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Design analysis of Rocker Bogie Suspension System and Access the possibility to implement in Front Loading Vehicles

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Abstract : *The place, where the value of gravity remain lower than earth's own gravitational coefficient, at that place the existing suspension system fails to fulfil desired results as the amount and mode of shock absorbing changes. To counter anti gravity impact, NASA and Jet Propulsion Laboratory have jointly developed a suspension system called the rocker-bogie Suspension system. It is 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 is currently the most favoured design for every space exploration company indulge in the business of space research. The motive of this research initiation is to understand mechanical design and its advantages of Rocker- bogie suspension system in order to find suitability to implement it in conventional loading vehicles to enhance their efficiency and also to cut down the maintenance related expenses of conventional suspension systems.*

Keywords: *exploration, efficiency, mission, rocker- bogie, Suspension,*

I. Introduction

The rocker bogie suspension system, which was specifically designed for space exploration vehicles have deep history embedded in its development. The term "rocker" describes the rocking aspect of the larger links present each side of the suspension system and balance the bogie as these rockers are connected to each other and the vehicle chassis through a selectively modified differential.

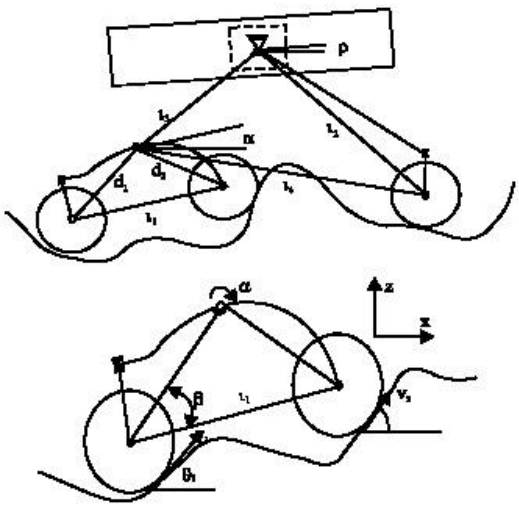

Fig: encounter area of rocker bogie suspension system.

As accordance with the motion to maintain centre of gravity of entire vehicle, when one rocker moves up-word, the other goes down. 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.

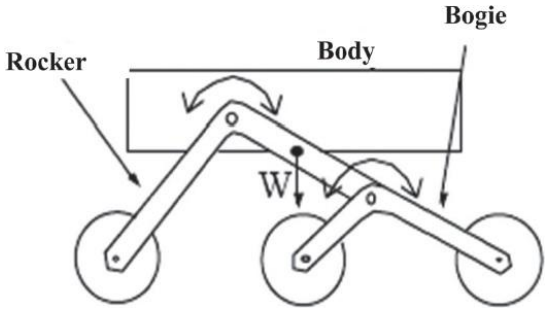

Fig: 2D Line diagram of Rocker-bogie suspension system and its motile joints.

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.

II. Literature Review

The 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. 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. The rovers needed to be very robust and reliable, as it has to withstand dust, strong winds, corrosion and large temperature changes under mysterious conditions. Maximum rovers remain powered by batteries which are recharged by solar panels during the day installed over there surface.

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 favoured. 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. 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. In this research, our endeavour is to transfer these major advantages embedded with the rocker bogie system into conventional vehicles in order to remove discomfort and complexities present in conventional suspension system in general and suspension system of heavy vehicles in particular.

III. 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.

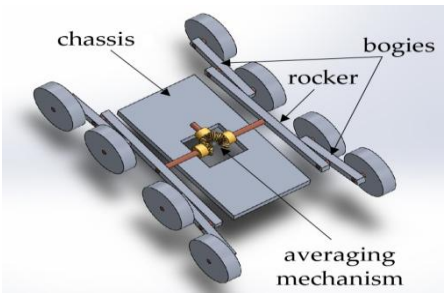

Fig: SOLIDWORKS 3D Model of Rocker Bogie system.

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.

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

A 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 derail the rythem 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 tapple 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.

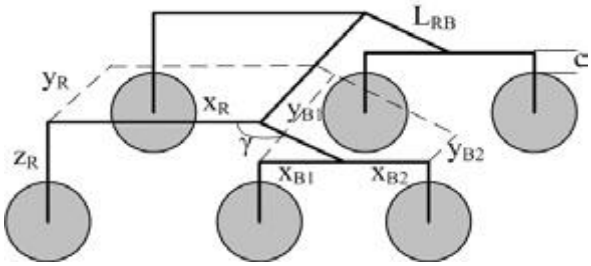

Fig: Geometry of Rocker Bogie.

After optimizing the ground profile it can be assumed that each of the rocker working with specified angle of inclination α, but can be changed by the users demand. The Genetic Algorithm requires evaluates of the fitness of each arm in the population and therefore justifies the goodness of each of these specific combinations of link lengths and variable angles of the rocker-bogie suspension mechanism.

For better observation and analysis, a 3D model of Rocker bogie system installed in ATV is developed and simulated. The generated results are shown below.

