Design of Rocker-Bogie Mechanism for Application in Agriculture

[1]Palash Purohit, Student, [2]Vishwajeet Singh Rathore, [3]Shreesh Agrawal, [4]Prafful Manker, [5]Prashant Geete

[1,2,3,4]Student, [5]Professor, Acropolis Institute Of Technology And Research, Indore, India,

[1]palash0104@gmail.com, [2]vishwajeetsingh.rathore96@gmail.com,

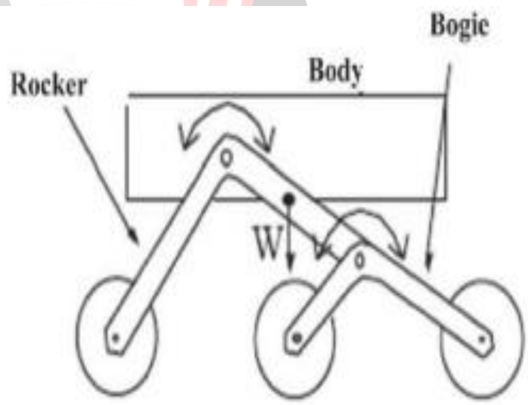
[3]Shreeshagrawal24@gmail.com, [4]praffulmanker@gmail.com, [5]prashantgeete@gmail.com

ABSTRACT: The rocker-bogie suspension design has proven its capability in 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 first preference due to its good obstacle climbing capacity and stability. The challenges in development of rocker bogie suspension system are weight of the system and it is not suitable for high speed operations.This paper will cover some important aspect regarding rocker bogie mechanism may used for agriculture purpose.

KEYWORDS -: ***Agriculture, Exploration, Rocker-bogie, Rover, Sprinkler, Suspension.***

I. INTRODUCTION

NASA recently started an exploration program of Mars.Pathfinder is the first rover explorer in this program[1].Future rovers will need to travel several kilometers over periods of months and manipulate rock and soil samples. They will also need to be somewhat autonomous. Rocker-bogie based rovers are likely preferred candidates for these missions [2]. When the Mars Exploration Rover (MER) Project was first proposed, the use of a rocker-bogie suspension was the choice due to its good obstacle climbing capacity [1].The rocker-bogie suspension is a mechanism that, along with a differential, enables a six-wheeled vehicle to passively keep all six wheels in contact with a surface even when driving on severely uneven terrain[4]. The first advantage is that the wheels' pressure on the ground will equal. This is extremely important in soft terrain where excessive ground pressure can result in the vehicle sinking into the driving surface[6]. The second advantage is that while climbing over hard, uneven terrain, all six wheels will remain in contact with the surface and under load, helping to propel the vehicle over the terrain.Rocker bogie suspension system has 6 independently driven wheels attached to a frame[3]. The frame has two rocker arms connected to a main body.Rocker arm is the longest link in the system. Each rocker has a rear wheel connected to one end and a secondary rocker, called a bogie, connected to the other. At each end of the bogie is a drive wheel and the bogie is connected to the rocker with a free pivoting joint. The rockers are connected to the main body with a differential so that the pitch angle of the body is the average of the pitch angles of the rockers. It should also absorb the impact loads during travel on uneven surface.



II. LITERATURE REVIEW

Since 1976, NASA has been exploring the surface of mars with rovers,starting with dual landing of viking 1 and viking 2 lander. In 1997, The mars pathfinder (MPF) lander delivered the Sojourner rover successfully. In early 2004, NASA again landed two more rovers on mars, spirit and opportunity. Most recently in 2011, NASA has launched the Mars science laboratory(MSL) with a rover named curiosity[3]. Curiosity rover is a car sized robotic rover exploring mars as part of NASA's Mars science laboratory mission.The 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[7]. The rovers needed to be very robust and reliable, as it has to withstand dust, strong winds, corrosion and large temperature changes under mysterious

