Design Optimisation and Analysis of an All-Terrain Vehicle chassis with balance Rocker Suspension

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Abstract — *Agricultural vehicles are perceptive machines that can be used to perform a variety of agricultural tasks including spraying, cultivating, fertilizing, harvesting and growth monitoring. Precision farming technology has also led to higher yields, reduced environmental impact and requiring less chemical application for agricultural production. Unstructured road or soil profiles combined with driving speeds and operating environments create the biggest challenge for off-road vehicles and autonomous systems in agriculture. However, the development of the off-road vehicle has received increasing interest and has been widely pursued by researchers.*

The balance rocker suspension is a novel mechanism which ensures full-time four-wheel drive in a complex road environment while maintaining the main body level always in the angle bisector of the two driving axle. According to the hillside terrain and agronomic characteristics of various crops, the ground clearance and the wheel track can be adjusted continuously and smoothly by hydraulic system. In this project, we intend to develop a model of an all-terrain vehicle chassis with balance rocker suspension. The model is modeled in Creo Parametric 3.0 and analyzed in Ansys 15.0. The model is then optimized for the shape optimization and material optimization.

Keywords- Balance Rocker suspension, Ground clearance, hydraulic system, Precision Farming Technology.

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

We can think more clearly about the behavior of a particular suspension, if we use a simplified conceptual "model", to describe that particular suspension. Each wheel print of a vehicle's suspension has one degree-of-freedom in its vertical motion relative to the vehicle's body. For a car with four wheels, there are four degrees-of-freedom for the vertical motions of the four wheel prints. We shall refer to each of the time varying degrees-of-freedom as a "mode" of the suspension movement.

The four degrees-of-freedom, or modes, taken together, will constitute a "suspension model. It is important to realize that we have a lot of freedom in how we define each of the four modes. Any choice of four modes that we use will describe a particular suspension movement, with a particular set of four numbers, for each point in time. Another choice of modes will result in a different set of numbers. That is, we have four infinities of different descriptions available to us, for the same particular suspension movement. Each of these descriptions is equally valid, but some are more illuminating than others.

II. REVIEW OF LITERATURE

According to Mr. Hrishikesh V Deo [3], the design of existing suspension systems typically involves a compromise solution for the conflicting requirements of comfort and handling. For instance, cars need a soft suspension for better comfort, whereas a stiff suspension leads to better handling. Cars need high ground clearance on rough terrain, whereas a low center of gravity (CG) height is desired for swift cornering and dynamic stability at high speeds. It is advantageous to have low damping for low force transmission to vehicle frame, whereas high damping is desired for fast decay of oscillations.

S. Madhavarao [4], in his paper discussed that vehicle ride comfort is one of the most important performances of vehicle; the research of automotive ride comfort is getting more and more important. He said this paper is to design and develop a system that is "Automatic ground clearance adjustment system" to overcome this problem by adjusting the ground clearance over this particular time period.

Paul W.Bartlett [10] designed a scarab rover for mobility and drilling in the lunar cold traps. The vehicle design employs a passive kinematic suspension with an active adjustability to lower for drilling and aid in driving. He explained that Scarab was designed and built in 2007 and is currently in lab and field testing and further development. In the laboratory, drawbar pull tests characterized the strength and traction of the rover. With the rubber skid loader tires in place, Scarab pulled 2,000 N in mixed grain sized sand, which is approximately 0.7 x vehicle weight, and 2,700 N on

concrete pavement, which is approximately equal to vehicle weight. Similar tests are planned where lunar gravity is simulated with an off-loading system.

Wesley B.Williams[11], was successful in designing, building, testing, and implementing a rocker bogie suspension on a competitive robot in the 2013-2014 NASA Robotic Mining Competition. The design portion progressed through logical steps of a literature review, kinematic analysis, finite element analysis, and clearance and interference checks. Similarly, the build progressed through component fabrication, verification, assembly, testing, and refinement. It was particularly satisfying for the students involved in the design to see the suspension successfully tackle the larger obstacles that were presented before it in testing. While the design calculations had been checked and double checked, the tension in the assembled students was apparent as the robot navigated those extreme mounds and depressions. He explains that in addition to being a success for the team, it was a success for the approach as the performance predicted in the design process was realized in the final product

III. MODELING OF AN ALL-TERRAIN VEHICLE CHASSIS WITH BALANCE ROCKER SUSPENSION

The modeling of An All-Terrain Vehicle Chassis with Balance Rocker Suspension is done in Creo Parametric 3.0 modeling software.

