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Working Model of Rocker Bogie Mechanism (Earth Rover)

Shivam Sanjay Chikurdekar[1], Pravin Prakash Gaikwad [2], Dhiraj Dilip Satpute[3], Vinayak Suresh Godase[4], Prathamesh Tanaji Pethkar[5], Subodh S. lande[6]
[1,2,3,4,5]*B.tech Student,* [6]*Assistant professor, Department of mechanical engineering, NMCE, Peth,, Maharashtra, India*

Abstract: ***The Paper work "Rocker Bogie mechanism Geo-survey Rover" deals with attempt of improving the rover from its previous designs. The Geo-survey rover has got to operate rough and harsh environments that it had been designed but several factors restrict its operational capabilities, therefore the focus of our research is to overcome restrictions or to decrease it to within an acceptable range for its smooth performance.. The rover has been completely made from PVC to increase its capability to withstand shocks, vibrations and mechanical failures caused by the tough environment where it's operated on. NASA made and developed this mechanism to use it on Space missions. Whereas these bogies are also preferred by many earthly situations where human interference is needs to be neglected. Usual mobility designs are complicate, using many wheels or legs. It is a multi-wheeled rover capable of travel through rough terrain using an effective higher degree of mobility. Drive train simplicity is the effective mechanical feature of the rocker bogie design, which is accomplished by using only six motors for mobility. All motors are located inside the body where thermal variation is kept to a minimum which increases reliability and efficiency. Six wheels are used because there are few obstacles on natural terrain that need both front wheels of the rover to climb simultaneously. A series of mobility experiments within the agriculture land, rough roads, inclined, stairs and obstacles surfaces concluded that rocker bogie can achieve a long way traverses on field.***
Keywords: Rocker bogie; Wheel type mobile robot, Stair climbing, Rover.

I. INTRODUCTION

The rocker bogie suspension system was first used for the Mars Rovers and is currently NASA's favored design for rover wheel suspension. The perfectly designed wheel suspension allows the vehicle to travel and pass over very uneven or rough terrain and even climb over small obstacles. The rocker bogie suspension may be a mechanism that permits a six-wheeled vehicle to passively keep all six wheels in touch with a surface even when driving on severely uneven terrain. This rocker suspension may be a sort of mechanism that permits a six wheel vehicle to constantly keep all six wheels in touch with a surface when driving on uneven terrain surfaces.
This paper describes a way of driving a rocker- bogie rover in order that it can progressively step over most obstacles instead of impacting and climbing over them. Most of the advantages of this method are often achieved without mechanical modification to an equivalent designs – only a change on top of things structure. Some machine changes are suggested to collect the utmost profit and to greatly increase the effective speed of future rovers. The rocker bogie mechanism is one among the foremost popular suspension mechanisms, which was initially designed for spaceflight vehicles having its own deep history embedded in its development.

