DESIGN AND FABRICATION OF ROCKER BOGIE MECHANISM GEOSURVEY ROVER

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***Abstract*: The Project work "Rocker Bogie mechanism Geosurvey Rover" deals with the important aspect of improving the rover from its previous designs. The Geosurvey rover has to operate on rough and harsh environments for which it was designed but several factors restrict its operational capabilities, so the focus of our research is to overcome restrictions or to decrease it to within an acceptable range for its smooth performance. Our research on the restrictions of the rover conducted by our team focused mainly on the drive system and its drive modules which were not efficient, the linkage, the overturning or tilt range of the rover and the battery inefficiency from the other restrictions and problems that were obtained from the literature review and research so, we conducted research on how to improve that. The rover has been completely made from PVC to increase its capability to withstand shocks, vibrations and mechanical failures caused by the harsh environment where it is operated on. Using CAD software the design of the rover has been fine tuned and by experimenting with prototypes and models of the rover in the experimental setup of the live test, improvements and feature were included into the Geosurvey rover. The result of the project was the implementation of independent directional control utilizing minimum drive modules which increases the efficiency of the battery and increases the operating time of the rover, near zero tilt of the main body of the rover by self balancing of the body counterweight method which decreases the tilt or overturning percentage of the rover and its stability and finally by direct linkage of the various links comprising the rover which increases the loading capacity. Thus the various improvements ensure structural, tilt stability, mechanical integrity and overall weight reduction and mechanical feasibility.**

***Index Terms*: D.C Gear Motor, Wireless Camera, PVC Pipe Fitting, RF Remote Control Systems.**

I. INTRODUCTION

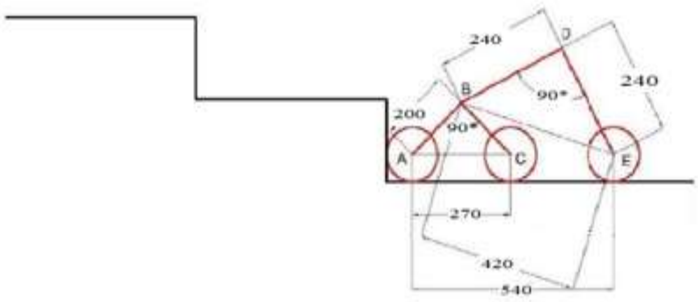
The rocker-bogie suspension design has become a proven mobility application known for its superior vehicle stability and obstacle-climbing capability. Following several technology and research rover implementations, the system was successfully flown as part of Mars Pathfinder's Sojourner rover. When the Mars Exploration Rover (MER) Project was first proposed, the use of a rocker-bogie suspension was the obvious choice due to its extensive heritage. The challenge posed by 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. 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 centre of gravity.

II. DESIGN OF ROCKER BOGIE ROVER

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 the 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 design the rocker-bogie model by assuming stair height 150 mm and length 370 mm. Using Pythagoras theorems, find the dimensions of the model. It have both angles of linkages are 90˚.

2.1. 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 150 mm and 370 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 as shown in Fig. 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.



Drawing for First Triangle

Now, need to obtain the distance between first and second wheel through CAD software (270 mm). Considering the right angled triangle ABC,

Using Pythagoras in ΔABC assume lengths AB and BC is x,

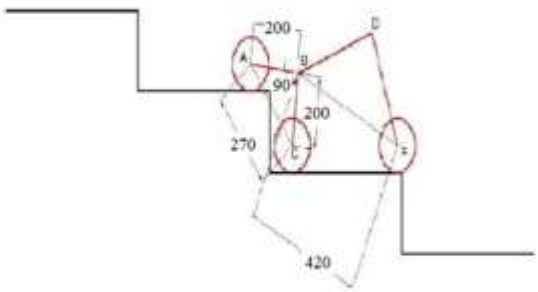
$AC^2 = AB^2 + BC^2$

$270^2 = x^2 + x^2$

$270^2 = 2x^2$

x = 135 + 65 (Add data from testing) mm

Hence, AB = BC =200 mm



Drawing for Second Triangle

Similarly, to find dimensions for rocker linkages first two wheel pairs should be placed at horizontal position. Third wheel pair should nearly complete its rising before starting of rising of first pair of wheel. By placing wheel in such manner we obtained dimension of link BE (420mm).