Creo Parametric is the first commercial CAD system entirely based upon the feature-based design and parametric modeling philosophy. Today many software producers have recognized the advantage of this approach and started to shift their product onto this platform.

Nevertheless, the differences between a feature-based, parametric solid modeling CAD system, such as Creo Parametric, and a conventional CAD system include:
•Creo Parametric Conventional CAD Systems
•Solid Model Wireframe and Solid Model
•Parametric Model Fixed-dimension Model
•Feature-based Modeling Primitive-based Modeling
•A Single Data Structure and Full Function-Oriented Data Structures
•Associativity with Format Interpreters
•Subject-oriented Sub-modeling Systems A Single Geometry-Based System
•Manufacturing Information Texts Attached to Geometry Entities
•Associated with Features
•Generation of an Assembly by Generation of an Assembly by
•Assembling Components Positioning Components
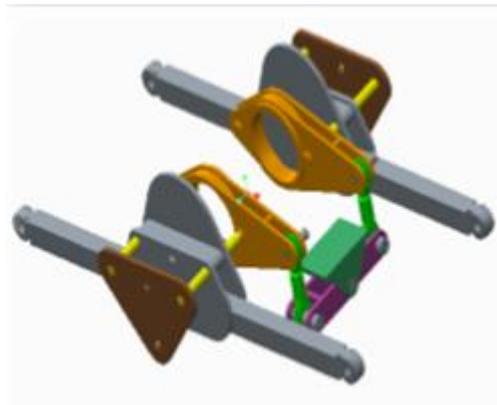The model of All-Terrain Vehicle Chassis with Balance Rocker Suspension is as shown in the Fig. 1.

Fig. 1 Model of an All-Terrain Vehicle Chassis with Balance Rocker Suspension

IV. COMPUTATIONAL FEA ANALYSIS

The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has developed simultaneously with the increasing use of the high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problem, started in terms of different equations or as an extrinum problem.

F.E.A is a way to deal with structures that are more complex than dealt with analytically using the partial differential equations. F.E.A deals with complex boundaries better than finite difference equations and gives answers to the 'real world' structural problems. It has been substantially extended scope during the roughly forty years of its use.

F.E.A makes it possible it evaluate a detail and complex structure, in a computer during the planning of the structure. The demonstration in the computer about the adequate strength of the structure and possibility of improving design during planning can justify the cost of this analysis work. F.E.A has also been known to increase the rating of the structures that were significantly over design and build many decades ago.

FEA can be used in new product design, or to refine an existing product, to ensure that the design will be able to perform to specifications prior to manufacturing. With FEA you can:

- Predict and improve product performance and reliability
- Reduce physical prototyping and testing
- Evaluate different designs and materials
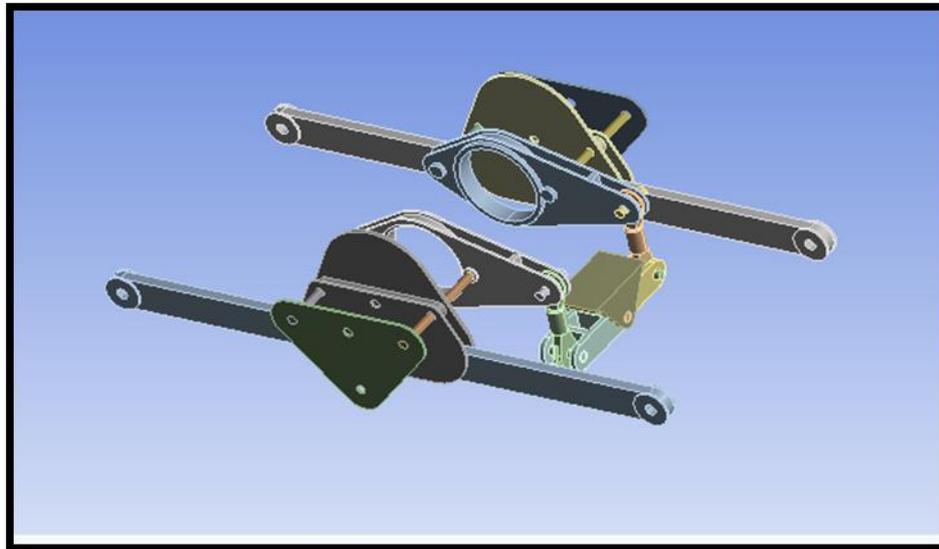- Optimize designs and reduce material usage

