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Design of Prototype based on Rocker Bogie Mechanism for Stair Climbing Material Handling Equipment

Akumalla Lukmanhakim A.[1], Kadri Shadab A.[2], Shaikh Aamir I.[3], Tevildar Eebad A.[4]

[1-4] *Student, Department of Mechanical Engineering, Rizvi College of Engineering, Mumbai, Maharashtra, India.*

Ameya Nadkarni[5]

[5]*Professor, Department of Mechanical Engineering, Rizvi College of Engineering, Mumbai, Maharashtra, India.*

Abstract - *In the field of production technology though there are many developments and advancements in Material handling, still there are difficulties to carry industrial loads over rough terrain surfaces, stairs or to elevated surfaces. Handling of finished goods at construction areas is a very important matter of concern. As goods need to be transported through all terrain conditions hence there exists a demand for a mobile user-friendly material handling device. We intend to produce a project a material handling device with a mechanism (rocker bogie mechanism) which can enable the device to move on all terrain surfaces like rough constructional areas, stairs etc consuming less effort, energy and portable in nature. Our project also aims at developing a project which facilitates a user-friendly mode of waste collection at domestic level. Our project "Waste Collection Stair Climbing Material Handling Equipment" incorporates a mechanism which can enable the garbage trolley to climb stairs during waste collection in society buildings. An additional modification of making the trolley completely foldable can also be incorporated in order to achieve optimum space utilization and to make it portable. A special modification was done of making the trolley power driven so that it reduces human effort and provides more flexibility in operation by using DC motors and power supply. Hence after static and dynamic testing and analysis on SOLIDWORKS and ANSYS with formulative design calculations "Waste Collection Stair Climbing Material Handling Equipment" was intended to be made.*

Key Words: **Material Handling, Rough Terrain Surfaces, Waste colletion Trolley, Rocker Boggie Mechanism.**

1. INTRODUCTION

In order to have his life on earth man must find a way to innovate his lifestyle and things in his surroundings. With increasing population there is an increase in the demand of accommodates and this increase in population results in increased waste formation in the form of plastic, medical waste, daily household waste, industrial waste, etc. A proper waste collection and dumping system should be incorporated in order to create a hygienic environment in the society of which we are a part of.

This equipment facilitates a user-friendly mode of waste collection at domestic level. "Waste Collection Stair Climbing Material Handling Equipment" incorporates a mechanism which can enable the garbage trolley to climb stairs during waste collection in society buildings.

Specialized Applications of Project

1) Waste collection Domestic Trolley.

2) Industrial Material Handling equipment.

There will be a future scope of providing the trolley with a smart bin which can automatically open by detecting the user, which can display the level of garbage inside the trolley and can segregate the dry and wet waste. This modification can be achieved by using several electronics sensors like ultrasonic, thermostatic and proximity sensors etc.

A further attempt has been made and the trolley is made completely power operated in order to reduce the effort of user. This was achieved by using D**C** motors and power supply through Batteries.

Hence a after static and dynamic testing and analysis on SOLIDWORKS and Ansys with formulative design calculations **"Waste Collection Stair Climbing Material Handling Equipment"** was made.

1.1 Need

In the field of Production Technology' though there are many developments and advancements in Material Handling' still there are difficulties to carry industrial loads over stairs or at elevated surfaces. Use of lift simplifies the effort of carrying loads at elevation with minimum possible time but these lifts cannot be used in all places as they result in more floor space, high installation & maintenance cost and cannot be used at constructional sites and at plant layout for movement of raw material from one station to another.

Lifting heavy objects to upper stores or transporting important & delicate pharmaceutical equipment or medicines upstairs is a tedious job and hence there prevails a demand for stair climbing trolley or a robot. Moreover, most of the buildings are structurally congested and do not have elevators or escalators in them.

There exists a difficulty in waste collection and dumping activity which is indeed very important in maintaining hyena and cleanliness in society's and public areas. Hence there exists a demand for a mobile user-friendly device which incorporates a mechanism which can enable the garbage trolley to climb stairs during waste collection in society buildings.

This is a wide field of study and is very less explored. So, this gave us the motivation for the development of this rocker bogie suspension system in a cost-effective manner. With the growth of industrialization and population our motto was to explore and develop a model which can benefit the industrial and human society. With certain development it can be used in defense related operation and wheelchairs.

This project introduces a new option of Material Handling equipment to carry goods upstairs or as a waste collection trolley for domestic purpose.

1.2 Importance of Material Handling

Material handling refers to controlling, moving, storing, protecting as well as storing materials like goods, Raw material, in process inventories, finished goods or waste/scrap materials etc. for manufacturing, disposal, consumption or even distribution to end user.

