of parts, strategies and many more.

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