Fig. 2 Geometric model of the All-Terrain Vehicle Chassis with Balance Rocker Suspension

The meshed model for the Assembly of All-Terrain Vehicle Chassis with Balance Rocker Suspension is as shown in the Fig. 3
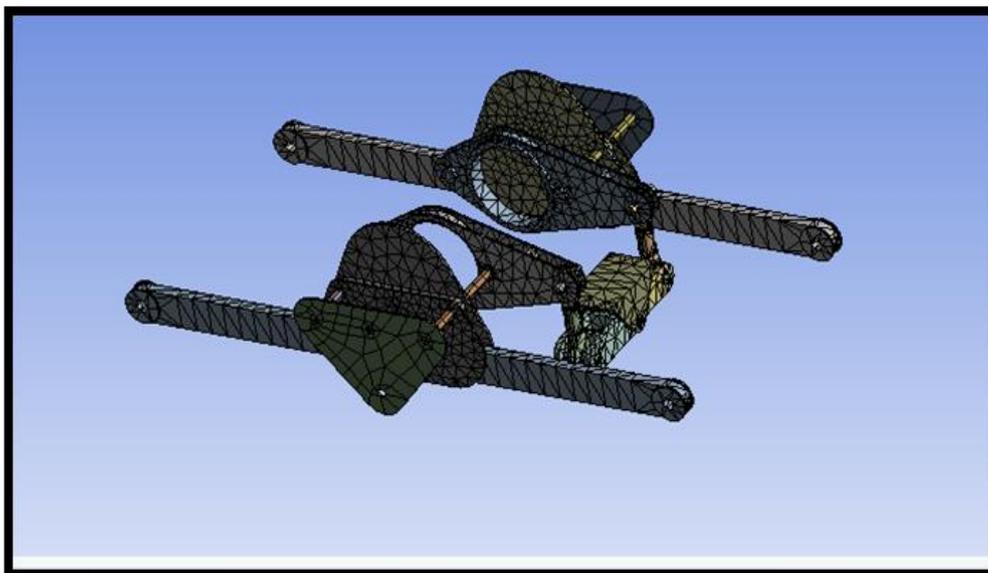

Fig. 3 Meshed model of the All-Terrain Vehicle Chassis with Balance Rocker Suspension

The Deformation for the All-Terrain Vehicle Chassis with Balance Rocker Suspension is as shown in the Fig. 4
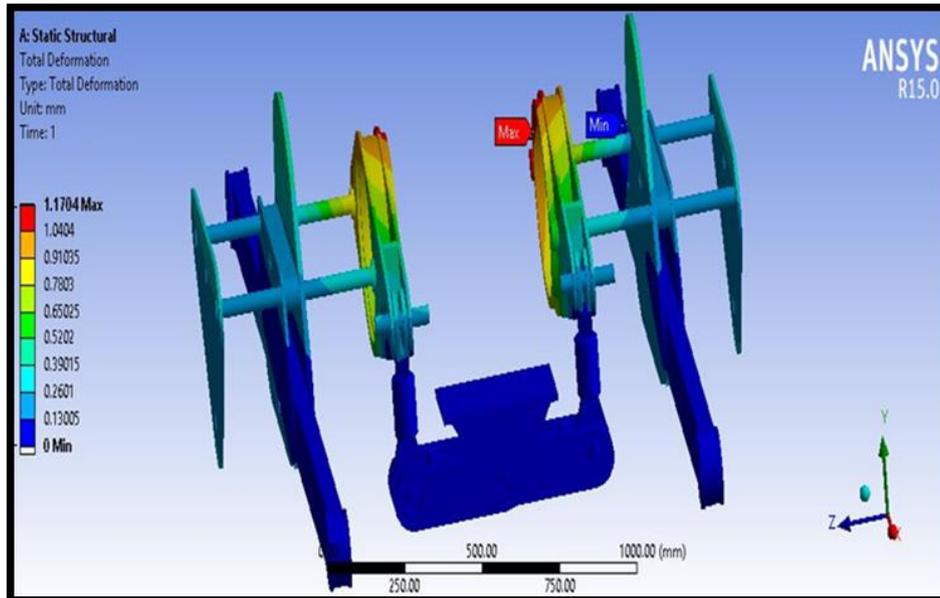
Fig. 4 Deformation of the All-Terrain Vehicle Chassis with Balance Rocker Suspension