Material Handling equipment are very important and crucial because goods should be handled well and made to reach their destinations safely and timely.

Proper Material handling is important because it will help us to,

- To speed up the movement of Material.
- To maintain hygiene by maintaining cleanliness.
- For better housekeeping.
- To improve plant accuracy.
- To minimize fatigue of user.
- To improve productivity.

2. LITERATURE REVIEW

2.1 {Arunkumar Balakrishnan Iyer} {2017} In this paper a detailed analysis of waste generation, segregation, disposal, reduction of waste and its importance is studied.

2.2 {Aishwarya AR} {2019} In this paper, use of rocker bogie mechanism as all terrain mobile robots for environmental observation, surveillance and assistance in an agricultural field is studied.

2.3 {S.F. Toha & Zakariya Zainol} {2015} In this paper, use of rocker boogie in a post disaster relief is studied, which will help in mitigating the effect of disaster.

2.4 {Jun Yang} {2017} In this paper it is discussed that rocker bogie mechanism is widely used in planetary rovers designed to explore unknown planets.

2.5 {Nitesh Naik} {2019} in this paper it describes how rocker bogie mechanism is used in extraction of mines.

3. PROBLEM STATEMENT

As we know rocker bogie mechanism finds its successful application in space travel vehicles having its own deep history embedded in its development but has very less scope to other application

There exists a difficulty in waste collection and dumping activities which is indeed very important in maintaining hygiene and cleanliness in society and public areas. There exists a demand for a mobile user-friendly device which incorporates a mechanism which can enable the garbage trolley to climb stairs during waste collection in society buildings.

The main problems encountered are its low speed and poor steering ability. Steering ability can be solved by incorporating mechanical steering system with the help of gears and motors. Also, the rocker bogies can be made power driven by using Dc motors and battery.

Actual Prototype

4. DESIGN DESCRIPTION

4.1 Material Selection

Aluminium is a metal physically, chemically and mechanically Similar to steel, brass, copper, Zinc, lead or titanium.

The most important advantage of the aluminium is that it is very light in weight metal with a specific weight of 2.7 g/cm3 about one third of that of steel. This cuts the cost of manufacturing with aluminium.

Its strength can be adapted to application required by modifying the composition of alloy.

This makes it a much more Cost-effective source material for production

Aluminium is ductile and has low melting point and density.

Recyclability -Aluminium is 100 % recyclable

Strength at Low Temp: - In Contrast to steel which rapidly becomes brittle at low temp, aluminium shows increased tensile Strength as temp drops.

1. Aluminium sp. wt-0.027 N/cc
2. Melting point-660°C
3. Rigidity- 0.25*10^5 N/mm^2
4. Young's modulus-0.675*10^5N/mm^2
5. Conductivity-0.53
6. Poisson ratio-0.24cal/jcm°C
7. Coefficient of linear expantion-23.4m/m°C

Table -1 Aluminium Properties

Alloy	***Aluminium content***	***Uses and reference***
1050	99.5	Drawn table
1060	99.6	Universal
1070	99.7	Thick wall drawn table
1145	99.0	Sheet plate

