Critical Scrutiny of 'J' Link Suspension System For Space Vehicle's

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Abstract- *In the modern world, various types of suspension system are used which are active as well as passive in nature. However, these suspension systems and techniques are tough for implementation in space exploring vehicles. The aim is to develop the existing mechanism with much lesser complexity with an effective output for any undesirable space conditions. The ultimate goal is achieve minimum chassis inclination compared to other space vehicles.*

Keywords- Suspension, Active, Passive, Chassis, Algorithm, bogie.

I. INTRODUCTION

After 19^{th} century we had seen a great boost in the space exploration for various purposes like exploring of space, research on various planets and natural satellite, along with human displacement from earth to space and the research still goes on. Less emphasis were given to the space vehicles and even lesser on its suspension system since no human activity were involved.But in the present time space exploration is carried with highly automated active suspension system which is further classified into pure active and semi-active suspension system. Active suspension system is a kind where transverse moment of wheel is control relative to the chassis. It is a combination of mechanical and electronic devices which gives the desired suspension. Such suspension systems are employed in terrain adaptive vehicles but the drawbacks which are usual encountered are larger deviation of chassis with respect to ground, more complexity of the system, though the output is not desired. The most important point as the complexity increases cost associated with it also increases.The various space vehicle associated to high cost are listed below:

- Soyuz-TMA spacecraft.
- Shenzhou spacecraft.
- International Space Station.
- Apollo 17 CSM orbiting the Moon.
- Orion ground test a le.
- Dragon spacecraft during an uncrewed cargo mission to the ISS.
- SpaceShip Two with mothership in hangar.

Suspension system using linkage mechanism in its simplest form is the key for such concepts. Here, a 'J' shaped link is introduced which is modified from the existing shape of the rocker bogie mechanism.

This J shaped link is capable of reducing the forces and accordingly the stress concentration on the driving mechanism. Moreover, for space exploration applications where the quality of soil and flatness of the surface can't be predefined, such suspension system will turn a boon. Here along with the J shaped link other link which acts as supporting link are provided which are shorter in length and can be called as shorter links. Three shorter link with one J shaped link are so arranged that they can oscillate about the pivots or connecting pins.The complex shaped and size of space rovers and rocker bogie is simplified to four assemblies of J links and shorter links at four instances similar to an ordinary automotive. This suspension system is usually controlled by a microcontroller and microprocessor in addition to a gyroscope sensor which helps to maintain the chassis horizontal.

II. OBJECTIVES

- To reduce inclination of chassis with respect to ground.
- To reduce the complexity in self-guided space vehicle.
- To reduce the cost associated in manufacturing.
- To improve stability and safety associated with the terrain vehicle.

III. COMPONENTS REQUIRED

The Major components required to achieve the goal of horizontal chassis is as follows:

Table 1- Components required for J shaped suspension.

Component's	*Quantity*
J shaped link	4
Shorter link	12
Servo motors	4
Gyroscope sensor	1
Microcontroller	1

IV. CONSTRUCTION AND WORKING

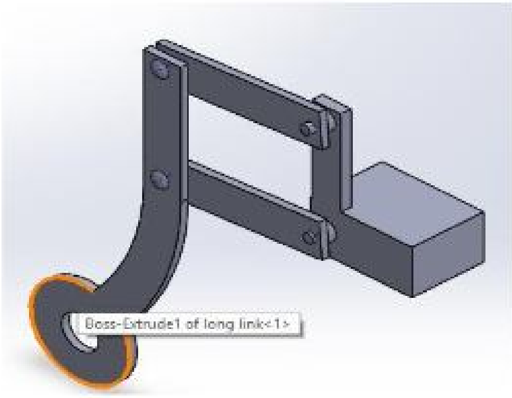


Figure 1- Assembly of J shaped link with shorter links.

