

Introduction of Mechanical Gear Type Steering Mechanism to Rocker Bogie

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Abstract- The rocker-bogie suspension mechanism which is currently NASA's approved design for wheeled mobile robots, mainly because it has sturdy 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 is 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 complicacy in design. Here an attempt is 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 paper the proposed steering mechanism is designed and the modeling is done in CATIA (V-5) and the same is analyzed for static analysis for the proposed torque condition of the motor in ANSYS. All the results in the analysis are analyzed for static analysis.

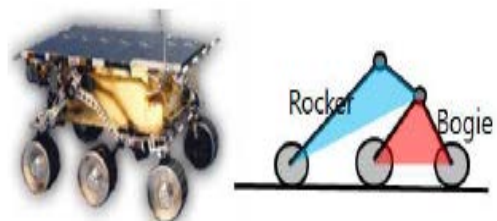
Index Terms - Rocker bogie, Steering system, Gear system, Suspension system.

1. Introduction

The rocker bogie mechanism is one of the most popular linkage mechanisms, which was initially designed for space travel vehicles having its own deep history embedded in its development. By construction it is a wheel robot which comprises of 6 actuated wheels. The term "rocker" describes the rocking aspect of the larger links present each side of the suspension system and these rockers are connected to each other and the vehicle chassis through a selectively modified differential in order to balance the bogie.

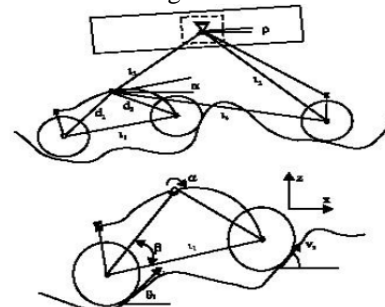
By construction it has main frame containing two linkages on each side that are called the "rocker" (see **Figure 1**). One end of the rocker is connected to the rear wheel, and the other end is connected to a small

linkage which is called the "bogie". Front wheel and the middle wheel are connected to it. The passive joint between rocker and the bogie enable the six wheels contact the ground at all times without any actuators. With this suspension mechanism the rocker bogie demonstrates great mobility on rough terrain and it can climb up an obstacle twice larger than the wheel diameter. Therefore, the rocker bogie shows strong mobility on unexpected terrain and it is used in the "Sojourner" which explores the unencountered terrain of the Mars.



(Figure 1. Sojourner and the rocker bogie mechanism)

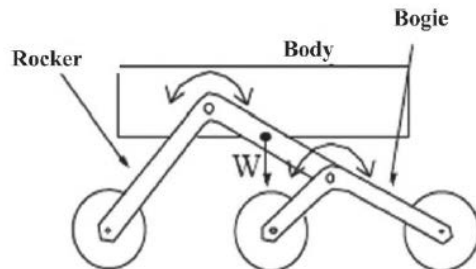
To maintain center of gravity of entire vehicle as accordance with the motion, when one rocker moves down-ward, the other goes upward (**Figure 2**). The chassis plays vital role to maintain the average pitch angle of both rockers by allowing both rockers to move as per the situation. As per the acute design, one end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie which provides required motion and degree of freedom.



(Figure 2. Encounter area of rocker bogie suspension system)

In the system, "bogie" refers to the conjoining links that have a drive wheel attached at each end.

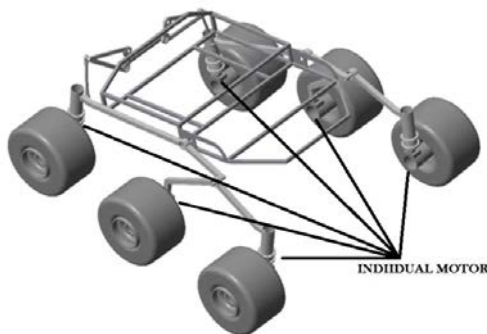
Bogies were commonly used to bare loading as tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks as that very time the trucks will have to carry much heavier load.



(Figure 3. Line diagram of Rocker-bogie suspension system and its motile joints)

2. Problem Identification

As we know rocker bogies give better movement in rough roads. But the main problem in it is steering system. Its construction does not allow the conventional steering system. Already the steering mechanism is possible by introducing individual motors (360 degree motors mounted vertically downwards) to individual wheel. It requires six motors at six wheels (Figure 4) that increase the cost as well as complication in maintenance.



