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Design and Fabrication of Powered Load Carrying Stair Climbing Device

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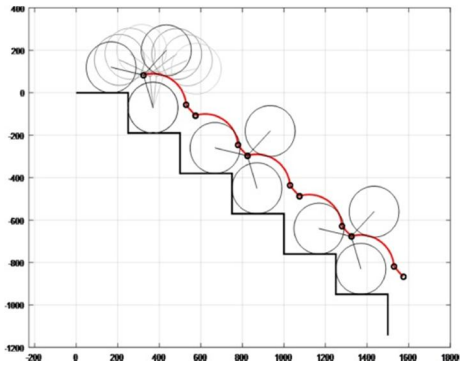
Abstract: ***In domestic as well as commercial buildings there are multiple times where the need to transport loads over stairs is observed. This is usually done by lifts or other mechanisms which are not certain enough. We can also see the utilization of paid labor in this process day in and day out. The devices that are available usually are trolleys which can be pushed or pulled by a number of members depending upon the amount of load and the distance over which it is to be carried. Thus, the current project aim is making a stair climbing load carrying device which can be used in such conditions. There are several devices available in the market that work around the same idea but are not commonly used due to many reasons, it is especially kept in mind to make this project economical and powered, to overcome the drawbacks of the present available systems. The device has a platform to carry the load and base conveyor belt assembly to cause the movement of the system, attached to the frame. The whole assembly is powered by motors that cause the pulleys to move.***
Keyword: Economical, Powered, Conveyor, Belt, Trolley.

I. INTRODUCTION

This work aims at designing and fabrication of a device that has multiple functions. The trolley is manufactured in such a manner that the frame is set on a conveyor mechanism that enables shifting the load over stairs. The belts provide better grip on the stairs. The existing challenges are mainly to balance the load over stairs and safety of the load while traversing.
The device is designed in such a way that it has two conveyors one on each side of the base. They are set so that it gives a good surface contact with the ground. It directly reduces human effort due to being powered.

II. LITERATURE REVIEW

There have been multiple attempts at making different devices that can be used to carry loads over the stairs one such device is a tri-star lobe shaped hand trolley that makes it easier to traverse the loads on the stairs, still the efforts of humans is necessary.
Another device which we found is a wheel chair that is made for transportation over stair the wheel chair interestingly uses a belt conveyor kind of system that is run by a set of driving and idler pulley.
A few devices that are available internationally are electric powered stair climbing trolley it has a frame structure to hold the load whereas a belt conveyor system at the base for transmission, however it is quite expensive.
Another device that can be studied in this area of concern is the Track O Stair climbing machine that has a belt assembly at base and a platform situated just above it to carry the loads, in this device the total load is concentrated at the base of the device making it heavy.



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III. PROBLEM STATEMENT

The problems that are currently faced in transportation of loads over stairs are-

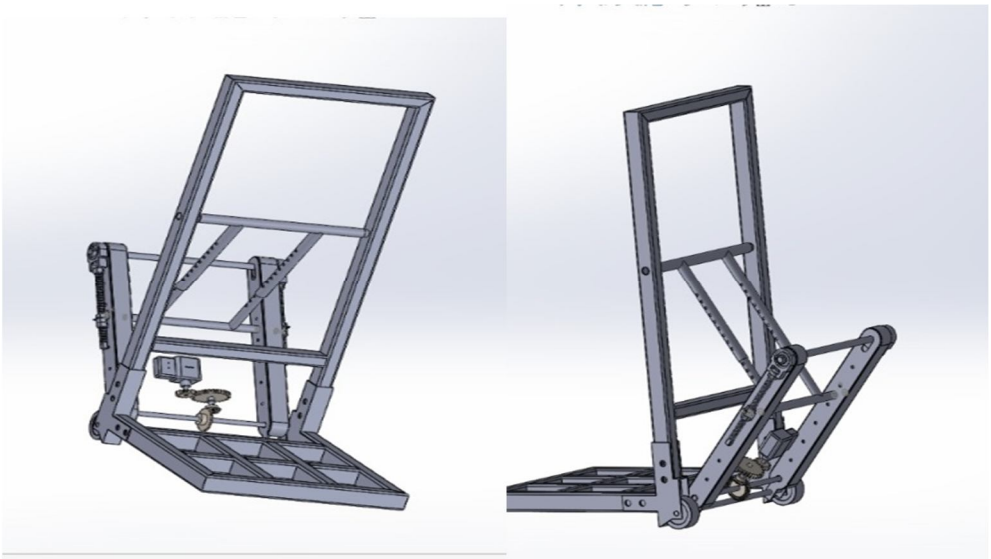
A. Decrease the human efforts.
B. Reduce the overall cost of the device.
C. Power the device for operation
D. Make it compact
E. Easily available for use.