There are four main components of this suspension system which are the main J shaped link, smaller link, servo motor and microcontroller with gyroscope sensor. As shown in figure 1, the assembly of J shaped link and smaller link form a parallel four bar linkage. At the intersection of horizontal shorter link with the vertical shorter link, a digital servo is attached which has the ability to lift and drop the main J shaped link over the bumps. This servo can be controlled by a microcontroller with proper programming. A gyroscope sensor is placed over the chassis, which will read the value of inclination of chassis with respect to ground and sends the feedback to microcontroller which again compensates the feed to servo moto and so a reduction in inclination is achieved. This process continues as the vehicle moves over any uneven surface. Proper Algorithms are to be applied so that correct response for each activity is generated. Flowchart for Algorithm depicts the flow of activity in the microcontroller using general relations of pitching and rolling:

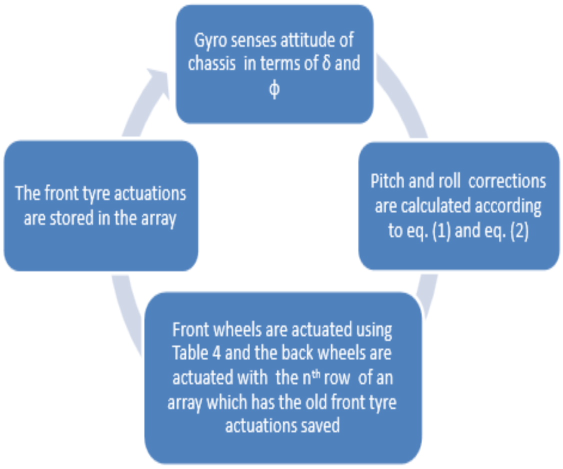


Figure 2 : Flowchart for Algorithm.

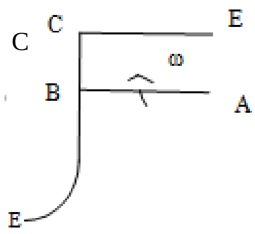
V. CAD FILE OF J SHAPED LINK AND SHORTER LINKS

Figure 3 : J shaped link.

Figure 4 : Shorter link.

VI. MATHEMATICAL RELATIONS

Following velocity diagrams were drawn for kinematics analysis to ensure that tyre moves in straight line.



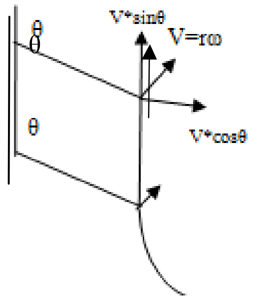


Figure 5 - line diagram   Figure 6 - Linear velocity relation

There is no relative motion between the point B and C. There is also no relative motionbetween the points B and E. From figure, linear velocity of link BC in Y direction= v*sinθ and in X direction = -v*cosθ.

VII. RESULT

After assembling all links and mounting it at four instances of the chassis similar to an automobile chassis, test is performed on uneven surfaces and the inclination of 0.1 to 0.5 degree is seen which is less compared to other terrain vehicles. This is represented with the help of graph having degrees on X-axis and time in seconds on Y-axis.

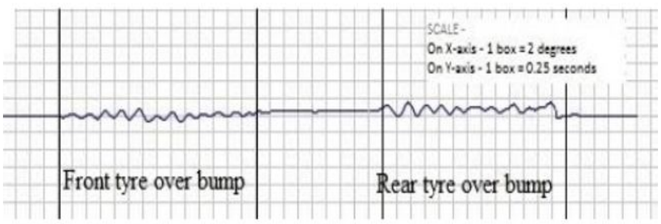


Figure 7 – Graph of the suspension.

VIII. CONCLUSION

The main aim of maintaining the chassis to horizontal position was achieved to a great extent. The bump to chassis ratio is a point of at most consideration because it will decide the inclination of the chassis. This ratio is higher than many conventional system but any system with such high ratio cannot maintain such high degree of accuracy. With some improvement in design it will also become feasible to climb over sharp obstacles.

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