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Rocker Bogie Mechanism

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ABSTRACT

Rocker Bogie is a suspension system used in mars rovers like Pathfinder, Curiosity etc. The specialty of this suspension system is that it does not have any springs. The term "rocker" comes from the design of the differential, which keeps the rover body balanced, enabling it to "rock" up or down depending on the various positions of the multiple wheels. Bogie means links that has driven wheels at each end.This mechanism can climb obstacles like rocks which are more than twice or three times the diameter of the wheels while the all six wheels are touching the ground, whereas the other suspension tilt stability is limited to centre of gravity (the less height the more stable).Our project deals when this mechanism is fixed with auxiliaries like cutting blades they can be used as lawn mowers which can climb the obstacles. These mechanisms can take a direct 55 degree climb without overturning.

1. Introduction

In the olden days peoples are used to travel long distances with the help of foot and the journey would take a lot of days or time to complete. As per the latest technology it has developed a lot making the travel distances has been lot smaller from days to hours, from hours to minutes. But some situations, where there few limitations will takes place for travelling. For example, for sight visiting in a forest we need not lay on the roads or inside of the forest, we just to modify the existing vehicle according to that atmosphere. In some cases these modifications does not improve the ride. In that situation we have to develop something new which adopts those types of situations.Most of the vehicles which are invented in the recent time it had a common element or system which enabled vehicle to move in any condition or situation. That common system is called suspension system.

It is the system of all the tires air, springs, and shock absorbers etc, they are attached to the vehicle and to the wheels. It allows the relative motion between the parts. System serves a multipurpose contributing for the vehicle on the road holding, handling for good active safety, and keeping the vehicle comfortable and to ride reasonably well isolated from the road noise, obstacles, and vibrations. These all are from the odds, so that the suspensions involves to finding the absolute compromise. It is most important for the system to keep the road and wheel in between contact with the road surface as much as possible, because all the ground forces are acting on the vehicle through the contact of the tires. The system also protects the vehicle itself and any luggage may be from damages and wear. The design of front and rear or back tire suspension of a car may be some different.

In these days a new vehicles have come into existence which do not have any suspension system but it can overcome the obstacles better than the suspension system. The Rocker bogie mechanism is one among them which does not have any suspension but it can overcome obstacles.

2. Literature Review

The starting of the system can be target to the further development of planetary rover which is mobile robot; it is mainly designed to move on a planet surface. In olden days rovers are tele operated like Lunokhod, while recent ones these are totally individual, such as FIDO, Discovery and recently developed Curiosity mars exploration rover. The rovers need to be very robust and reliable, it has to withstand dust, strong winds, corrosion and large temperature changes under few conditions. Maximum rovers are mainly powered by the batteries or generators that which are recharged by the solar panels during the day installed over the surface.

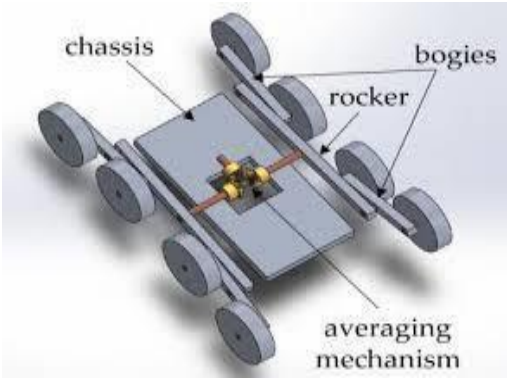
The system of rovers still crucial to enabled to reach objective paths, conduct research, and collect the data and to position it, it depends according to the demand. There are three important types of rover locomotion developed very far i.e., wheeled, legged and caterpillar locomotion. The difference between the miscellaneous models of planetary robots lies on the type of the system. Also after developing many legged and hybrid robots, most researchers are still focus on the wheeled locomotion for rovers, why because of its locomotive ease and advantages and among all wheeled locomotion design, the rocker bogie suspension system based on the design remain most favored. The ancient FIDO rover and the Sojourner contain six independently steered and driven wheels suspended from the rocker-bogie mechanism to get maximum suspension and ground clearance. Rocky Seven Rover has a similar suspension system just different from the front wheels. The Nanorover & Nomad Rovers have 4 steered wheels suspended from the 2 bogies & CRAB Rover utilizes 2 parallel bogie mechanisms on every side to overcome obstacles and big holes. As far as the initial research it is concerned, the software optimization seeks for an optimum in that constrained solution space given an initial answer and Dr. Li et al. derive a mathematical expression to generalize rover suspension parameters which define the geometry of the rocker-bogie system. The objective behind evolution of rocker bogie suspension system is to develop a system which is minimizes the energy consumption, the vertical displacement of the rover's centre of mass and its pitch angle. In the research, our Endeavour is to be distribute these major advantages embedded with the rocker bogie conventional suspension system in general and suspension system of heavy vehicles in particular.