4.2 Tilt Angle

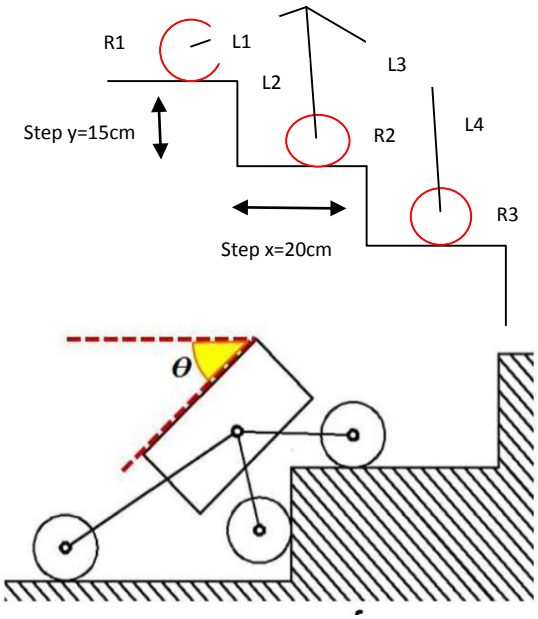

Fig-1: Tilt Angle

$\theta = \tan^{-1}\frac{y}{x}$

$\theta = \tan^{-1}\frac{15}{20}$

$\theta = 36.86°$

Tilt angle (θ)
= 36.86°

4.3 Rocker Arm Specification

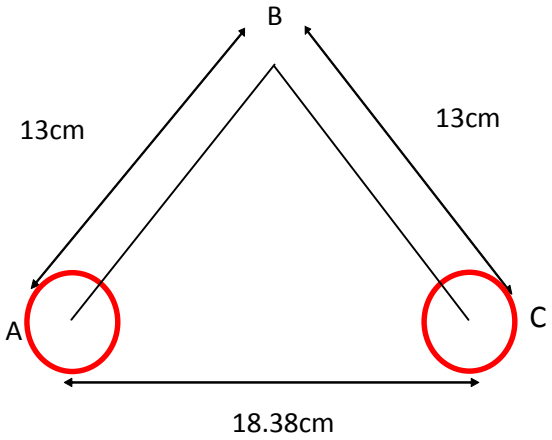

Fig-2: Rocker Arm

Centre to center distance between two front tires

By Pythagoras theorem,

AC = $\sqrt{AB^2 + BC^2}$

AC = $\sqrt{13^2 + 13^2}$

AC = 18.38 cm

Length CD = Length AC + Length AD

= 18.38 + 27

= 45.38cm

The important factor in manufacturing of rocker bogie mechanism is to determine the dimensions of rocker and bogie linkages and angles between them. The lengths and angles of this mechanism can be changed as per requirement. In the work aim is to manufacture the rocker bogie mechanism which can overcome the obstacles of 150 mm height (like stones, wooden blocks) and can climb over stairs of height 150 mm. Also, another target is to climb any surface at an angle of 45°. To achieve the above targets, we had designed the rocker-bogie model by assuming stair height 150 mm and length 200 mm.

Using Pythagoras theorem, find the dimensions of the model. It has both angles of linkages are 90˚

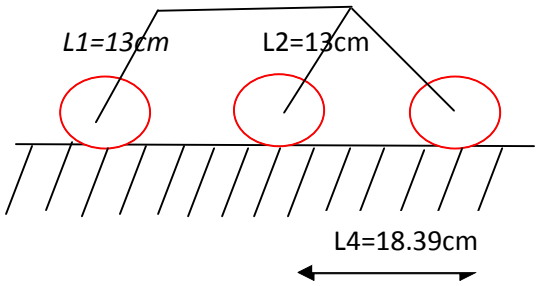

Fig-3

L1 + L2 >L4 ...L1= L2 = length of rocker arm

L2 + L4 >L1 ...L4= distance between rocker arm L4 + L1 > L1
r1= radius of front wheel of rocker r2= radius of rear wheel of rocker
L4 > r1 + r2

L3 - r3 > L2 + r2

L4 = 18.39cm

MAXIMUM TILT ANGLE OF CARGO

The maximum angle comparison between simulation and experiment a noticeable error is evident and error increase as slope increase.

CONSTRAINTS

There are five constraints from the geometric relations between links and wheels. The configuration used to calculate each constraint:

(a) Maintenance contact on a horizontal plane

The radius of each wheel should maintain contact with the stair tread for stable stair climbing. The upper radius limit is from the wheel contact condition (the extreme stair dimension is used as the worst case). The lower limit of the wheel radius is determined by commercial availability.

(b) Formation of triangular-shaped link

Parameters (L1, L2, L4), which are related to link L, are positioned in a triangular shape. Constraints are defined to maintain this triangular shape. The three inequalities shown on the right side were based on this limitation.

(c) Avoidance of wheel overlap between 1st and 2nd wheels

Due to the design complexity problem of the rocker-bogie cart, overlapping between wheels should be prevented. To avoid wheel overlapping distance between w1 and w2 (which means l4) must be longer than the sum of r1 and r2.

(d) Avoidance of wheel overlap between 2nd and 3rd wheels

Wheel overlapping between the 2nd and 3rd wheel should be avoided. w3 can be rotated along to the passive joint between link 1 and link 2, and w2 and w3 can be overlapped. From this condition, the constraint is defined as shown in Fig.

(e) Size limitation

The size of the hand-carrying cart can be varied depending on the purpose of the cart. In this study, the size range of the rocker-bogie cart was limited based on the size of an ordinary commercial shopping cart. In addition, the wheel radius was limited to be shorter than the link length for design simplicity.