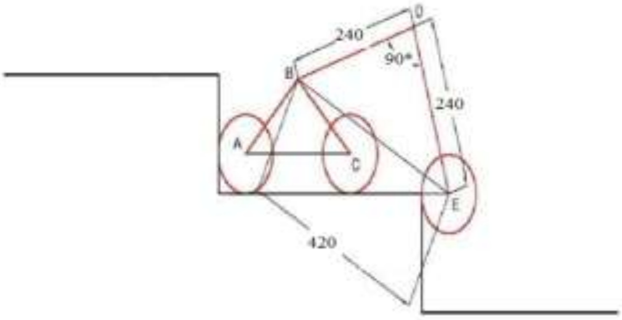
Now consider ΔBDE

$420^2 = BD^2 + DE^2$

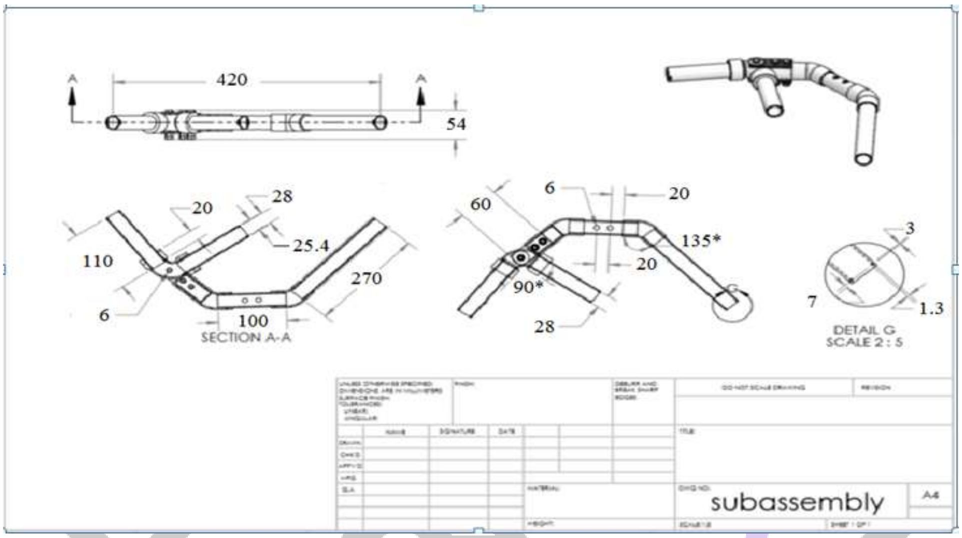
$420^2 = 2y^2$

y = 210 + 30 mm

Hence, BD = DE = 240 (Add data from testing)



Drawing for both Triangles



3D Model of Rover Frame

2.2 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: 40 mm

Shaft Diameter: 6mm

2.3 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. 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 up to 45˚. Hence,

Acceleration of inclines:

$$= \frac{9.81 * \sin \text{angle of inclination} * \pi}{180}$$

$= 0.121\ m/s^2$

Total Acceleration = 0.25+0.121 = 0.371 m/s^2

III WORKING PRINCIPLE

The rocker-bogie design consisting of no springs and stub axles in each wheel which allows the chassis to climb over any obstacles, such as rocks, ditches, sand, etc. that are up to double the wheel's diameter in size while keeping all wheels on the ground maximum time. As compared to any suspension system, the tilt stability is limited by the height of the centre of gravity and the proposed system has the same. Systems employing springs tend to tip more easily as the loaded side yields during obstacle course. Dependent upon the centre of overall weight, any vehicle developed on the basis of Rocker bogie suspension can withstand a tilt of at least 50 degrees in any direction without overturning which is the biggest advantage for any heavy loading vehicle. The system is designed to be implemented in low speed working vehicles such as heavy trucks, Bulldozers which works at slow speed of around 10 centimeters per second (3.9 in/s) so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

IV METHODOLOGY

As per the research it is find that the rocker bogie system reduces the motion by half compared to other suspension systems because each of the bogie's six wheels has an independent mechanism for motion and in which the two front and two rear wheels have individual steering systems which allow the vehicle to turn in place as 0 degree turning ratio. Every wheel also has thick cleats which provides grip for climbing in soft sand and scrambling over rocks with ease.

In order to overcome vertical obstacle faces, the front wheels are forced against the obstacle by the centre and rear wheels which generate maximum required torque. The rotation of the front wheel then 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. At last, the rear wheel is pulled over the obstacle by the front two wheels due to applying pull force. During each wheel's traversal of the obstacle, forward progress of the vehicle is slowed or completely halted which finally maintain vehicles centre of gravity. The above said methodology is being practically proved by implementing it on eight wheel drive ATV system in order to gain maximum advantage by rocker bogie system.