Rocker Bogie

The arrangement is too used in the mechanical robot. It is explained for the mars pathfinder and also it is useful on the mars exploration rover and mars science laboratory missions. Now it is currently NASA's favored project.The term "rocker" it is the rocking aspects of the larger links on the every side of the system. These rockers are attached to each other and the vehicle chassis through the differential, and it Relative to the chassis, when one rocker goes up and down. Chassis maintains the minimum pitch angle of rockers. One side of the rocker is fitted to a drive wheel and the other end is connected to the bogie.The word "bogie" refers to the links and that have a drive wheel at each end. Bogies were commonly used as load wheels on the tracks of army tanks its distributing the load over the terrain. Bogies were also commonly used in the trailers of semi-trailer trucks. The rocker-bogie does not have springs that allows the rover to climb the obstacles, as with any suspension system, the tilt stability is limited to the height or distance of the center of gravity. The suspension system arrangement is used in Mars rovers discussed for the Mars Pathfinder and is used in the Mars Exploration Rover and Mars Science Laboratory missions.

Working of Rocker Bogie:

As per the research it is find that the rocker bogie system reduces the motion by compared to the other suspension systems because each of the bogies have 6 wheels has an independent mechanism for motion and in which the 2 front and 2 rear or back wheels have individual steering systems that allows the vehicle to turn in place as zero degree turning ratio. Each wheel also has thick cleats which allow the grip for climbing in smooth sand and scrambling over the rocks with ease. In that way it overcomes the vertical obstacle faces, and the front wheels are forced against to the obstacle by the middle and back wheels which generate maximum required torque. The rotation of the front wheel lifts the front of the vehicle up and over the obstacle and obstacle overtaken. Those wheels which remain in the middle, is then pressed against the obstacle by the rear wheels and pulled against the obstacle by the front till the time it is lifted up and over.



Rocker Bogie Mechanism

Types of Joints:

Robots using rocker bogie mechanism, it makes the use of a suspension mechanism system that consists of various fixed elements those are attached to the joints of a certain number of degrees of freedom that resulting in a structure that has 1 system of DoF. This enables them to move along uneven terrain without losing contact with the ground. Following table represents 3 such possible joints:

The suspension has 8 wheels with symmetric structure for both sides. Each side has 4 wheels which are connected to each other with two links. The main linkage called rocker has 2 joints. While 1st joint is connected to the front wheel, and 2nd joint assembled to another linkage that called bogie, which is similar to the train wagon suspension.

Advantages:

Load on each wheel is nearly identical.

It has no axles or springs which helps to maintain equal traction force on all the wheels.

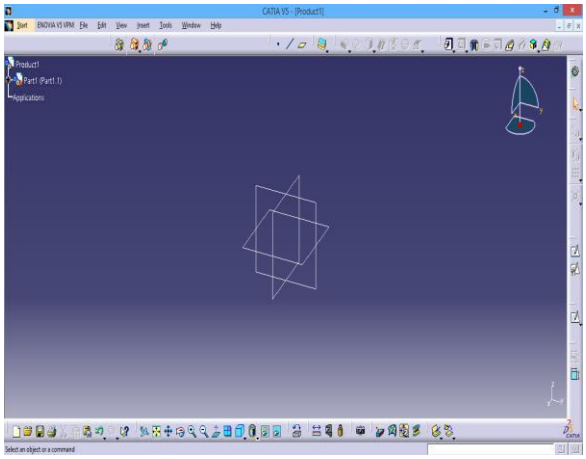
Can climb over blocks twice the height of the wheel while keeping all 6 wheels on the ground

Each wheel can individually lift almost the entire mass.