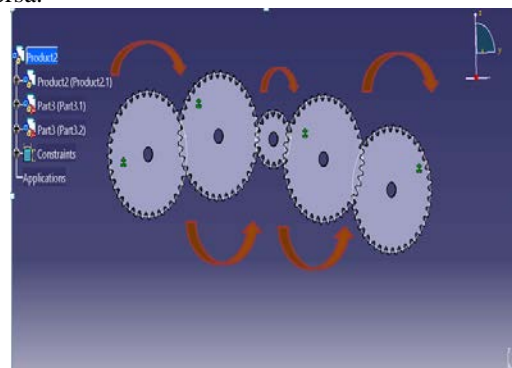
(Figure 4. Arrangement of individual motor for steering)

Already the steering mechanism is incorporated by introducing six motors with either direct cable connection or automatic with micro controllers. Here an approach is taken for incorporating mechanical steering system with the help of gears and single motor.

3. Design Methodology

In this design front two wheels are connected to the steering mechanism so that they can be turned as and when it is required. The rest of the four wheels will be self-guided as per the motion of front wheels.

Each of the front wheels is connected to the gears at their horizontal shaft. The body contains one motor at the lower side. The motor shaft is connected to the master gear. The gears are connected to the wheel gears with the help of idler (Figure 5). The motor can be controlled by the help of micro controller or directly. Here it is connected to a cable and the cable is connected to a control panel. Whenever it is required to have the turn of the mechanism then the controller in the control panel will be operated which in turn will rotate the motor. The master gear connected to the motor will also rotate with the motor. As the idlers are connected to the motor they will rotate in the opposite direction to the rotation of motor. The wheel gears connected the idler will also rotate along with this which will enable to rotate the wheels in the required direction. Here the idlers are incorporated to avoid the confusion of operation. This enables the operator to get sure that if the controller is rotated clock wise the mechanism will also rotate clock wise and vice versa.



(Figure 5. Arrangement of mechanical gears for steering)

4. Technical Specification of parts of steering system

Motor: 10 rpm, 12V DC geared servo motor, 120 N-m torque.

Master Gear: 25 teeth, 4 cm diameter, straight teeth, 1.6 cm thickness

Wheel Gears: 56 teeth, 8.5 cm diameter, straight teeth, 1.6 cm thickness

Idlers: 56 teeth, 8.5 cm diameter, straight teeth, 1.6 cm thickness

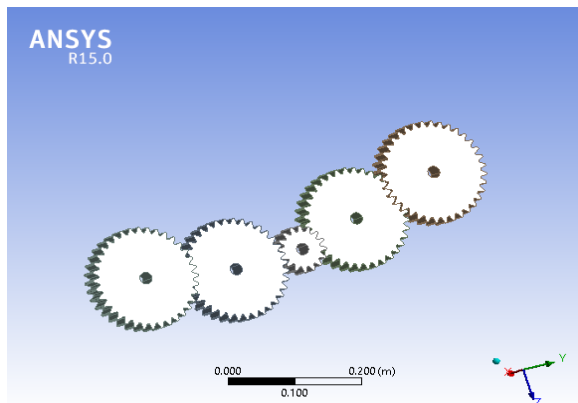
Material of gears: Mild steel AISI grade 1015

Composition of material: 0.13-0.18% Carbon, 0.30-0.60% Manganese, 0.04% (Max) Phosphorus, 0.05% (max) Sulphur

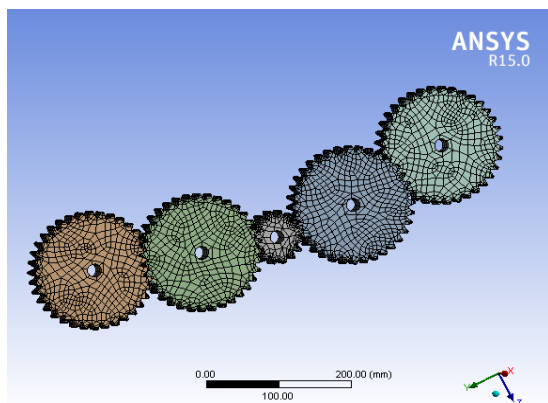
Ultimate strength of material: 490 N/mm²

5. Static analysis of steering system

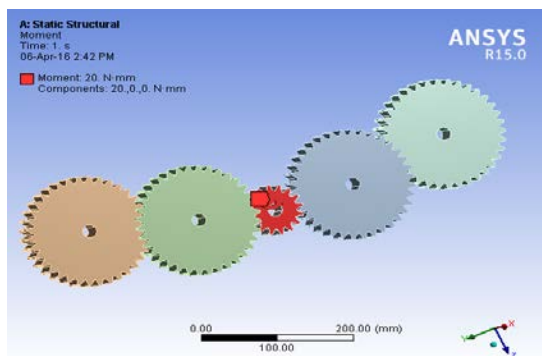
Here analytical approach is considered manually for deciding the dimension of gears. During static condition the gears are subjected to radial and tangential loads due to the torque of motor and resistance force. By considering the design methods for gears different dimensions and parameters are decided. Then the same model is prepared in CATIA and analyzed for different failure parameters in ANSYS.



