A Comparative and Comprehensive Analysis of Two Wheeler Suspension System

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Abstract: *Why do we need suspension? The simple answer is due to 'Road irregularities'. In the ancient days, wooden wheels were used and there were no intermediate flexible members connecting axles and chassis. This made the ride uncomfortable on unpaved roads. The invention of pneumatic tyres helped to improve the ride comfort by getting elastically deformed and thereby absorbing road shocks. . As in the case of any other engineering design problem, suspension design needs to satisfy those needs, which are conflicting. Their design should satisfy Comfort, Road holding and Handling needs. So design can be made specifically for a particular application, either for comfort, as in case of passenger cars or for handling, as in case of motorsports application. in this research work the suspension system has been designed and Analysis has been carried out to find out the Acceleration value. in this work the principle of Vibration Analysis has been carried out.*

Keywords: *Suspension system, comfort, road irregularities, Acceleration, Vibration.*

1. INTRODUCTION:

It is worth noting that the problem of control design for active suspension systems should be paid considerable attention. In addition, the vehicle suspension systems can provide as much comfort as possible for the passengers and ensure the other suspension performance by serving the basic function of isolating passengers from road-induced vibration and shocks. Hence, the control design problem of proper active suspension systems is always an important research topic for achieving the desired vehicle suspension performances[1]. The change which this elastic member brought was enormous. The passengers felt less road shocks than before. The drawback of this system was, when the vehicle goes through a road undulation, the sprung mass will get start oscillating, which dies out very slowly. This caused the wheel to bounce excessively and thereby losing the road grip. To control the oscillation, a damper was connected parallel to the elastic member, which dissipated the energy responsible for the oscillation. This was the first suspension system for an automobile. As in the case of any other engineering design problem, suspension design needs to satisfy those needs, which are conflicting. Comfort is quantified by the vertical acceleration of passenger locations. Lower values of the vehicle body acceleration implies lower inertia forces experienced by passengers and thereby indicates superior comfort. Road holding quantifies the performance of the vehicle in high speed corners and fierce acceleration and braking conditions. Handling performance can be measured by roll and pitch motions during acceleration, braking and cornering. For two wheelers, suspension dynamics can be modeled by modeling the in-plane dynamics of the system. In- plane dynamics concerns motion of the vehicle in which plane of symmetry does not move [2].

Several performance characteristics should be considered and need to be optimized for designing a good performance suspension system. It is widely accepted that three main suspension performances should be taken into account when designing a suspension controller, namely, ride comfort (i.e., directly related to acceleration sensed by passengers), road handling (i.e., associated with the contact forces of tires and road surface), and suspension deflection (i.e., referred to the displacement between the sprung mass and unsprung mass) However, it is difficult to minimize all three parameters simultaneously as these performances are often conflicting with each other, For example, the minimization of suspension travel cannot be accomplished simultaneously with the maximization of the ride comfort. In other words, enhancing ride comfort performance results in larger suspension stroke and smaller damping in the wheel-hop mode. Hence, how to derive an appropriate trade-off between these performances is the main task for successfully designing a vehicle suspension control system [3].

When the first motorcycle was manufactured by Daimler-Benz in 1885, suspension was not a priority. Sporting iron-banded wooden wheels and a rigid chassis, the motorcycle was nicknamed the "bone crusher" due to its lack of a comfortable ride[4].The first type of suspension introduced on motorcycles was a seat with springs underneath. Soon motorcycle developers realized that a more useful suspension was in order for motorcycle designs, and the emphasis of the development was placed on front suspension. Initially front suspension consisted of a sliding fork with springs. While boasting more comfort than the original rigid fork design, the new suspension tended to oscillate indefinitely because of its lack of damping capability. The decades between the 1920s and 1940s saw an increase in motorcycle suspension designs; these included leading link designs and frame mounted swing-arms. With the addition of a damper, the simple 2 sliding sprung fork design proved to be the most robust motorcycle front suspension design available. Most modern motorcycle suspensions are still based on a telescopic cartridge fork design, which houses both the spring and damper unit. This design proved to be lightweight, inexpensive, and sturdy enough to handle the loads of today's motorcycles. Damper technology, however, has continuously evolved. Mono-tube dampers have given way to twin tube dampers, while fixed orifice damper valving has been replaced by rider adjustable compression and rebound adjusters. The end goal has been to provide the rider with better ride performance while maintaining comfort[5].

1.1 HISTORY:-

- 1903 :- Motors from Germany fitted a car with shock absorbers.
- 1920 :- Leyland used torsion bars in its suspension system.
- 1922 :- Unitary construction and independent front suspension were pioneered on the Lancia Lambda.
- 1932:- By this year ,the independent front suspension become more common in popular cars.
- 1948:- Triumph Mayflower introduced the combined coil spring/damper unit.
- 1950 :- Ford adopted the McPherson strut independent front suspension on MK 1 consul.
- 1959:- Use of independent rubber suspension.
- 1962:- Introduction of hydrostatic suspension [6].

1.2 BASIC PARTS OF SUSPENSION SYSTEM [7]:-

- **Control arm** – movable lever that fastens the steering knuckle to the vehicle's body or frame.

*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-1 control Arm*

- **Steering Knuckle** – provides a spindle or bearing support for the wheel hub, bearings and wheel assembly.