3. Design

Design Software:

We used CATIA as our CAD modeling software for Digital Prototyping the Rocker bogie. We checked working of all the links in the assembly of the Rocker bogie suspension.CATIA is acronym for Computer Aided Three-dimensional Interactive Application. It is started as the house development project by the French aircraft manufacturer Avions Marcel Dassault.



CATIA User Interface

CATIA provides a wide range of applications for tool design, for both generic tooling and mould & die.In Designing process, CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. Some of the industries which use CATIA as their CAD software are

Aerospace Industries:

Canadian aircraft maker Bombardier Aerospace has done all of its aircraft design on CATIA.

Vought Aircraft Industries uses CATIA V4 and V5 to produce its parts

Automotive Industries:

Goodyear uses it in making tires for automotive and aerospace and also uses a customized CATIA for its design and development.

Web asto uses CATIA to design its roof.

Shipbuilding:

GD Electric Boat used CATIA for design the latest fast attack submarine class for the United States Navy (USN).

The Virginia class, Newport News Shipbuilding also used CATIA to design the Gerald R. Ford class of super carriers for the US Navy

In 2004, it has been adopted by the Benita Group for development of new sailing and leisure motor boats.

Some of the tools we used in CATIA for modeling are the:

Sketcher
Pad
Pocket
Reference
Geometry Patterns
Assembly

The sketcher is used to model all the in 2D form. It is used to create Extrusions (which Is a 3D model)

Pad: Pad is used to extrude a 2D sketch into a 3d model. When a closed 2D sketch is selected and the Pad option is selected it extrudes the 2D sketch in the 3D model in the specified direction.

Pocket: Pocket is used create holes. It is also used to remove the material from the 2D sketches which are made in the sketcher.

Reference geometry: It is used to create reference planes at a circular surface tangentially or any other surface with proper constraints.

Patterns: It is used to duplicate the work done to save the time. It is used making the tyre thread marks.

Assembly: in this step, the all modeled parts are assembled to form the complete rocker bogie. In this step, we can check if the assembled parts are working Properly according to the design or not. If not, then the necessary adjustments will be made.

Components of rocker bogie:

1. 8 Tyres (4 on each side).
2. Different types of links.
3. A Rod or link which connects either sides of a Rocker Bogie

Designing of wheel diameter:

As the main aim of rocker bogie is to climb obstacles.

So for climbing obstacles the diameter of wheel should be between the ranges of 0.5 - 0.9 times the obstacle .so it can climb the obstacles of size 1.5 times it diameter.

Designing of links:

The main purpose of links in rocker bogie is to climb the obstacles without springs and it ensures that tyres remain in contact with ground all the time.Dimensions of links depend upon wheel. Depending on the diameter of wheel the links dimensions vary.

The important factor that we have to consider while designing the Rocker Bogie is:-

It should climb the stairs effectively without slipping

The tyres should remain in contact with ground always.