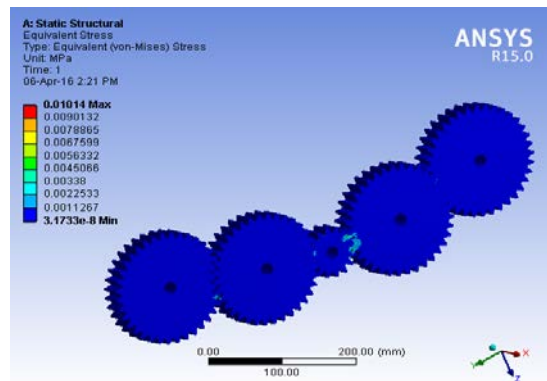
(Figure 6. CAD model of Gear System)



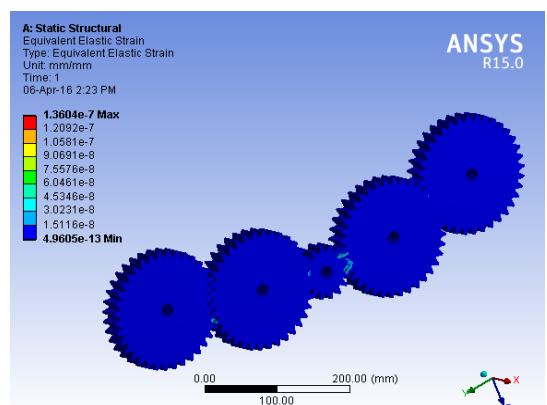
(Figure 7. Meshing for analysis)



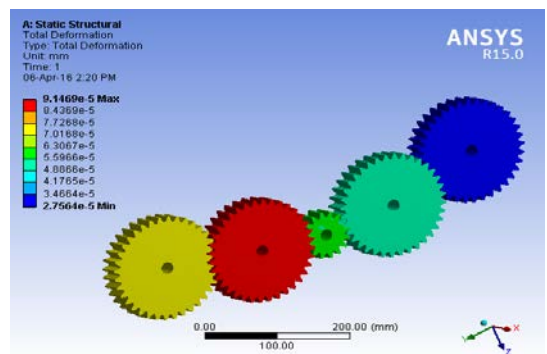
(Figure 8. Application of Torque)



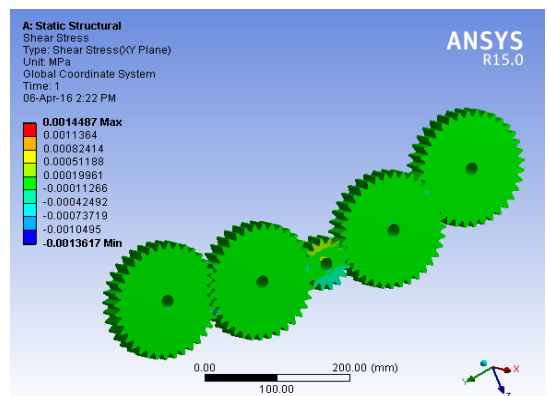
(Figure 9. Equivalent stress analysis)



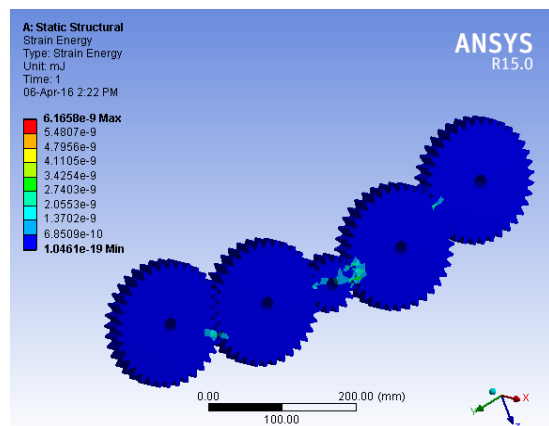
(Figure 10. Equivalent elastic strain)