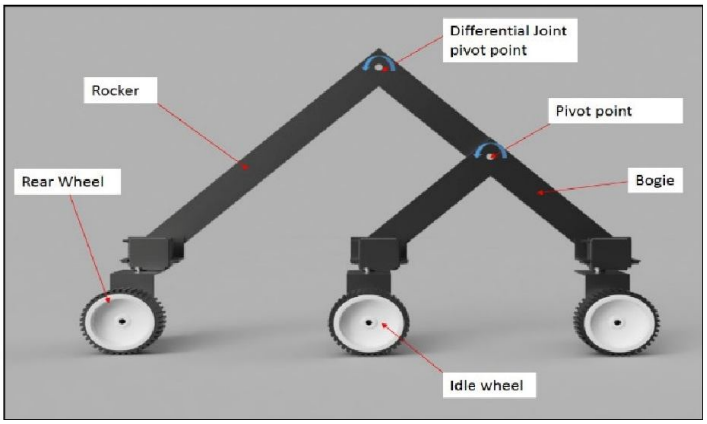

Fig. no.1 Parts of system

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By design it's a wheel robot which comprises of 6 motorized wheels. The word “rocker” describes the rear a part of the larger links present each side of the suspension and therefore the se rockers are connected to every other and the vehicle chassis through a selectively modified differential so as to balance the bogie. By construction it's main frame containing two linkages on all sides that are called the “rocker” (see Figure 1). One end of the rocker is connected to the rear wheel, and therefore the other end is connected to take care of center of gravity of entire vehicle as accordance with the motion, when one rocker moves down-word, the opposite goes upward. It plays vital role to take care of the typical pitch angle of both rocker and bogie by allowing both rockers to maneuver as per things . As per the particular design, one end of a rocker is jointed with a drive wheel and therefore the other end is pivoted to a bogie which provides required moment and degree of freedom.

II. THEORY

Using CAD software, the planning of the rover has been fine-tuned and by experimenting with prototypes and models of the rover within the experimental setup of the live test, improvements and feature were included into the Geo-survey rover. The results 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 most body of the rover by self-balancing of the body counterweight method which decreases the lean or overturning percentage of the rover and its stability and eventually by direct linkage of the varied links comprising the rover which increases the loading capacity. Thus, the varied improvements ensure structural, tilt stability, mechanical integrity and overall weight reduction and mechanical feasibility.

A. What is Rocker Bogie Robot ?

The Rocker bogie suspension may be a suspension arrangement utilized in Mars rovers. This mechanism enables a six-wheeled vehicle to stay all wheels in touch with a surface even when driving on severely uneven terrains. Suspension is the term given to the system of springs, shock absorbers and linkages that connect the vehicle to its wheels. Suspension system server’s dual purpose: contributing to the car’s road handling and braking.

B. Objective of the Project

The objective of this project is to design a small, strong and highly controllable rover robot.
It will be designed for performing on the various platforms like -

1) Rough terrains
2) Smooth surfaces
3) Overcoming obstacles of certain height.
4) The main objective is to be light weight suspension system.

C. Working Principle

1) In order to go over an obstacle, the front wheels are forced against the obstacles by the rear wheels. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle.
2) The middle wheel is pressed against the obstacle by the rear wheel and pulled against the obstacles by the front, until it is lifted up and over
3) Finally, the rear wheel is pulled over the obstacle by the front two wheels. During each wheel’s traversal of the obstacle, forward progress of the vehicle is slowed or completed halted. These rovers move slowly and climb over the obstacles one portion at a time.

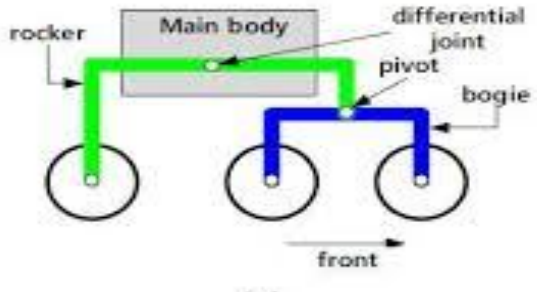

Fig. no. 2 Working Principle

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The rocker-bogie design consisting of no springs and stub axles in each wheel which allows the chassis to climb over any obstacles, like rocks, ditches, sand, etc. that are up to double the wheel's diameter in size while keeping all wheels on the bottom maximum time. As compared to any suspension , the lean stability is restricted by the peak of the center of gravity and therefore the proposed system has an equivalent . Systems employing springs tend to tip more easily because the loaded side yields during obstacle course. Dependent upon the center of overall weight, any vehicle developed on the idea of Rocker bogie suspension can withstand a tilt of a minimum of 50 degrees in any direction without overturning which is that the biggest advantage for any heavy loading vehicle. The system is meant to be implemented in low speed working vehicles like heavy trucks, Bulldozers which works at slow speed of around 10 centimeters per second (3.9 in/s) which minimizes dynamic shocks and any damage to the vehicle when overpassing sizable obstacles.