The Equivalent Stress for the All-Terrain Vehicle Chassis with Balance Rocker Suspension is as shown in the Fig. 5
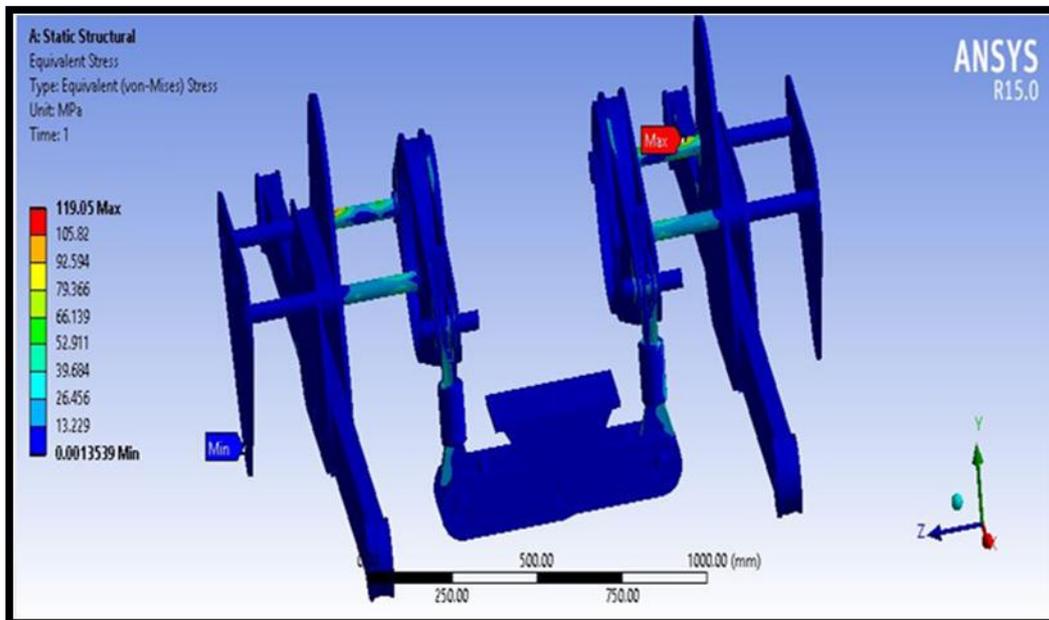

Fig. 5 Equivalent Stress for the All-Terrain Vehicle Chassis with Balance Rocker Suspension

Dynamic analysis can be done via the explicit solver or the implicit solver. In nonlinear implicit analysis, solution of each step requires a series of trial solutions (iterations) to establish equilibrium within a certain tolerance. With ANSYS explicit dynamics products, you get a comprehensive set of advanced tools to help gain insight into virtually any event that can be simulated. Explicit STR extends the capabilities of Mechanical to problems involving short-duration severe loading, large material deformation and material failure. You can perform a transient explicit dynamics analysis in the Mechanical application using an Explicit Dynamics system.

The factor of safety for the All-Terrain Vehicle Chassis with Balance Rocker Suspension is as shown in the Fig. 6.
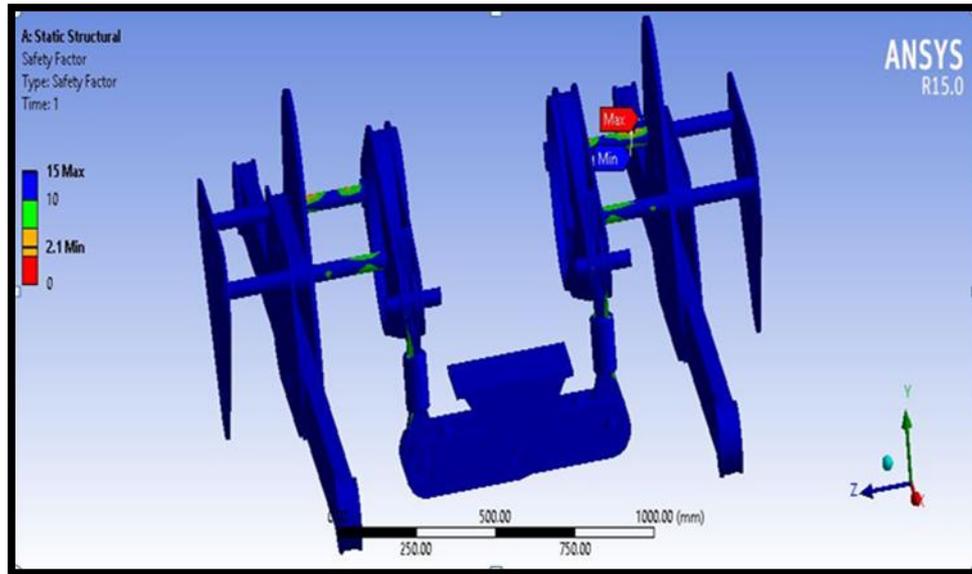
Fig. 6 Factor of safety for the All-Terrain Vehicle Chassis with Balance Rocker Suspension