IV. OBJECTIVES

The objectives of the project are as follows :

A. To design a prototype and make it work with least human interference and effort.
B. The climbing of the device is smooth and motorized.
C. The speed of device is enough so that the function is performed quick enough but operator can catch up with it.
D. The device should be economical enough for being commonly used.
E. The device and operator safety is prioritized.

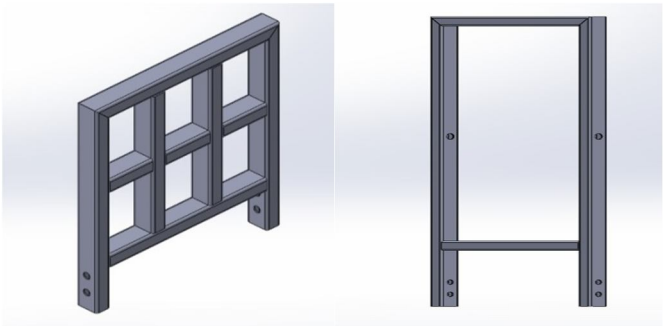
V. PROPOSED DESIGN



Cad Model

VI. SELECTION OF MATERIAL AND COMPONENTS

A. Chasis, Frame And Platform



3D CAD Model

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1) Material

Carbon Steel

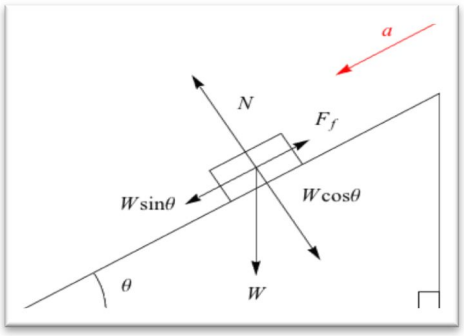
Composition: - Carbon→ 0.20 % - 0.30%

Manganese→ 0.30% - 0.60%

Properties: - Tensile strength 44.54 kgf/mm²

Yield stress 28 kgf/mm²

Hardness 170 BHN



B. Selection Of Motor

Stair Dimensions:

Land=254mm

Height=178mm

Slope of Stair (Θ) =$\tan^{-1}(\frac{178}{254})$

= θ≈35°

Total mass acting (including setup) =200kg =200×9.81≈2000N

Normal force acting(F_n)

=mgcosθ=2000cos35

=1638.30N

Frictional force ($F_{F)}$=μ×F_n

=0.2×1638.30

=327.66N

Opposing Force ($F_{o)}$=Mgsinθ

=1638.30×sin35

=939.69N

Total Torque Required=(F_f+F_f)×Radius of pulley

=(939.69+327.66)×68×10^{-3}×0.5

T =43.899N-m≈45N-m

Motor Power= P=$\frac{2\pi NT}{60}$=$\frac{2\pi N\times 45}{60}$

Power taken =0.5hp

=372.849W≈373W

373=$\frac{2\pi N\times 45}{60}$;

N=79.15rpm N_1=80 rpm.

C. Gear Box

The gear box here is used to provide the required speed to the driving shaft. We have used spur gears.

Gear Reduction Ratio =$\frac{RPM\ OF\ MOTOR}{RPM\ OF\ PULLEY\ REQUIRED}$

=$\frac{80}{140}$

= 0.571

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D. Differential

We use a pair of bevel gears with the speed ratio of 1:1 to transfer the power of motor at right angles to the driving shaft.