D. Experimental SETUP

The vehicle controls manually by a user employing a joystick to manually override the system just in case of failure. The main body is attached to the IMU to locate the initial state and pitch angle of the rover. The pitch angle of the most body is said to terrain condition and normal gravity.

Each bogie and rocker are been attached the angular sensor to work out the incline angle of a vehicle. Then the servo motor will move the rocker and boogie supported angular value and IMU data to avoid the vehicle from flip. Each motor must have an encoder to work out it speed and torque. The data are wont to control the slip's problem. The bogie and rocker can move and cross maximum cross-hill and downhill.

On earth, it brilliantly controls and maximizes the angle of cross-hill and down-hill grade ability. While on water, retracted bogie and rocker are necessary to reinforce the vehicle movement. The robot has six tires that move independently, it consume tons of power for a motor to maneuver and therefore the difference motor's speed made it difficult to maneuver. Synchronizing all tire using an algorithm are discussed during a motorized vehicle that have more tire to scale back the facility consumption and enhancing the robot's stability. Therefore, in this paper, we presented an attempt to move the wheel position toward body center and distribute the angles caused by the inclined surfaces via distribution among the robot joints. Since the vehicle features a retractable wheel, the mechanism is employed to distribute the angle and made it stable when traverse on the uneven paved surface.

1) *Downhill And Front Grade Ability:* Down-Hill Grade ability is to live maximum incline angles that stabilize the vehicle from slip and flip. Wheel slip can damage the vehicle and jeopardize the entire rescue mission during the post-disaster occurrence. The Down-Hill Grade ability is often analysis statically. The vehicle must have trainability aspects to beat the unpredicted terrain and overpassed the obstacle. Downhill grade ability are often enhancing by minimizing the wheel's slip or maximizing the rover traction. Intelligently control the slip will affect the facility consumption. The slip made the vehicle use tons of power to beat it.
2) *Cross-Hill Grade Ability:* The speed movement of rocker bogie mechanism is extremely slow to avoid it flipping while turning. It consumed a time that are most important during disaster. Furthermore, a traditional vehicle will avoid the terrain that made it flip. Cross-hill grade ability is to live the utmost angle that suitable for a vehicle to cross. Flip are often overcome by increasing the tire radius or increasing the width of a vehicle. However, it'll change the vehicle specification and wish another analysis. Thus, the controlling distance of tire towards the center on a body is proposed.
3) *Tractive Force of Wheels:* The wheel is a crucial component of the vehicle to maneuver in both land and water surface. The wheel radius supports the rover in climbing an obstacle, and a width prevents it from sinking in muddy place. Using an off-road tire will reduce the slip and supply a mechanical grip since a thread will dig the bottom and increase a contact ratio. The table shows the vehicle specifications. The advantage of a rocker-bogie mechanism is that the load equally distributed on all wheels.
4) *Gradeability:* Gradeability is defined because the highest grade a vehicle can ascend while maintaining a specific speed. It commonly utilized in slope analysis, where the vehicle weight act against the direction of motion which is proportional to the angle of inclination of the paved surface

III.METHODOLOGY

As per the research it's 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 during which the 2 front and two rear wheels have individual steering systems which permit the vehicle to show in situ as 0 degree turning ratio. Each wheel provided with thick cleats which gives grip for climbing in soft sand and over rocks with ease.

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In order to beat vertical obstacle faces, the front wheels are forced against the obstacle by the center and rear wheels which generate maximum required torque. The rotation of the front wheel then lifts the front part of the rover up and over the obstacle and overtakes it. Those wheels which remain within 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 thanks to applying pull force. During each wheel's travel over the obstacle, forward motion of the rover is slowed or completely stopped which finally maintain center of gravity of the vehicle. The above said methodology is being practically proved by implementing it on eight wheel drive ATV system so as to realize maximum advantage by rocker bogie system.

