



DESIGN OF ALL TERRAIN VEHICLE USING ROCKER BOGIE MECHANISM

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ABSTRACT

The need to develop a highly stable suspension system capable of operating in multi terrain surfaces while keeping all the wheels in contact with the ground. To design a mechanism that can traverse terrains where the left and right rockers individually climb different obstacles. To sustain a tilt of over 50degree without tipping over the sideways .Rocker bogie are important for conducting scientific analysis of objectives that are separated by many meters to tens of kilometers. Current mobility designs are complex, using many wheels or legs. They are open to mechanical failure caused by the harsh environment on Mars. A six wheeled rover capable of traversing rough terrain using an efficient high degree of mobility suspension system. Six motors are located inside the body where thermal variation is kept to a minimum, increasing reliability and efficiency. Six wheels are used because there are few obstacles on natural terrain that require both front wheels of the rover to climb simultaneously. A series of mobility experiments in the agriculture land, rough roads, inclined, stairs and obstacles surfaces concluded that rocker bogie can achieve some distance traverses on field.

Key words: Rocker bogie; All Terrain Rover; Stair climbing; Rover

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1. INTRODUCTION

The rocker-bogie system is the suspension arrangement used in the Mars rovers (mechanical robot) introduced for the Mars Pathfinder and also used on the Mars Exploration Rover (MER) and Mars Science Laboratory (MSL) missions. It is currently NASA'S favored design .The term “rocker” comes from the rocking aspect of the larger links on each side of the suspension system. These rockers are connected to each other and the vehicle chassis through a differential. Relative to the chassis, when one rocker goes up, the other goes down. The chassis maintains the average pitch angle of both rockers. One end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie. The term “bogie” refers to the links that have a drive wheel at each end. Bogies were commonly used as load wheels in the tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks. Both applications now prefer trailing arm

suspensions. The challenge posed by Mars Exploration Rover (MER) was to design a lightweight rocker-bogie suspension that would permit the mobility to stow within the limited space available and deploy into a configuration that the rover could then safely use to egress from the lander and explore the Martian surface [4]. When building a robot you'd like it to be as simple as possible. In most cases you'd never need a suspension system, but there were several instances when a suspension system cannot be avoided. The term "bogie" refers to the links that have a drive wheel at each end. Bogies were commonly used as load wheels in the tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks. Both applications now prefer trailing arm suspensions. The rocker-bogie design has no springs or stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity.

2. LITERATURE REVIEW

The concept of our research work is to create a rocker bogie drive system based on those of NASA. NASA developed the rocker-bogie suspension system for their rovers and was implemented in the Mars Pathfinder's and Sojourner rover. 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 traction and maneuverability (Harrington & Voorhees). The rocker-bogie suspension mechanism which was currently NASA's approved design for wheeled mobile robots, mainly because it had study or resilient capabilities to deal with obstacles and because it uniformly distributes the payload over its 6 wheels at all times. It also can be used for other purposes to operate in rough roads and to climb the steps. It was having lots of advantages but one of the major 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 causes arise in cost and complicity in design. Here an attempt was made to modify the existing design by incorporating a gear type steering mechanism which will be operated by a single motor which simplifies the design as well as the total cost and operating cost of the mechanism. In this work the proposed steering mechanism was designed and the modeling was done in SOLIDWORKS and the same was analyzed for static analysis for the proposed torque condition of the motor in ANSYS. All the results in the analysis were analyzed for static analysis [1]. The researchers discusses the concept and parameter design of a Robust Stair Climbing Compliant Modular Robot, capable of tackling stairs with overhangs. Modifying the geometry of the periphery of the wheels of our robot helps in tackling overhangs. Along with establishing a concept design, robust design parameters based Taguchi Method was adopted for providing an optimal setting for the design parameters of the robot. The robot prototype was shown to have successfully scaled stairs of varying dimensions, with overhang, thus corroborating the analysis performed [2]. An analysis method to make the rocker bogie mechanism can climb up a stair was achieved in the work. The east coast of Malaysia faced a massive flood from heavy downpour, leading to huge flood damage and caused irreparable loss to life and property. The flood carries the debris, soil and trees along their path, damaging the road and building structure, leaving the road become uneven. This situation gives difficulty to task force bearing aids during the post disaster management. The research paper proposed an intelligent inclined motion control of an amphibious vehicle while moving on uneven terrain surface [3]. The research paper deals with the designing and modeling of stair climbing robot based on the well-known rocker bogie mechanism in ANSYS rigid body dynamics module. The robots often suffer from undesired phenomenon slip, sticking and floating while climbing steps and stairs, which may cause instability of the mobile robot. The Taguchi method was used to chosen as an optimization tool to make