E. Shaft

Torque calculation

Take τ = 70 N/mm2

Shear stress is given by=$\frac{16T}{\pi d^3}=\tau$

70=$\frac{16\times45}{\pi d^3}$; d=14.84mm = 15mm

Considering factor of safety=1.5

D=1.5×15 =22.5mm

Choose d=25mm

We select dia. Of shaft = 25mm.

F. Pulley

We have used plastic polymer which is light and can be easily driven.

Total 16 pulleys are used. Out of which 2 are the driving pulleys and the rest are support pulleys for the belt.

G. Gripped Conveyor Belt

Conveyor belt is an important component of the design. The pulleys drive the belt. It provides better grip over stairs and also the required friction force to move over the stairs.

H. Velocity Of Belt Required

No.of stairs	Time taken to traverse	Total distance(10×310.16)m	Velocity($\frac{dist}{time}$)
10	6.98	3.101m	0.444m/s
10	5.65	3.101m	0.5488m/s
10	8.02	3.101m	0.3866m/s

Hypotenuse distance of each stair=$\sqrt{\mathbf{178^2 + 254^2}}$

=310.16mm

Velocity of belt required= 0.35-0.6 m/s

Rpm of pulley for required belt speed=$\frac{\pi DN}{60}$=V

=$\frac{\pi\times68\times10^{-3}\times N}{60}$=0.5

N_2=140RPM

(It is observed that overtime the belt might slack and lead to decreased efficiency thus, on the base frame a long nut tightening mechanism is provided so that the belt is self-tightened whenever needed.)

VII. WORKING

The trolley is motor powered. The motor is switched on or off to operate it. The motor is then connected to gear box which provides with the required reduction ratio to achieve given belt speed. To this gear box a differential is connected to power the driving pulley shafts. Over the driving pulley the conveyor v-belt is mounted which enables the movement of the structure. The belt is also provided with support pulleys. The load of the required value is placed on the platform on the frame, the platform may be inclined or kept at a stationery position.

Once the pulley is switched on the device starts to move along the stairs, an operator can accompany the device while traversing for safety.

VIII. CONCLUSIONS

The given presentation describes the research, design, modelling, Computer Based analysis and the fabrication of a powered stair climbing trolley. The trolley is based on the conveyor belt mechanism as primary means of movement. After SOLIDWORKS and ANSYS simulation we have concluded our design. The device is structurally safe at applied loads. The material selected and conveyor mechanism is capable of climbing stairs up to a certain height and angle. We have been successful in eliminating the slip of the wheels while climbing, which was done by providing a rubber conveyor with grooves on it. This allowed to better grip the surface and provide a higher coefficient of friction, needed to get the required frictional torque. And also, we implement the material handling with less human efforts in minimum time without damaging the material while transportation. The concept of the trolley is to make the device viable and available in domestic as well as commercial usage.

IX. FUTURE SCOPE

This mechanism can be further modified and used in various other applications.
We consider there are some improvements that need to be done in future**:**

1) Make a prototype and perform experimental tests on it, also replace parts which could give better efficiency.
2) We can adopt internal braking system.
3) Make it portable and detachable so we can carry anywhere, also make it less bulky.
4) Add SENSORs and LED's to know when safety is hampered.
5) The trolley can be transformed into a wheel chair for specially abled people by keeping the base same and making modifications to the loading areas.
6) Test for other materials instead of Mild Steel.
7) Make it completely automated and give remote operation.

X. ACKNOWLWDGEMENT

We would like to express our deep sense of respect and gratitude to our guide, Prof. M.A. Gulbarga, who didn't only guide the academic project work but also stood as a teacher and Mentor in realizing the imagination in pragmatic way, we want to thank him for introducing us to the field of Optimization and giving us the opportunity to work under him. His optimism has provided an invaluable influence on our careers and outlook of the future. We consider it our good fortune to have got an opportunity to work with such a wonderful person. He has been great source of inspiration to us and we thank him from bottom of our heart. We like to express our gratitude to our workshop staff, our head of the department, Prof. M.A. Gulbarga and our Principal Dr. Aqueel Ahmad Shah for their valuable advice and permission for carrying out project work inside the college premises. We also are thankful to the college, the workshop s & vector staff for their help, guidance and support throughout. We are especially indebted to our families for their love, sacrifices and support whenever and wherever needed in life.