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conditions. Maximum rovers remain powered by batteries which are recharged by solar panels during the day installed over there surface[5]. 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[8]. 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. There are three main types of rover locomotion developed so far i.e. wheeled, legged and caterpillar locomotion. The main difference between the miscellaneous designs of planetary robots lies in the type of locomotion system. Even after developing many legged and hybrid robots, most researchers still focus on wheeled locomotion for rovers because of its locomotive ease and advantages and among wheeled locomotion design, the rocker bogie suspension system based design remain most favored. The ancient FIDO rover and the Sojourner contain 6 independently steered and driven wheels suspended from a rocker-bogie mechanism for maximum suspension and ground clearance. Rocky Seven Rover has a similar suspension system just differ in front wheels. The Nanorover & Nomad Rovers have four steered wheels suspended from two bogies & CRAB Rover utilizes two parallel bogie mechanisms on each side to overcome obstacles and large holes[9]. As far as the initial research is concerned, the software optimization seeks for an optimum in the constrained solution space given an initial solution and Dr. Li et al. derive a mathematical model 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 minimizes the energy consumption, the vertical displacement of the rover's centre of mass and its pitch angle.

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[10]. 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 centimetres per second (3.9 in/s) so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles[1].

III. 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[10]. 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.

IV. 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 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 theorem, find the dimensions of the model. It have both angles of linkages are 90˚. A. 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.1. And second pair should be placed just before the start of

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rising. There should be some distance between vertical edge of stair and second pair of wheel to striking of wheels.

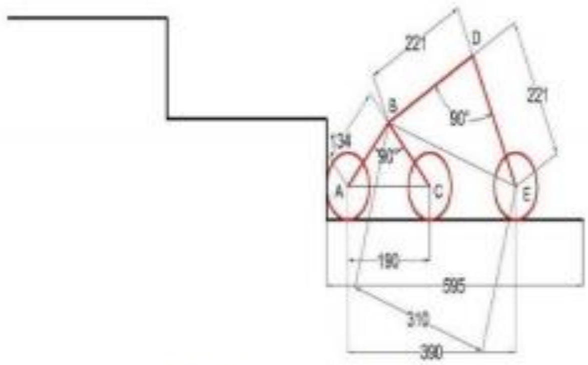

Fig. 1. Cad drawing for first triangle

Now, need to obtain the distance between first and second wheel through CAD software (190 mm). Considering the right angled triangle ABC, Using Pythagoras in ΔABC (Fig. 2.) assume lengths AB and BC is x. $AC^2 = AB^2 + BC^2$, $190^2 = x^2 + x^2$, $190^2 = 2x^2$, x = 134 mm. Hence AB = BC =134 mm (Fig. 2.)

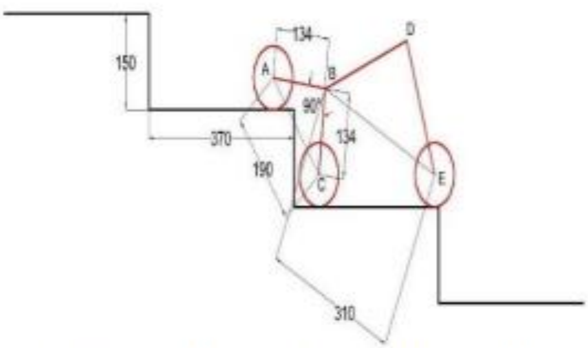

Fig. 2. Cad drawing for second triangle

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 BC (311mm). Now consider ΔBDE (Fig. 3.), $BE^2 = BD^2 + DE^2$ $311^2 = 2y^2$ y = 221 mm Hence, BD = DE = 221 mm (Fig. 3.)

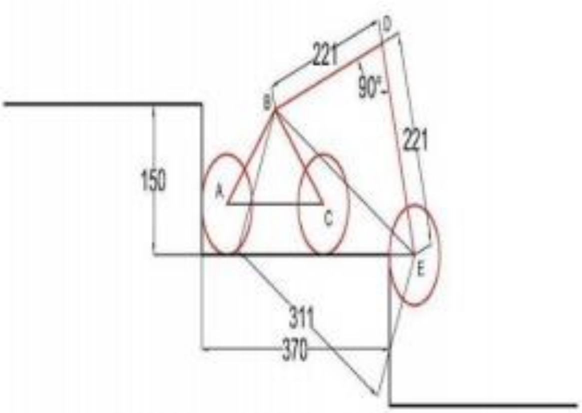

Fig. 3. CAD drawing of both triangles

By considering all these lengths and angles we have drawn whole mechanism. Above Fig. 3, shows all dimensions of robot. We take acrylic width is 40 mm suitable for drilling 15 mm diameter holes. B. Drawing After the calculation of triangle dimension using CAD software 2D drawing is prepared as per calculated dimension and same drawing views are shown in Fig. 4.

