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Design and Fabrication of Rocker Bogie System

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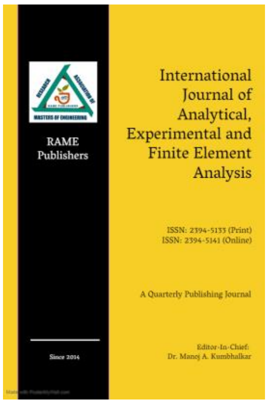

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Abstract: This paper presents the design and fabrication of rocker bogie robot for overcoming the rough terrain and uneven surfaces. The primary objective of this robot is to overcome the rough terrain and without tipping over, while carrying load. The design of rocker bogie mechanism is inspired by NASA's Mars rovers. This is currently NASA's favored design. Many spaces organization are currently working on this mechanism. The fabrication process involves the selection of material, assembly of components and utilization of electronic components for motion and control. The robot capabilities are evaluated through field tests and its performance through real world scenario. The results show the effectiveness of the design in achieving the agile motion and showing its potential for applications in overcoming the rough terrain, search and rescue missions.

Keywords: Rocker Bogie; Wheel type Robot; Mission;

1. Introduction

In the realm of robotics, the pursuit of mobility in challenging terrains has been a longstanding endeavor, with applications ranging from planetary exploration to disaster response on Earth. Among the various locomotion mechanisms, the rocker bogie system stands out for its exceptional ability to overcome uneven terrain and rugged terrain remarkable stability and agility.

This paper presents the design and fabrication of a rocker bogie robot, an innovative platform engineered to navigate complex environments with ease and efficiency. Inspired by the NASA's design of Mars rovers and drawing upon advancements in robotics and, our project aims to push the boundaries of mobility in rough terrains, offering a versatile solution for exploration and tasks with the rocker bogie mechanism, consist of multi-legged configuration and articulated suspension system, enables the robot to traverse obstacles, climb steep slopes, inclines, and maintain stability on uneven surfaces. Its motion is similar to the natural movement of a. walking creature, this design ensures adaptability and resilience in dynamic environments, enable it for a variety of real-world applications. our endeavor encompasses both the conceptualization and implementation phases of the robot's development. Through rigorous analysis and simulation, we have optimized the mechanical design to achieve optimal performance in terms of mobility, stability, and energy efficiency. Leveraging cutting-edge fabrication techniques and high-performance materials, we have carefully crafted each component to withstand the impacts and vibration of rugged terrain while traversing the uneven surfaces and while minimizing weight and maximizing durability.

Furthermore, our platform integrates advanced control systems, allowing for different operation. Such as search and rescue operations. Where humans cannot reach due to the risk of life involved. The robot can carry the medicinal aid and travel from one place to another. In summary, the design and fabrication of our rocker bogie robot represent a advancement in the field of mobile robotics, offering a robust and versatile platform for exploration, reconnaissance, and disaster response missions. Through innovation and collaboration, we strike to develop the way for the future development in robotic technology.

2. Literature Review

The initiation of rocker bogie suspension system can be traced to the development of planetary rover which are mobile robots, especially designed to move on a planet surface [1]. Early rovers were tele-operated like the Lunokhod I while recent ones are fully autonomous, such as FIDO, Discovery and recently developed Curiosity mars exploration rover [2]. The rovers needed to be very robust and reliable, as it has to withstand dust, strong winds, corrosion and large temperature changes under mysterious conditions [3]. Maximum rovers remain powered by batteries which are recharged by solar panels during the day installed over there surface [4]. The locomotion system of rovers remains crucial to enable it to reach objective sites, conduct research, and collect data and to position itself according to the demand [5]. There are three main types of rover locomotion developed so far i.e. wheeled, legged and caterpillar locomotion.[6, 11]

The concept of our research work is to create a rocker-bogie suspension system based on those of NASA. It established the rocker-bogie suspension system for their rovers and was applied in the Mars Pathfinders and Sojourner rover [7]. The latest planetary exploration rovers being created by NASA employ a rocker-bogie system, which is a six-wheel-drive configuration (three wheels on either side) for best stability and control over rough terrain. Each side of the robot has both a rocker and a bogie as suggested by the name itself [8]. The rocker consists of two wheels connected by a linkage to a pivot on the main chassis, while the bogie consists of a single front wheel connected to a pivot on the rocker linkage [9]. The rocker-bogie suspension system passively keeps all six wheels on the robot in contact with the ground even on uneven surfaces. This creates for great grip and manoeuvrability.[10-12]