(Figure 11. Total Deformation)



(Figure 12. Shear stress)



(Figure 13. Strain Energy)

6. Result analysis

Table 1. Mechanical properties analysis

FIGURES	MECHANICAL PROPERTIES	MAX VALUE	MIN VALUE
FIG 9	Equivalent stress(Mpa)	0.01014	3.173 $\times 10^{-8}$
FIG 10	Equivalent elastic strain(mm/mm)	1.3604 $\times 10^{-7}$	4.960 $\times 10^{-13}$
FIG 11	Total Deformation(mm)	9.1469 $\times 10^{-5}$	2.756 $\times 10^{-5}$
FIG 12	Shear stress (MPa)	0.0014487	0.0013617
FIG 13	Strain Energy(mJ)	6.1658 $\times 10^{-9}$	1.046 $\times 10^{-19}$

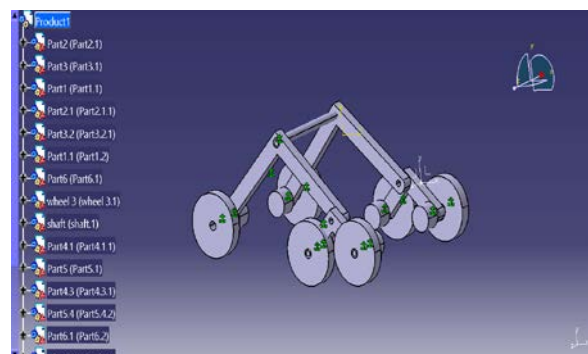
7. Model preparation

We studied the existing models of rocker bogie suspension enabled rovers and tried to manufacture a similar kind with the materials available. We made a slight modification with the introduction of mechanical gear type steering system.

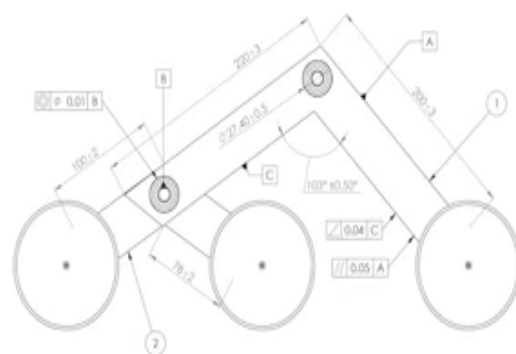
The materials used in the manufacturing of the rover were aluminum plates and plywood. The rocker bogie arms were made using aluminum plates of 5mm thickness and holes were punched throughout the arms to reduce the weight of the rover. The rocker and bogie were joined using bearings. Both the rocker bogie arms were connected using stainless steel rod and bearings. For the steering system plywood base was cut according to the required dimensions on which six gears were mounted (one master gear, two idlers and two wheel gears). All the gears used were of mild steel grade

1507. The master gear was of 4cm diameter and connected to a servo motor of 10rpm and producing a torque of 120N-m. Two idlers of 8cm diameter were mounted on either side of main gear. Two wheel gears of 8.5cm diameter were connected to each of the idlers in such a manner that the centers of all the gears lied in a single straight line. The wheel gears were connected to each of the wheels of the rocker arm by using shafts. The shafts were fixed to the gears at one end and the other ends were welded to L-clamps fixed to the wheels. This mechanism enabled the rover to change the directions easily and maintain the stability. When the main gear rotated in clockwise direction due to the high torque motor the idlers rotated in anticlockwise direction and vice versa. The wheel gears connected to these idlers rotated in same direction as that of the main gear and thus steering mechanism was successfully maintained.

The rocker arms were connected to the shafts between the wheel gears and L-clamps by devising casing mechanism which enabled the rocker arms to slide over the shafts adjusting itself according to the terrain surface. 60rpm motors were connected to each of the wheels for the traversal of the rover. Bus wires were soldered to the motors for the purpose of manual control using remote switches.



(Figure 14. CAD 3D model of Rocker Bogie)



(Figure 15. CAD of Rocker Bogie with dimensions)

8. Conclusion

The steering mechanism was successfully installed and operated using mechanical gears in the existing rocker bogie rover design. The drawback of this system is that the rover designed with this steering mechanism is limited to traverse in less rough or only plain surface. Attempts can be made to modify and solve this problem to design a more stable rover so that the vehicle can travel in both smooth and rough surface.

9. Acknowledgements

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10. References

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