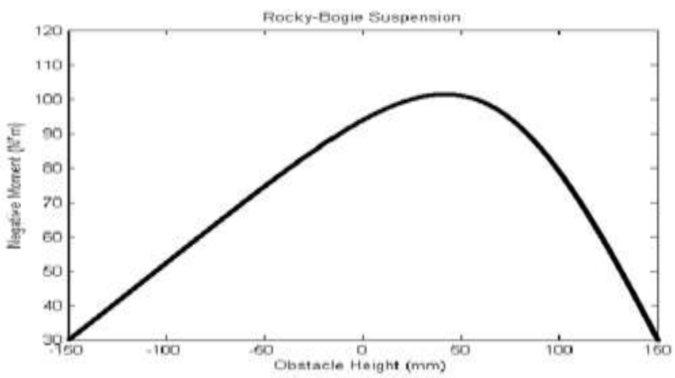
V.OBSERVATION AND RESULTS

5. 1 OBSERVATION:

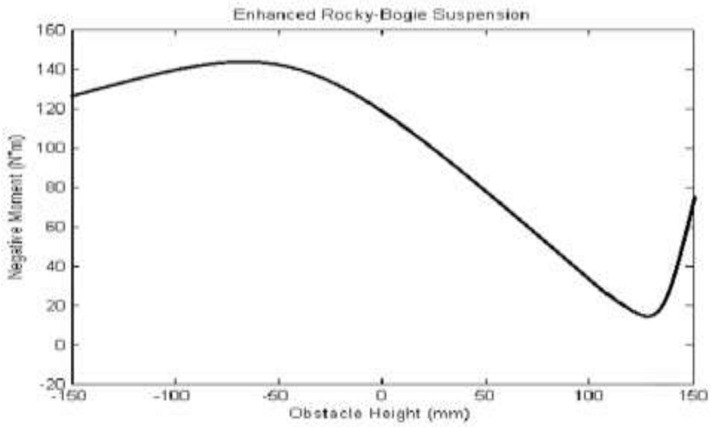
The main problem associated with current suspension systems installed in heavy loading vehicles rovers (including those with active and semi active suspension systems) is their slow speed of motion which derails the rhythm to absorb the shocks generated by wheels which remain the result of two factors. First, in order to pass over obstacles the vehicle must be geared down significantly to allow for enough torque to raise the mass of the vehicle. Consequently, this reduces overall speed which cannot be tolerated in the case of heavy loading vehicles. Second, if the vehicle is travelling at a high speed and encounters an obstacle (height greater than 10 percent of wheel radius), there will be a large shock transmitted through the chassis which could damage the suspension or topple down the entire vehicle. That is why current heavy loading vehicles travel at a velocity of 10cm/s through uneven terrain. The software based testing of rocker bogie suspension system describes the momentum and efficiency related utilities in cumulative manner.

5.2. RESULTS:

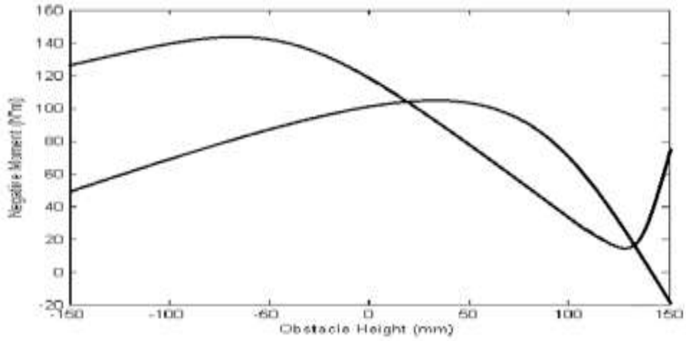
Various tests were conducted to determine how the improved geosurvey rover would perform against its predecessor designs by use of Negative Moment vs. Obstacle Height and their responses were obtained and their graphs were plotted and comparisons were made.



Response of rocker-bogie suspension against obstacle height.



Response of enhanced rocker-bogie suspension against obstacle height.



Comparison for response of each suspension against obstacle height.

VI.CONCLUSION

The proposed paper introduces a novel design in pursue of increasing the rocker-bogie mobility system in conventional heavy loading vehicle behavior when high-speed traversal is required and to increase the battery efficiency and operating time of the rover, which was made possible using the independent directional control system which utilizes minimum drive modules dependent upon the operating condition and situation. Under reasonable assumptions, it is possible to determine the rover attitude and configuration, given its position and ground characteristics, and whether the rover will slide, tip over or maintain its balance using sensors and instruments. The near zero tilt system using the rovers power supply attached to the main body of the rover to as a counter weight and self-balance itself reduces the percentage and chances of tilt or overturning. The mechanics of the rover has been developed, and the over-actuation of the system leads to the ability to affect the normal forces by applying specific wheel torques. This property has been verified experimentally and can be used for the design of an active traction control. A graphical interface can be designed and implemented onto the current geosurvey rover design to enhance understanding of the system and to view all data regarding its operation which will be helpful in further advancing the system.

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˚. Also we tested for the Web cam with AV recording mounted on rocker bogie system and found satisfactory performance of its capabilities for providing image and video data.

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