trajectory of center of mass close to straight line while all wheels keep in contact with ground during climbing stairs. Taguchi method was adopted due to its simplicity and cost effectiveness both in formulating the objective function and satisfying multiple constraints simultaneously. In the Optimization, Seven kinematic parameters of rocker bogie mechanism were optimized which include four link lengths and three wheel radius. The kinematic Model of proposed mechanism was built and it was simulated in ANSYS Rigid body dynamics. Three different shapes of typical stairs were selected as user conditions to determine a robust optimal solution. The result obtained shows the variation of center of mass position with time, variation of velocity of joint with time, variation of force with time [5]. It was basically a suspension arrangement used in mechanical robotic vehicles used specifically for space exploration. The rocker-bogie suspension based rovers has been successfully introduced for the Mars Pathfinder and Mars Exploration Rover (MER) and Mars Science Laboratory (MSL) missions conducted by apex space exploration agencies throughout the world. The proposed suspension system was currently the most favored design for every space exploration company indulge in the business of space research. The motive the research initiation was to understand mechanical design and the application of Rocker- bogie suspension system in areas of mining.

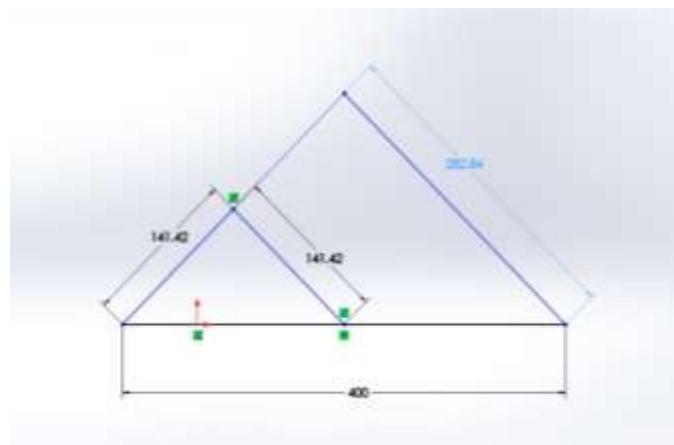
Important fields of application are homeland security, surveillance, demining, reconnaissance in dangerous situations, and agriculture. The design of the locomotion systems of mobile robots for unstructured environments was generally complex, particularly when they were required to move on uneven or soft terrains, or to climb obstacles. The three main categories of locomotion systems (wheeled – W, tracked – T and legged – L) and the four hybrid categories that can be derived by combining these main locomotion systems were discussed with reference to maximum speed, obstacle-crossing capability, step/stair climbing capability, slope climbing capability, walking capability on soft terrains, walking capability on uneven terrains, energy efficiency, mechanical complexity ,control complexity and technology readiness. The current and future trends of mobile robotics were discussed [7]. The optimization of a particular suspension system known as the “rocker-bogie” for our Mars Rover. This type of mechanism has been used on most of the rovers on Mars and has proved to be a simple and elegant design .A Genetic Algorithm was implemented and used to optimize the geometry and kinematics of the rovers wheel suspension system subject to the defined performance metrics. This work shows the effectiveness of the optimization of a rocker-bogie suspension system using a Genetic Algorithm. It also reveals that the resulting system meets all constraints and that significantly reduces the error of individual performance metrics and the overall system .It was shown that the overall fitness of the rover suspension system can be increased by an average of 28% after 100 iterations compared to an initial guess. All performance metrics defined were improved significantly throughout the optimization. The method can be applied to different types of rovers in order to optimize the wheelsuspension mechanism’s geometry [8].

3. DESIGN OF ROCKER BOGIE

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 160 mm height (like stones, wooden blocks) and can climb over stairs of height 160 mm. Also another target is to climb any surface at an angle of 45°. To achieve the above targets we had design the rocker-bogie model by assuming stair height 160 mm and length 400 mm. Using Pythagoras theorem, find the dimensions of the model. It have both angles of linkages are 90°.