VI. Result & Discussion

After the realized simulation, the results has been generated and analysed which comparing the disturbances in the ATV's Centre of Gravity position in each of the two operating modes, contrasting the response of these two distinctive configurations of the rocker-bogie suspension against upcoming obstacles that can be present along the system generated obstacles and roadblocks. The test track used for these experiments is a 10 square meters platform with one cylindrical bumper. The simulated rover has a total mass of 260 Kg.

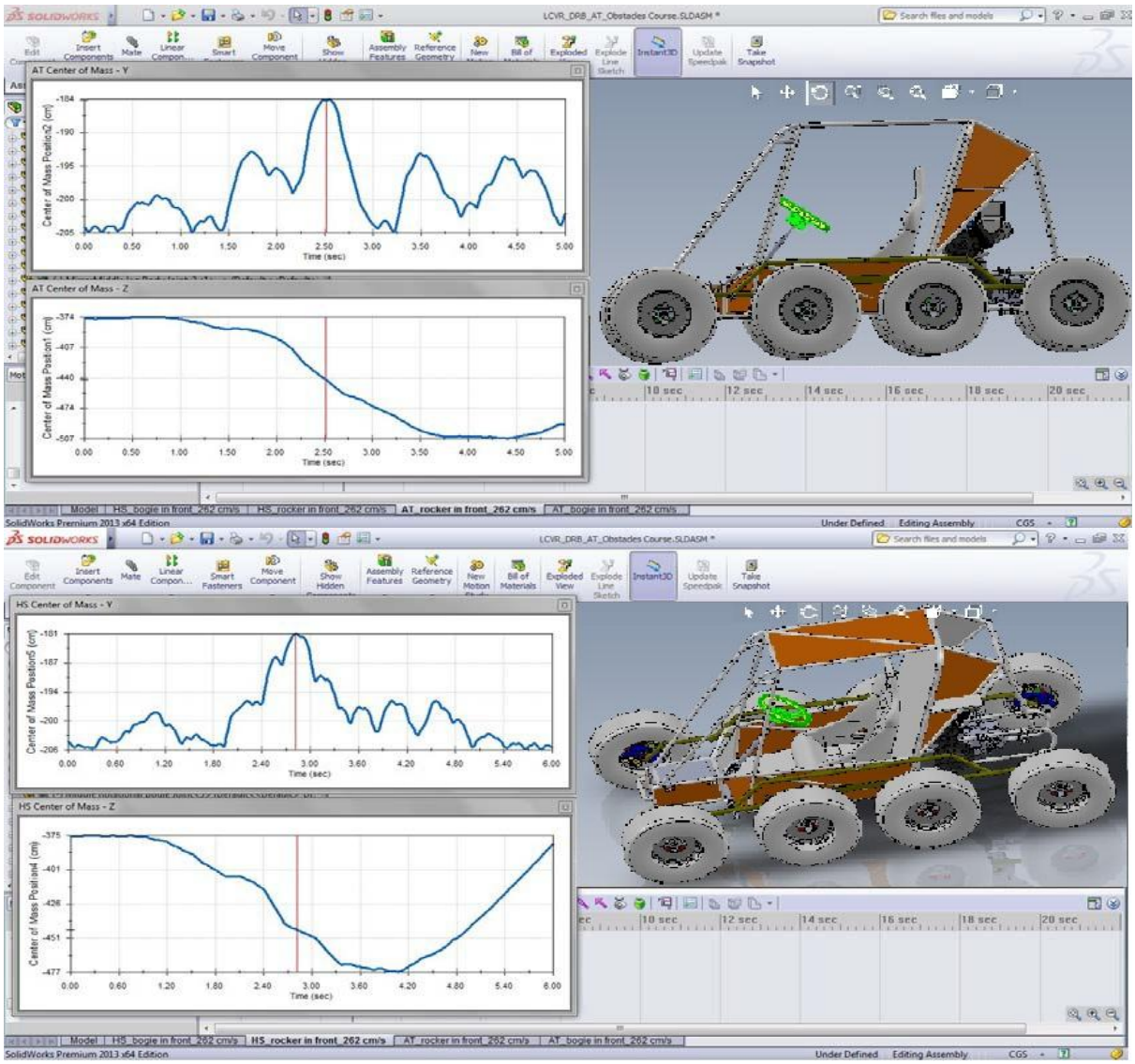

Fig: Dynamic rocker-bogie high-speed ATV configuration SOLIDWORKS simulation results.

VII. Conclusion

The proposed paper produces a novel design in pursue of increasing the rocker-bogie mobility system in conventional heavy loading vehicle behaviour when high-speed traversal is required. Presented situation was faced presenting two modes of operation within same working principle which is a rocker-bogie system with a robust obstacles traverse features and another is an expanded support hexagon achieved by rotating the bogies of each side of the vehicle. The proposed modification increases in the stability margin and proved with valuable and profitable contrasting the SSF metric with the 3D model simulations done in SOLIDWORKS. In future, if the system installed in heavy vehicles and conventional off road vehicles, it will definitely decreases the complexity as well as power requirements to retain bumping within it.

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