A. Problem Statemen

The Rocker bogie suspension may be a suspension arrangement utilized in Mars rovers. This mechanism enables a six-wheeled vehicle to stay all wheels in touch with a surface even when driving on severely uneven terrains.

Suspension is the term given to the system of springs, shock absorbers and linkages that connect the vehicle to its wheels. Suspension system server's dual purpose: contributing to the car's road handling and braking.

B. Introduction to the Work

One of the main short comings of rocker bogie rovers is that they're slow. In order to be able to overcome significantly rough terrain without any type of risk of flipping the vehicle or damaging the suspension, these this robot move slowly and climb over obstacles by having wheels lift each bit of the suspension over the obstacles one portion at time.

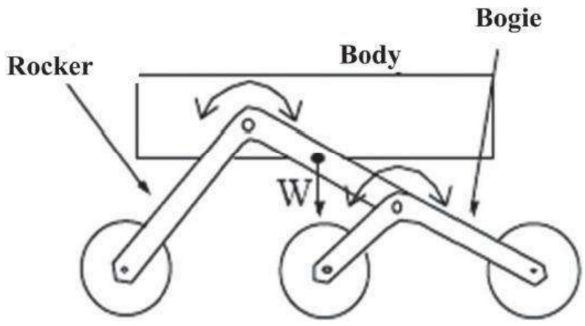

Fig. no. 3 Line diagram

C. How the Machine Works?

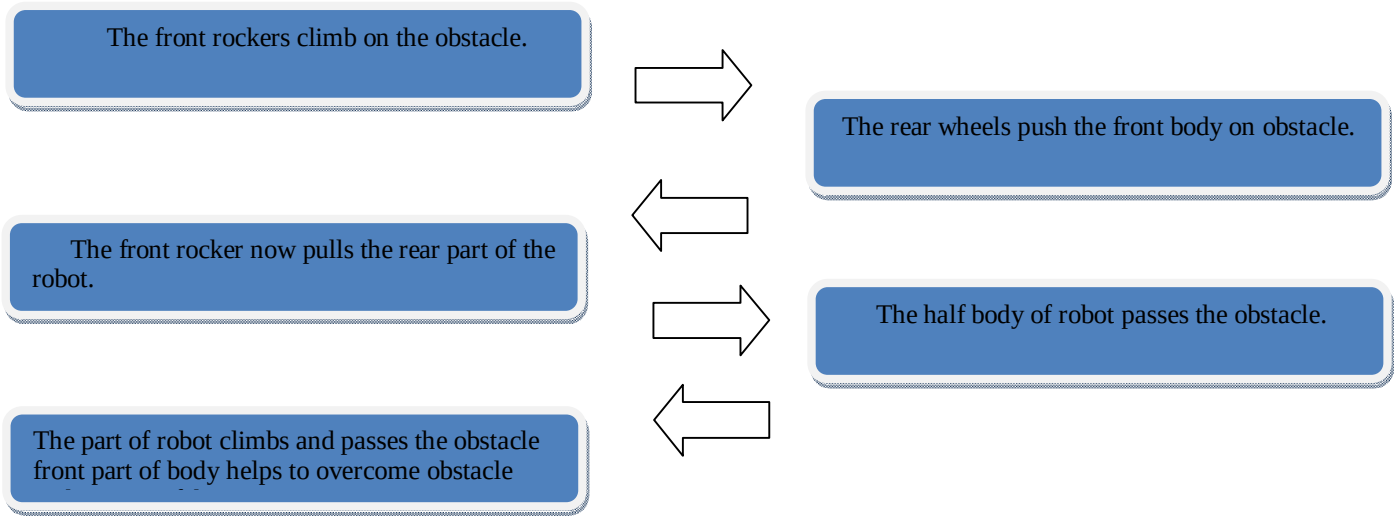

Fig. 4.Working setup

The part of the robot climbs and passes the obstacle on the other way the front part of the robot help is to climb and pass safely.