The rocker-bogie suspension mechanism which was presently NASA's approved design for wheeled mobile robots, primarily because it had study or strong abilities to deal with hurdles and because it uniformly distributes the payload over its six wheels at all times. It also can be used for other purposes to operate on rough roads and to climb the steps. It was having lots of advantages, but one of the main disadvantages is the rotation of the mechanism when and where is required. The rotation can be possible by providing individual motors to individual wheels which sources arise in cost and complicacy in design. Here an effort was made to transform the existing design by integrating a mechanism of gear type steering which is single motor operated that simplifies the design as well as the total cost and operating cost of the mechanism[13]

Although legged mechanisms have shown a tremendous advantage in traversing uneven terrain and climbing over obstacles, these robots have complex designs, need advanced control strategies and suffer from a sluggish motion. A wheeled mechanism is a better option due to its design simplicity, lower power consumption and quick mobility. This justifies our choice of a wheeled robot.[14]

3. Research Gap

Diameter of the wheel is less that decreases the load carrying capacity of the robot. Six motors are used for each wheel. It helps in controlling the motion of each wheel. Light weight material such as MS pipe is used for the fabrication of robot. RF controller is used to control the rocker bogie robot.

4. Problem Identification

The rocker bogie system is a suspension mechanism that is commonly used in exploration vehicles, and rovers. The problem definition associated with the rocker bogie suspension involves to effectively traverse the uneven terrain while maintaining the stability, without getting stuck or tipping over. The suspension design should minimize the risk of tipping over due to uneven surfaces.

The system must be able to climb over the obstacle, descend through slopes and turn in tight space. Constraints such as size, power consumption, compatibility, weight, durability are considered. The robot should be able to withstand the impacts, vibration and other factor without compromising its performance. Its design should be such that its maintenance should be done quickly so as to serve in the field.

5. Methodology

We have used six motors for each wheel. It will help to control the robot's motion effectively. It also increases the load carrying capacity. Hard rubber wheels are used so that increases the grip over the surfaces and reduces the chance of slipping. Light weight material such as MS pipe are used for the frame work. Gas studs are used to balance the bucket. In order to overcome an obstacle by the front wheel, the rear wheel forces the front wheel against the obstacle until the front wheel is of the robot is lifted up and traverse the obstacle. The middle wheel is then pressed against the obstacle while the rear wheel forces the middle wheel against the obstacle the front wheel pulls the middle wheel. Finally, the rear wheels are pulled by the other two wheels.