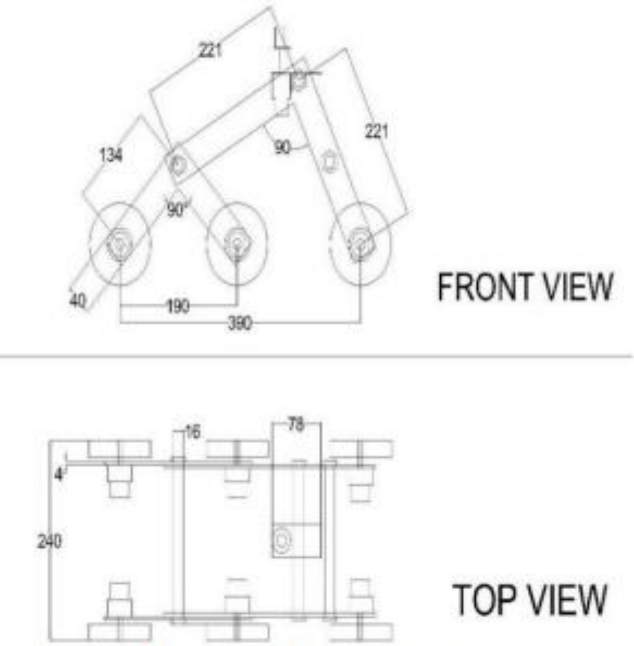

Fig. 4. 2D Drawing of Rocker Bogie Mechanism

C. 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 (as shown in Fig. 5.) 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 Shaft Diameter : 6mm

Fig. 5. Photo Image of Rubber Wheel

D. 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.

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Hence the acceleration of robot will be 0.5/2 means 0.25 m/s2 . This means it would take 2 seconds to reach maximum speed. If robot is going up inclines (as per Equ. No.1) or through rough terrain, you will need a higher acceleration due to countering gravity. We needed to climb the angle upto 45˚. Hence,

$$\text{Acceleration of inclines} = \frac{9.81 * \sin(\text{angle of inclination}) * \pi}{180} \quad (1)$$

$$= 0.121 \text{ m/s}^2$$

$$\textbf{Total Acceleration} = 0.25+0.121 = 0.371 \text{ m/s}^2$$

V. ADVANTAGES

1. Load on each wheel is nearly identical.

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

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

4. Each wheel can individually lift all the entire mass.

5. Distributing the weight and drive torque to 6 wheels instead of 4, gives the rover greater traction and stability.

VI. LIMITATION

As per the previous models of applications of rocker bogie mechanism it was found that the rocker bogie model is not suitable to work at speed higher than 10 cm/s.

VII. APPLICATIONS

1. Can be useful in designing suspension system in future automobiles.
2. Can be used to serve in defence purpose for security of nation.
3. Can be used in load decking and material handling process.
4. Can carry a sprinkler device on it which will be an useful tool for spraying of fertilizer and pesticide in agricultural field as surface on agricultural field in uneven.

VIII. CONCLUSION

In this paper we were able to understand the concept of rocker bogie mechanism in suspension system.By analyzing the applications of this mechanism we come to a point that it is most effective in exploration purposes where it is difficult for a normal vehicle or humans to go. We have to also design the rocker bogie system as per the requirement. This paper also discuss about some projects which were initiated during space exploration which had applications of rocker bogie mechanism. Further , work must be done on its application on commercial automobile sector and its stability.The purpose of this study is to put another stone on the pyramid of scientific knowledge, there is no doubt that future robotics study will continue to search for new mechanisms.

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