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IV. DESIGN

Our main goal is to style, develop and test a rover to function a mobility platform: suitable for testing planetary surface exploration technologies in harsh earth environments. The design will specialize in incorporating features that are believed to be essential for many planetary exploration missions supported research of past and current rovers. From the information gathered we have learned about existing rovers and the types of missions they aim to accomplish: our design goals for our rover have been made into these categories:

1) Mobility and navigation
2) Size and weight restrictions

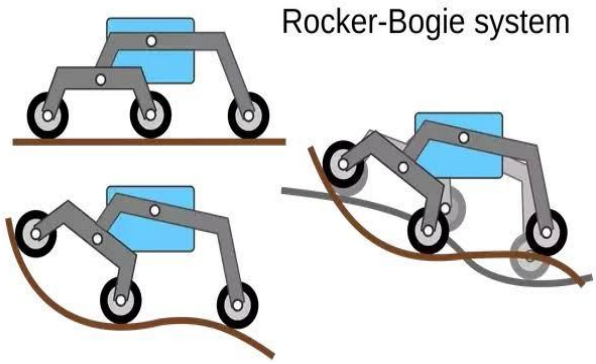

Fig.no.5 Mobilty

A. Selection of material

Selection of material is an important step in designing of any component The main advantages of material selection are :

1) It increases the reliability of product
2) It reduces the cost of product
3) It can also optimize the weight of product

B. Design of rocker bogie rover

The important think about manufacturing of rocker bogie mechanism is to work out the size of rocker and bogie linkages and angles between them. The lengths and angles of this mechanism are often changed as per requirement. In the work the aim is to manufacture the rocker bogie mechanism which may overcome the obstacles of 150 mm height (like stones, wooden blocks) and may 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 size of the model. It have both angles of linkages are 90˚.

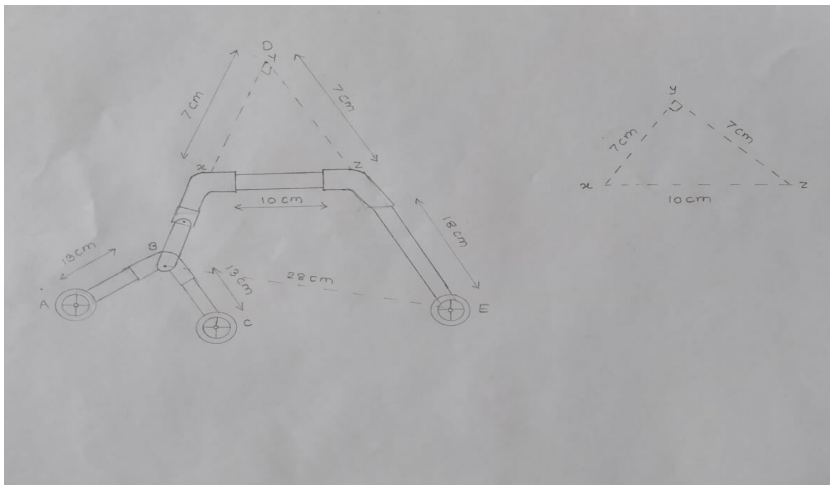

Fig. no.6 Actual Dimensions

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C. Design Calculation

The objective of the research work is Geo-survey. To achieve proper survey the size of linkages should be proper. To climb obstacles, it's required that just one pair of wheel should be in rising position at a time. Hence to seek out dimension of bogie linkages, first pair of wheels should be placed at horizontal position means at the top of the rising as shown in and second pair should be placed just before the beginning of rising. There should be a long way between vertical fringe of stair and second pair of wheel to striking of wheels.