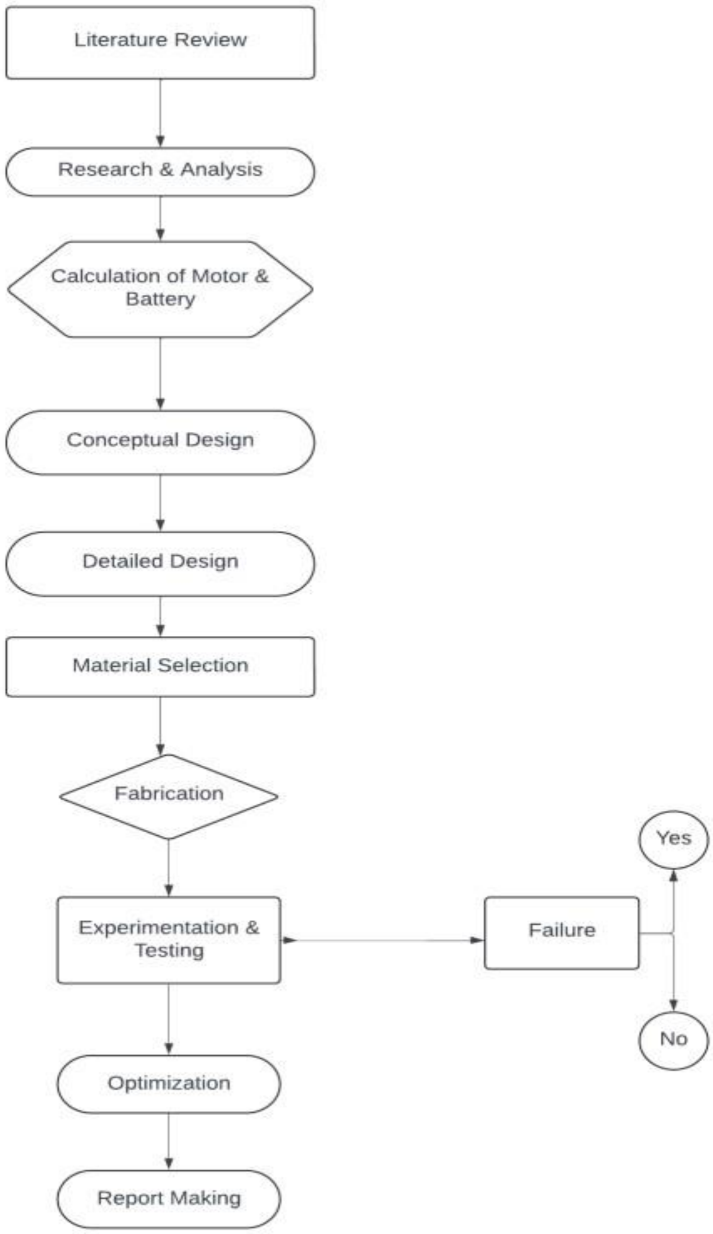

Figure 1. Proposed Methodology with Flow Chart

6. Components

The rocker-bogie system consists of several key components. The frame is made from mild steel (MS) pipes with dimensions of 2 cm x 1 cm, providing a sturdy foundation for the structure. The system includes six bushings made from MS rods with a 25 mm diameter, which act as pivots for the wheel assembly. The six wheels, each with a 16 cm diameter, are mounted on the frame and driven by six motors rated at 80 Kg-cm torque and 30 RPM, providing sufficient power for movement across uneven terrain. The shaft is also made from an MS rod with a 10 mm diameter, ensuring robustness and stability in the rotational components.

A bucket, made from aluminum, with dimensions of 40 cm x 30 cm x 18 cm, serves as the main cargo or payload area. The control system comprises an RF 2.4 GHz multi-channel wireless remote and motor drivers, allowing for remote operation of the vehicle. The system is powered by a 12V 10Ah battery, which provides sufficient energy to run the motors and control systems. Additionally, the system is equipped with two gas studs made from zinc, each measuring 12 inches and having a load capacity of 15 kg, to provide suspension and shock absorption.

This combination of components makes the rocker-bogie system highly effective for traversing rough terrain while maintaining balance and stability.

Table 1. Components and their Specification

Sr. No.	Components	Material	Specification	Quantity
1	Frame	MS Pipe	2cm x 1 cm	1
2	Bush	MS Rod	25 mm Diameter	6
3	Wheel		16 cm Diameter	6
4	Motor		80 Kg-cm, 30 RPM	6
5	Shaft	MS Rod	10 mm Diameter	1
6	Bucket	Aluminium	40 cm x 30 cm x 18 cm	1
7	Controller		RF 2.4GHZ multi cahnnel Wireless remote and motor driver	1
8	Battery		12 V 10 Ah	1
9	Gas Stud	Zinc	12 inches, Load capacity 15 kg	2

7. 2D and 3D Model

To design a 2D and 3D CAD model of the rocker-bogie system, software like AutoCAD, SolidWorks, or Fusion 360 can be used. In the 2D design, you start by sketching the frame, bushings, wheels, motors, shaft, and bucket to their specified dimensions. For the 3D model, you extrude these 2D sketches to give them depth. The frame can be hollowed out for realism, and cylindrical components like the bushings and wheels are created using the revolve tool. Once all components are modeled, they are assembled in the CAD software using mating constraints to simulate movement and ensure proper alignment for the rocker-bogie suspension system.