The links should not obstruct the motion

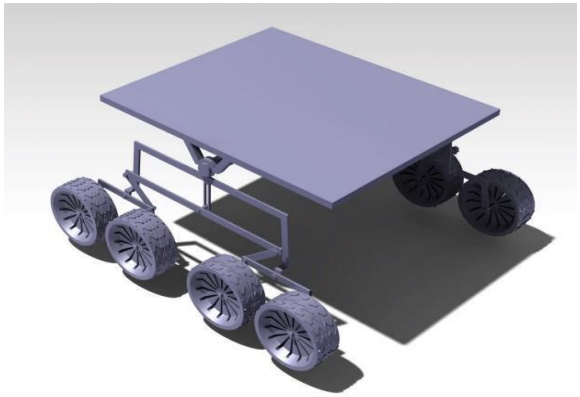
The pivot joint should not be tight

Various links of a Rocker Bogie suspension system:-

1) Main Links
2) Support Links
3) Inclined Links
4) Wheel Links

One side view of Rocker Bogie

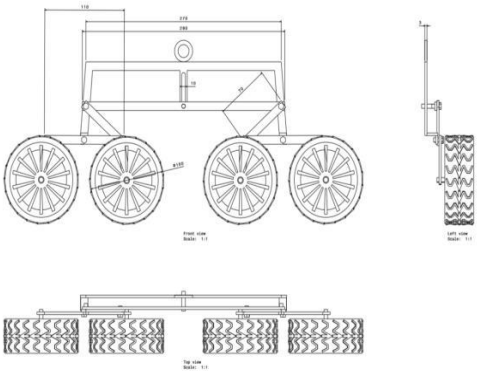
(Rendered in CATIA V5)



Complete View of Rocker Bogie

(Rendered in CATIA V5)

CAD Drafting and Calculations:



Orthographic views

Wheels: Diameter: d

Main Link: 3d

Height: 1.6d to1.8d

Bending: 0.3d to 0.4d

Support link: 3d

Wheel link: 1.3dto 1.4d

Inclined link: 0.8d

Thicknesses of all links are 3mm

Bending Angle of Main Frame: 10^{o} to the Vertical

4. Fabricating the Rocker Bogie

Materials required for manufacturing Rocker Bogie:-

1) Tyres:

There are various types of materials for preparing tyres but we are using vinyl plastics as they have some desirable properties like:

They are cheap compared to others.
High rigidity.
They are more flexible when climbing stairs

2) Links:

For producing links and frame of rocker bogie we can use aluminum and mild steel. But considering cost as a factor we are using mild steel as possess the following

Desirable properties:

They have high strength.
They are rigid.
The cost of mild steel is less when compared to Aluminium.

3) A rod which connects either side of a Rocker Bogie:-

This serves an important part in the Rocker Bogie as it connects either sides of it. So the rod or link which is used to connect should possess high strength with light weight. Aluminum can be the best material to use as it possesses light weight with high Strength.

Desirable properties:-

Less weight
Easy to machine
Aluminium is a excellent conductor of heat and electricity
Aluminium is a non-magnetic (actually paramagnetic) material.

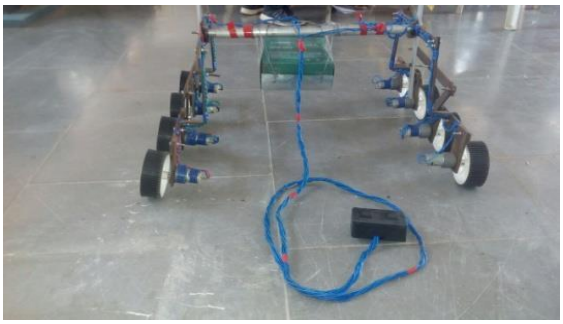
Manufacturing processes:

1) Forging
2) Drilling
3) Milling
4) Welding
5) Cutting

Fabricated Rocker Bogie Images:-

Fabricated Rocker Bogie (1)

Fabricated Rocker Bogie (2)



Fabricated Rocker Bogie (3)

Drive System

The Elements of Drive System:

D.C Motor
DPDT Switch
Power Source

5. Conclusion

We have designed, fabricated and tested Rocker Bogie Mechanism which can move on any surface without the aid of any stub axles, springs and suspension. So the problem of climbing obstacles is overcome by using rocker bogie mechanism.

While climbing over any obstacles all wheels remains in contact with the ground thus maintaining stability and the Load is equally distributed on all wheels.It can also be steered in any direction like other vehiclesSo this Rocker Bogie can be used for applications like:-

1) By using Rocker Bogie we can cut grass by placing a frame and a grass cutting mechanism over it.
2) It can be used for smooth movement in bumpy roads
3) The left side and right side move independently, and hence the rocker can traverse terrains, where the right and left rockers go over different type of obstacles.

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