1) Design of Linkages

From fig.6

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

$AC^2 = 13^2+13^2$

(From Triangle XYZ,) $XZ^2=XY^2+YZ^2$

$AC^2 = 338cm^2$ from geometry of fig

AC= 18.38cm $10^2=2*P^2$

P=7.07cm

Whereas,

$BE^2=BD^2+DE^2$ $BE^2=12^2+25^2$

$BE^2=769\ cm^2$

BE=27.73cm

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

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 incline:

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

$= 0.121\ m/s^2$

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

V. MATERIALS AND PARTS

A. Mechanical Components

1) PVC pipes and Joints
2) Jubilee Clamps
3) Motors – 30 RPM
4) 12 volt 7.5 Amp Battery.
5) Plywood
6) Nuts and bolts
7) Superglue
8) Rubber surfaced wheels

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B. Electrical Components

1) Arduino Uno
2) 4-Channel Relay Circuit
3) Bluetooth Model HC-05
4) IC Circuit – 780V
5) Key
6) Buzzer
7) Different colored wires for connection

Fig.no.7 Ardiono Unit

The Arduino Uno is an open-source microcontroller board which is embedded with the Microchip ATmega328P microcontroller. The board is provided with sets of digital and analog input/output pins which will be interfaced to varied expansion boards and other circuits the board has 14 digital I/O pins, 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a sort B USB cable. These are often powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also like the Arduino Nano and Leonardo.

In Italian the word "UNO" means "one" and was chosen to mark the initial release of Arduino Software. The Uno board is that the first during a series of USB-based Arduino boards; it and version 1.0 of the Arduino IDE were the reference versions of Arduino, which have now evolved to newer releases. The ATmega328 on the board comes preprogrammed with a bootloader that permits uploading new code thereto without the utilization of an external hardware programmer.

Fig. 8. DC motor

A gear motor may be a specific sort of electrical motor that's designed to supply high torque while maintaining a coffee horsepower. or low speed, motor output. Gear motors are often found in many various applications and are probably utilized in many devices in your home. Gear motors are commonly utilized in devices like can openers. garage door openers, washer time control knobs and even electric alarm clocks. Common commercial applications of a gear motor include hospital belt, commercial jacks, cranes and many other applications that are too many to list.