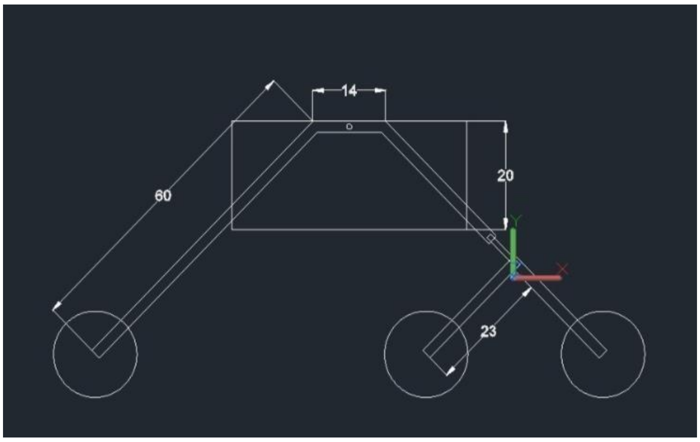

Figure 1: 2D Model

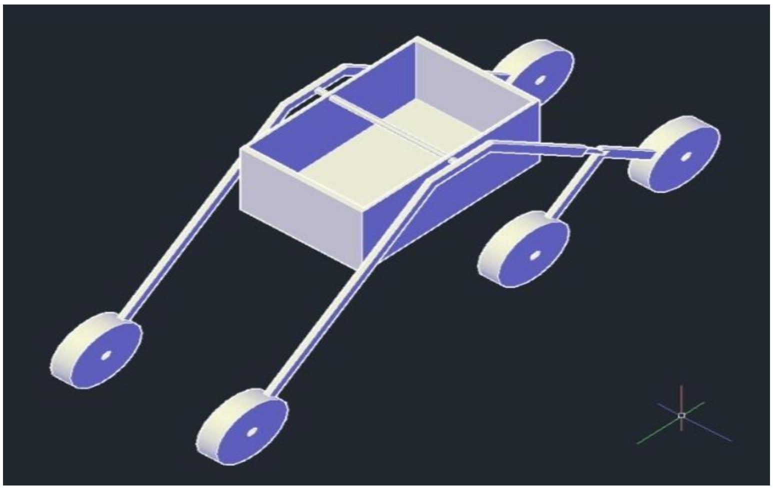

Figure 2: 3D Model

7. Calculation

For the design of the rocker-bogie system, we need to calculate the mass of the mild steel (MS) rectangular pipe and the required motor torque. The pipe has outer dimensions of 5 cm x 2 cm, a thickness of 0.005 m, and a length of 2.74 m. The mass is determined by calculating the volume of the pipe's outer and inner sections, which gives a net volume of 0.001644 m^3. Using the density of mild steel (7850 kg/m^3), the mass of the pipe is approximately 12.90 kg.

For the motor calculation, with a wheel diameter of 16 cm (radius 0.08 m) and assuming a total system mass of 50 kg, the required torque is found to be 39.24 Nm. The motors used, rated at 80 Kg-cm (7.85 Nm), work collectively to meet the torque requirement for effective operation across rough terrains.

7.1 Motor Calculation

Diameter of wheel = 16 cm = 0.16 m , radius = 0.08 m
Rectangular pipe = 5 cm x 2 cm
Mass of MS Rectangular Pipe
Length = 2.74 m
Thickness = 0.005 m
Width = 5 + 5 + 2 + 2 = 6 cm = 0.14 m
Mass = Volume x Density (Density of MS = 7850 kg/m^3)
Mass = 2.74 x 0.002 x 0.14 x 7850
Mass = 6.02 kg
Total mass of rectangular pipe = 6.02 kg = 59.05 N Mass of motor = 8 kg = 78.48 N

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Mass of wheel (6 kg) + Bush (2 kg) = 8 kg = 78.48 N
Mass of Gas stud (0.8 kg) + MS Rod (1.2 kg) + Battery (1.5 Kg) + Load Capacity (10kg) = 13.5 kg = 132.43 N
Total Weight = 59.05 + 78.48 + 78.48 + 132.43 = 348.44 N
Torque = Force x Perpendicular Distance
= 348.44 x 0.08 x 1.5 (FOS)
= 41.81 Nm
Required Torque per Motor = 6.96 Nm or 71.03 Kg-cm.
Selecting motor of 80 kg-cm or 7.2 Nm Torque with 30 RPM.

V = 3.14 x D x N / 60 D = 16 cm , N = 30 rpm
V = 25.13 cm/s = 0.25 m/s

7.2 Battery calculation

N = 30 RPM, T = 7.85 Nm

Power = 2 x 3014 x N x T / 60
Power = 2 x 3.14 x 30 x 7.85 / 60
Power = 24.66 watts
Power for 6 motor = 24.66 x 6 = 147.56 watts

Amphere hour (Ah) x Volts (v) = watt (w) x hour (h)
Amphere hour (Ah) = Watts (w) x hour (h) / Volts (v)
Amphere hour (Ah) = 250 x 0.3 / 12
Amphere hour (Ah) = 6.25 Ah

8. Results

These works show the modification in stability, and increase in load carrying capacity. The study of the existing model of rocker bogie system enabled rovers and tried to manufacture a similar kind of with the available material considering the budget. There was slight modification with the introduction of wheeled mechanism having different links and each link having wheels with it. As we have provided each wheel with motor there is better control over the robot. The robot travels through uneven surfaces with increase in load carrying capacity. To balance the robot gas studs are provided. The robot can overcome the obstacle, while maintaining its balance. If the obstacle is in front of one wheel that wheel will overcome the obstacle, while the other wheels be connected to the ground.

9. Conclusion

This work shows how the rocker bogie robot works in different surfaces. As per the different loads that act on the links determines the torque applied on it, also for different wheel size, speed can differ. Individual motor can help in better control of the robot. By assuming the size of the obstacle, accurately measured rocker bogie robot can overcome obstacle with stability and without tipping over. The concern during the development of rocker bogie robot was to observe the speed and load carrying capacity so that the robot does not tip over while overcoming the obstacle.

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