The Explicit dynamics for the All-Terrain Vehicle Chassis with Balance Rocker Suspension is as shown in the Fig. 7
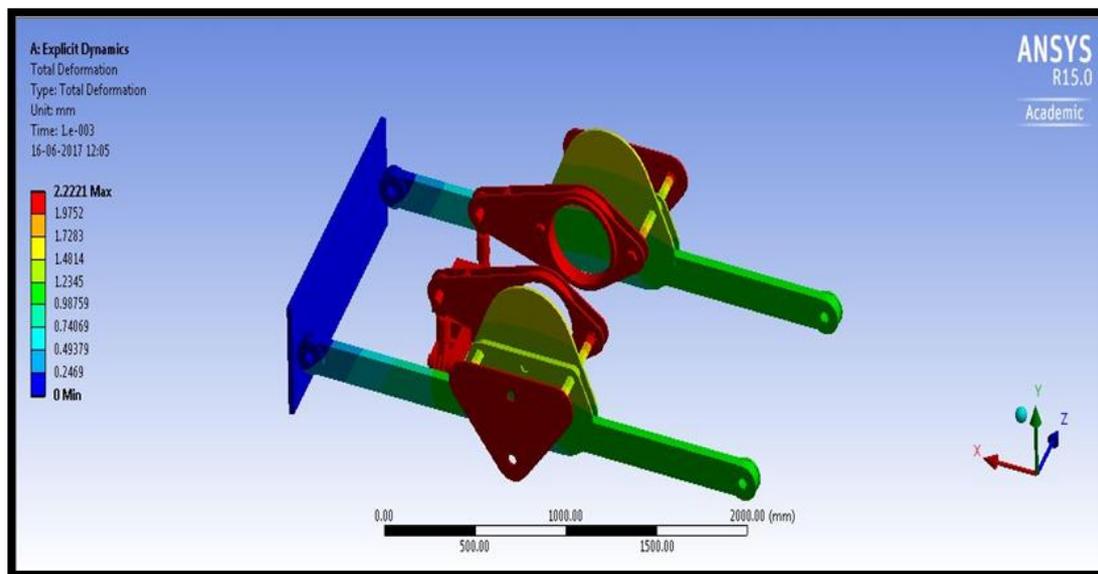

Fig. 7 Explicit dynamics for the All-Terrain Vehicle Chassis with Balance Rocker Suspension

The results obtained for various materials are as shown in the below Table. 1

Table 1 Results obtained for various materials

S. No	Material	Stress (Mpa)	Deformation (mm)	Weight (kgs)
1	Structural Steel	119.05	1.1704	580
2	Aluminum	119.19	3.3045	204
3	Cast Iron	118.95	2.1239	534
4	Glass Epoxy	122.5	33.078	192

V.   CONCLUSIONS

The following conclusions can be outlined by considering the analysis on Assembly of All-Terrain Vehicle Chassis with Balance Rocker Suspension. The modeling is done in Creo Parametric 3.0 modeling software. The analysis is performed in Ansys 15.0 workbench. The results of optimized model with different materials are as follows. In this project, before design optimization the weight of model i.e. structural steel   is 580 kg. After design optimization the weight of model i.e. structural steel reduced to 580 kg. By replacing structural steel with aluminum the decrease in

weight is 64.827 % .By replacing structural steel with cast iron the decrease in weight is 7.93 %. By replacing structural steel with composite material glass epoxy the decrease in weight is 66.89 %. While considering weight aluminum gives best result but while considering stress and deformation structural steel gives best result. When performing explicit dynamics, when the velocity of vehicle is 8 km/hr the deformation is body is 2.222 mm which is less and we can conclude that our model is safe.

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