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VI. ASSEMBLY AND DRAWING

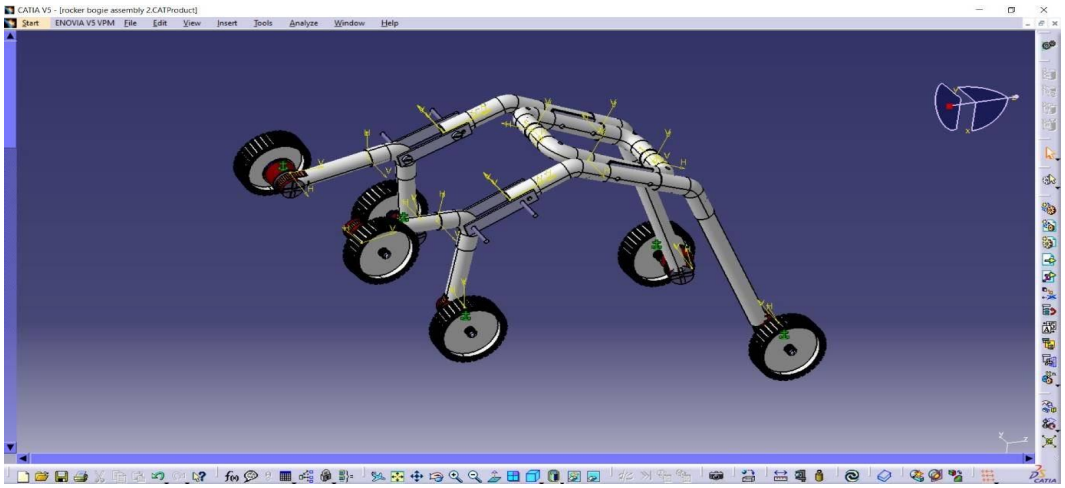

Fig.9 Assembly of rocker bogie

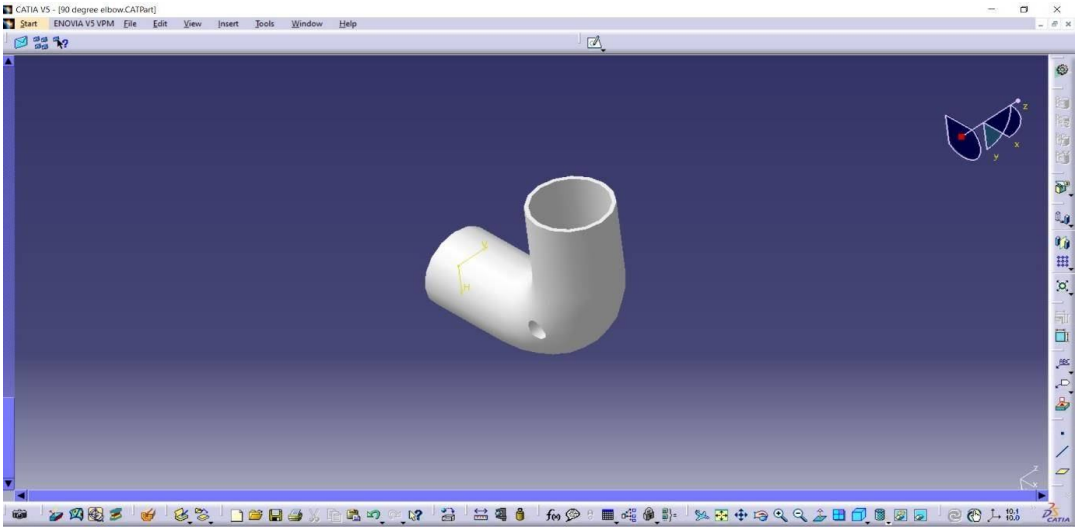

Fig.10 Elbows

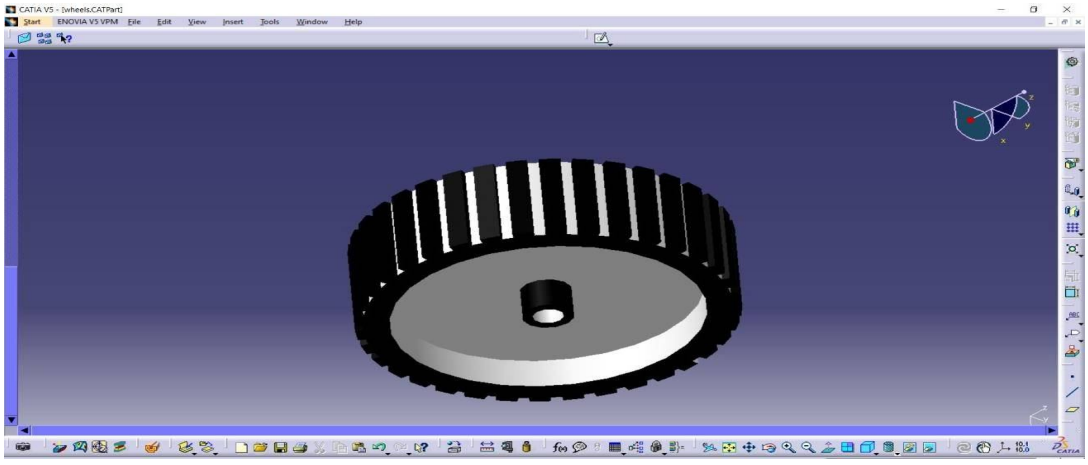

Fig.11 Wheel

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VII. 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's possible to work out 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 therefore the over-actuation of the system results in the power to affect the traditional forces by applying specific wheel torques. This property has been verified experimentally and may be used for the planning of a lively traction control. A graphical interface are often designed and implemented onto the present geosurvey rover design to reinforce understanding of the system and to look at all data regarding its operation which will be helpful in further advancing the system. This paper indicates that how rocker bogie vehicle operates on different surfaces. As per the various weight working on link determines torque applied thereon. We can develop this mechanism to create wonders and be used in almost all our related fields. We have tried our best to make this project much more economical and efficient places where humans may face some danger.