3.1. Design calculation

The objective of the research work is stair climbing. To achieve proper stair climbing the dimensions of linkages should be proper. Assume the stair height and length 160 mm and 400 mm respectively. To climb stairs with higher stability, it is required that only one pair of wheel should be in rising position at a time. Hence to find dimension of bogie linkages, first pair of wheels should be placed at horizontal position means at the end of the rising and second pair should be placed just before the start of rising. There should be some distance between vertical edge of stair and second pair of wheel to striking of wheels. Now, need to obtain the distance between first and second wheel through DWG EDITOR software (200mm).



Considering the right angled triangle ABC,

Using Pythagoras in ΔABC

Length of link AC:

$$BC^2 = AB^2 + AC^2$$

$$40^2 = 2(AB^2)$$

$$AB = AC = 280\text{mm}$$

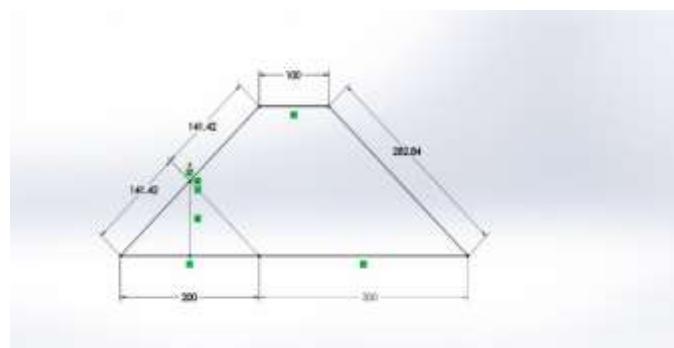
Length of link DB:

$$BE^2 = DB^2 + ED^2$$

$$20^2 = 2(DB^2)$$

$$DB = DE = 141\text{mm}$$

By considering all these lengths and angles we have drawn whole mechanism.



Above Figure shows all dimensions of rover. We take pipe diameter as 25mm suitable for drilling 15 mm diameter hole.

3.2. Design & Selection of Wheel

Design of wheel is required at velocity up to 0.5 m/s. Assume speed is 60 - 100 rpm motor. Using velocity relation velocity is calculated for assumed speed. Using calculated velocity value need to find out diameter of wheel is 95.35 mm. Hence we select the wheel of 100 mm diameter (standard wheel). Selection of rubber thread bonded to the wheel makes it light weight and durable, provides excellent traction, \ friction. These plastic wheels offer a low cost solution that is durable enough for a combat robot yet still light enough to be practical. For robot used six wheels. Wheel Diameter: 100 mm Wheel Width: 20 mm. Selection of acceleration for robot. For a typical robot on flat terrain, it's needed to take acceleration about half of maximum velocity. Maximum velocity of robot is 0.5 m/s^2 . Hence the acceleration of robot will be $0.5/2$ means 0.25 m/s^2

This means it would take 2 seconds to reach maximum speed. If robot is going up inclines or through rough terrain, you will need a higher acceleration due to countering gravity. We needed to climb the angle upto 45° . Hence, **Acceleration of inclines** = $9.81 * \sin \text{angle of inclination} * \pi / 180$ (1) = 0.121 m/s^2 Total Acceleration = $0.25 + 0.121 = 0.371$.

4. CONTROL SYSTEM

The All Terrain Rover can be controlled via Bluetooth from our Mobile Phones. In order to achieve this Arduino UNO board has been used. To power the motors 12V DC battery has been used. To control the flow of power from the battery to the six motors driver module L-298 has been used. To connect the mobile application and the arduino board Bluetooth Module has been used.

The thus developed All Terrain Rover can be used in areas of Manual Replacement. It can be used as a substitute for humans in areas of mining. People die at a rate of 1000 per year involved in mining activities. This can be achieved by attaching arms over the All Terrain Rover.

5. CONCLUSIONS

This work shows how rocker bogie system works on different surfaces. As per the different weight acting on link determines torque applied on it. By assuming accurate stair dimensions, accurately dimensioned rocker bogie can climb the stair with great stability. The design and manufactured model can climb the angle up to 45° .

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