4.4 Solid Model of Prototype

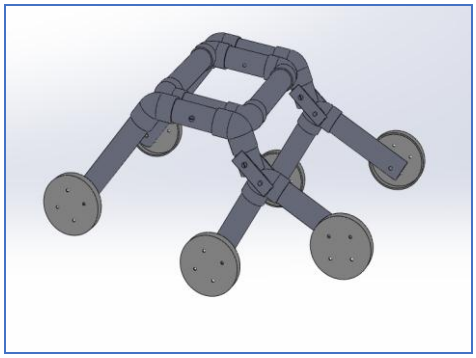

Fig-4: Solid Model of Prototype

4.5 Schematic diagram & Solid Model of Trolley

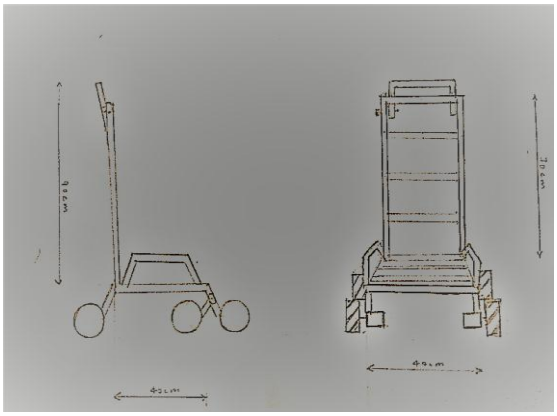

Fig-5: Schematic diagram

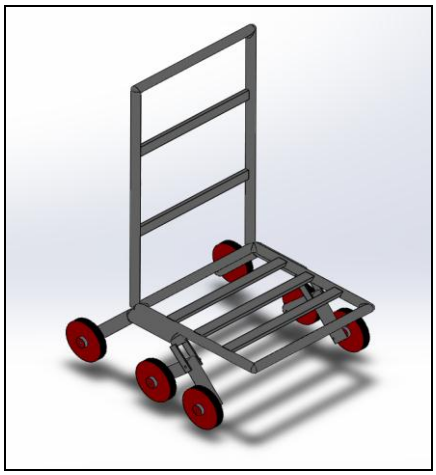

Fig-4: Solid Model of Trolley

A Solid model of trolley has been made with proper dimensions on SOLIDWORKS 2019.

4.6 Analysis of Trolley

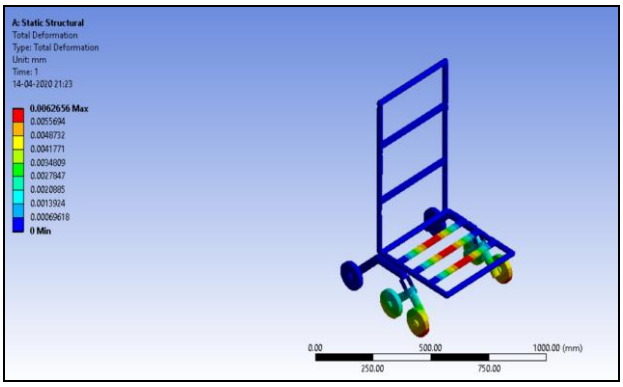

Fig-5: Analysis of Trolley

Analysis of Trolley has been done with a load of 20kg on ANSYS 18.1 and the results were found safe for application.

5. FUTURE SCOPE

- A future modification of providing the trolley with a smart bin which can automatically open by detecting the user, which can display the level of garbage inside the trolley and can segregate the dry and wet waste. This modification can be achieved by using several electronics sensors like ultrasonic, thermostatic and proximity sensors etc.
- It can be made fully automatic without any human involvement by adding Arduino and bluetooth controlled.
- There is an additional need of Fixtures to hold the load while moving the trolley on stairs.
- Use of other materials like Mild steel, Plastic etc. can also be done to manufacture this trolley but may result in weight addition.
- This trolley can also be made portable by manufacturing foldable links.
- Proper calculations of Centre of gravity will result in noise reduction and improved stability of trolley.

6. CONCLUSIONS

Though, this project has not been implemented into practice yet. It can be considered to be a small step forward, as far as stair climbing vehicles are concerned.

Introducing this project will have wide spread demand depending on the areas of applications like domestic Garbage trolley, commercial use or Industrial material handling equipment.

The design consideration of trolley may differ as per the field of application and future modification can be done by providing the trolley with a smart bin by using several electronics sensors like ultrasonic, thermostatic and proximity sensors etc.

As far as commercial aspects of this proposed project is concerned, if this product 'Stair climbing trolley with rocker boogie mechanism' will be introduced to the market, it's acceptance will be unimaginable. Presently there are no competitors for "**Waste Collection Stair Climbing Material Handling Equipment**" hence this project will have wide spread demand in the market.

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Photographs of Trolley

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BIOGRAPHIES

Akumalla Lukmanhakim A.
Student
B,E Final Year
Rizvi College of Engineering

Kadri Shadab A.
Student
B,E Final Year
Rizvi College of Engineering

Shaikh Aamir I.
Student
B,E Final Year
Rizvi College of Engineering

Tevildar Eebad A.
Student
B,E Final Year
Rizvi College of Engineering

Ameya Nadkarni
Professor
Rizvi College of Engineering