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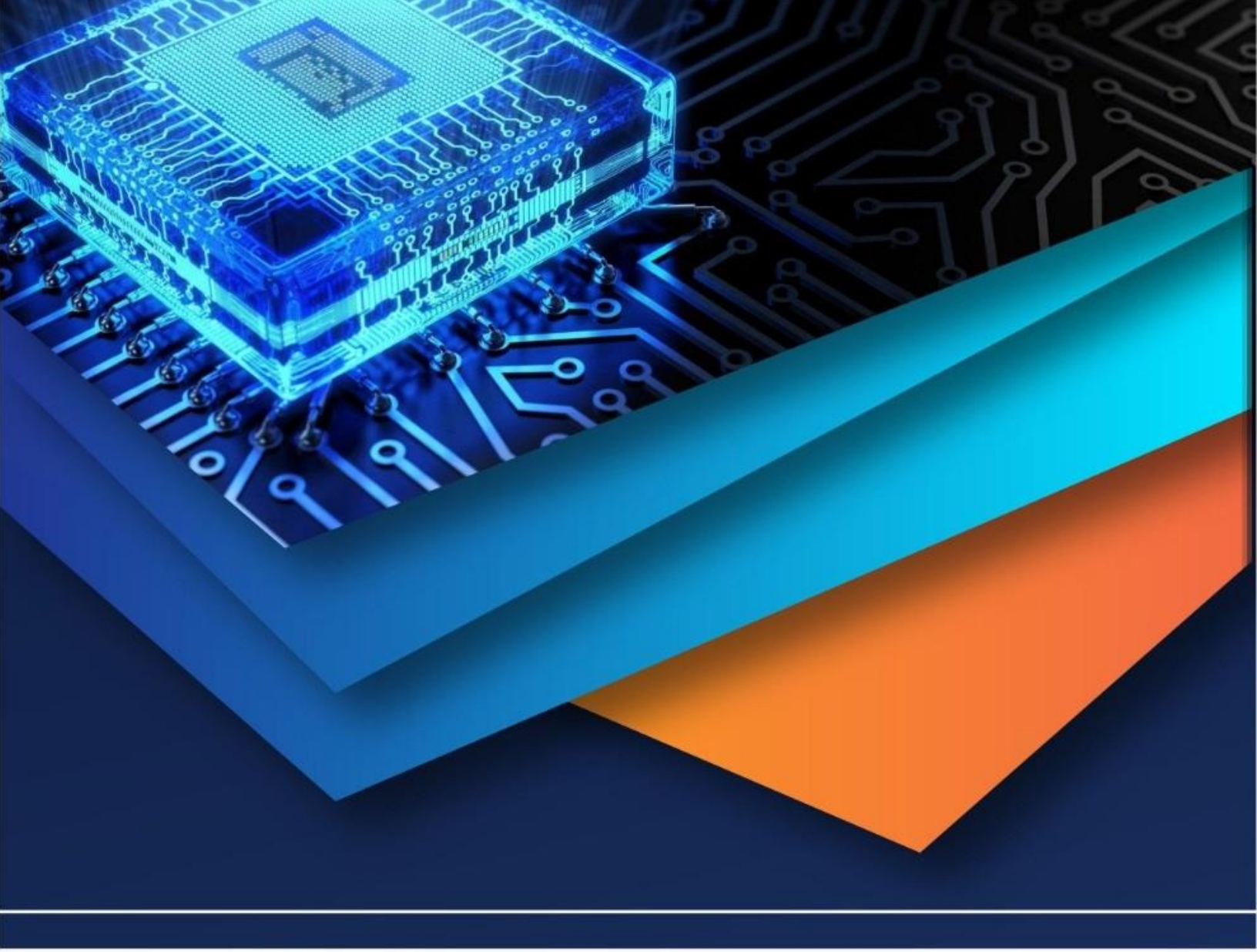

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