XI. CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article

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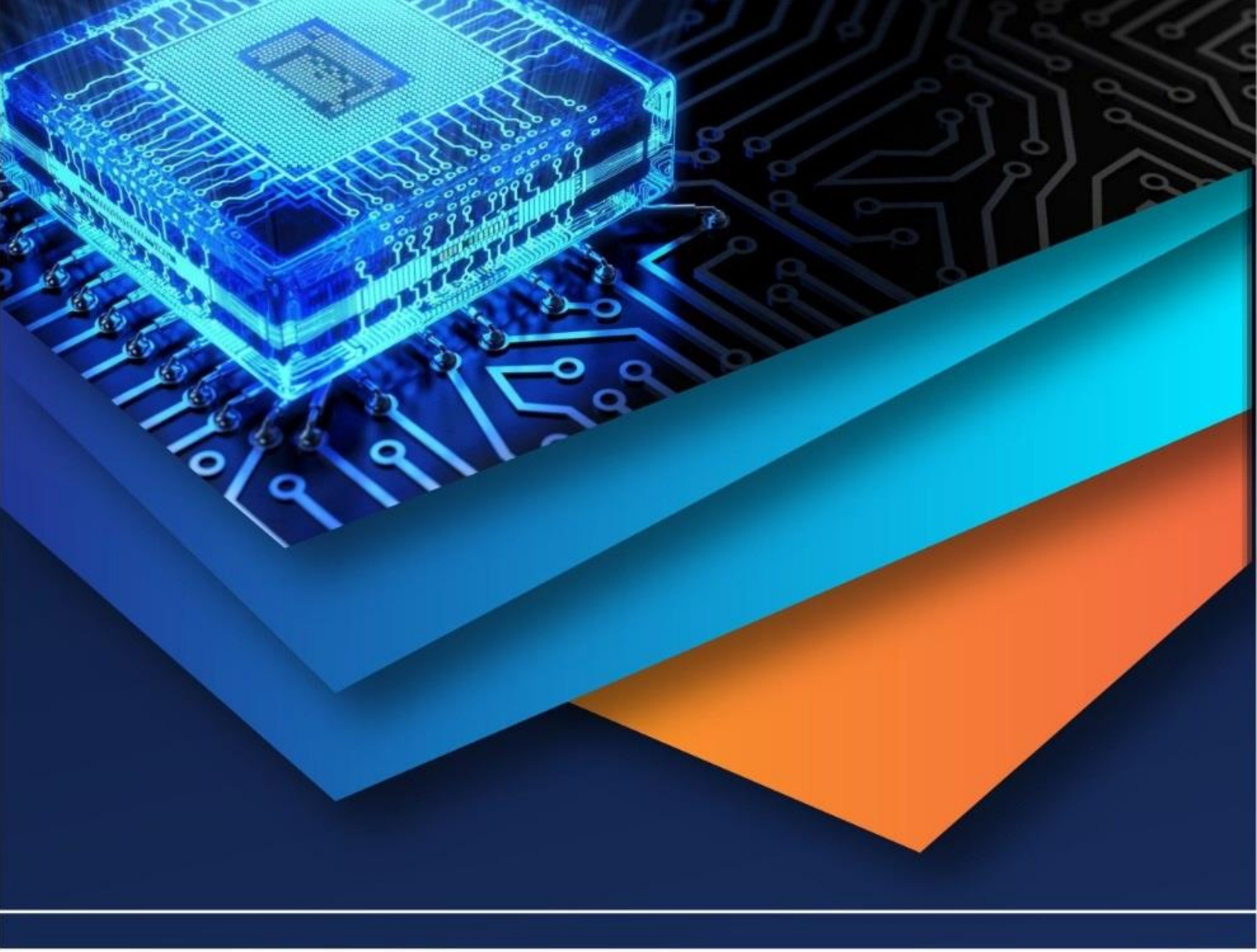

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