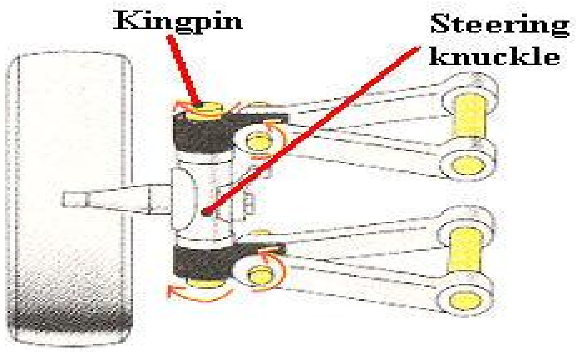


*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-2 Steering Knuckle*

- **Ball Joints** – swivel joints that allow control arm and steering knuckle to move up and down and side to side.

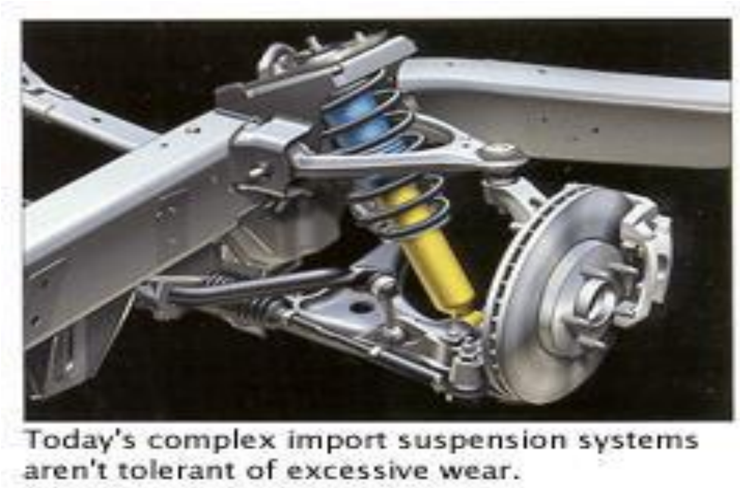


*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-3 Ball joints*

- **Springs** – supports the weight of the vehicle; permits the control arm and Wheel to move up and down. Springs are resilient members and as such act as reservoirs of energy . They store the energy due to the sudden force which comes when vehicle encounters a bump or a ditch . This energy is released subsequently and with the action of damper, the energy is converted into heat and bounce is avoided. Springs used for suspension system should absorb road shocks quickly and return to the original position slowly.

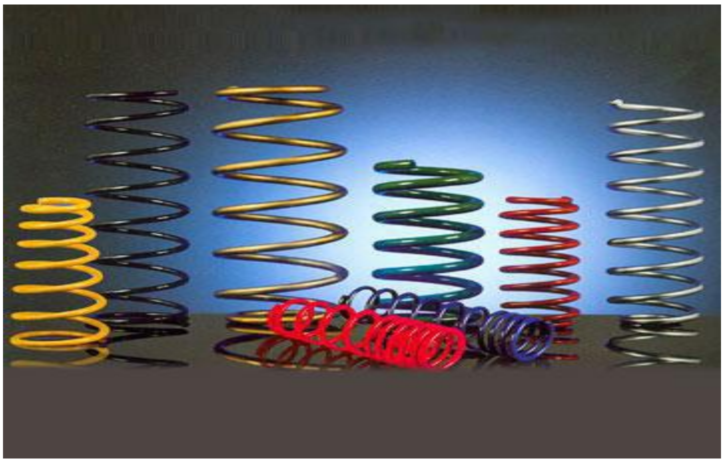


*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-4 Springs*

- **Shock absorbers or dampeners** – keeps the suspension from continuing to bounce after spring compression and extension.

*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-5 Shock absorbers or dampeners*

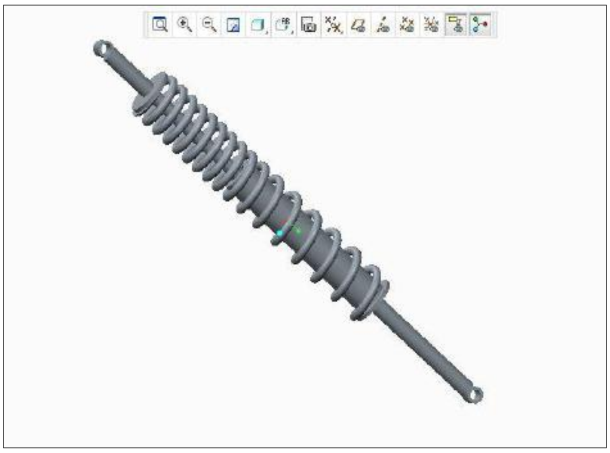
2. ANALYSIS:

The Structural Analysis has been carried out to find out the various types of Shear Stresses which are occurred at various parts of suspension system. The geometry is designed by using the Creo Parametric. then the geometry has been imported to the ANSYS. The static structural Analysis has been carried out by using ANSYS.

2.1 Creo:

Creo is a feature based, parametric solid modeling program. As such, it's use is significantly different from conventional drafting programs. In conventional drafting (either manual or computer assisted), various views of a part are created in an attempt to describe the geometry. Another unique attribute of Creo is that it is a solid modeling program. The design procedure is to create a model, view it, assemble parts as required, then generate any drawings which are required. It should be noted that for many uses of Creo, complete drawings are never created. A typical design cycle for a molded plastic part might consist of the creation of a solid model, export of an SLA file to a rapid prototyping system (stereo lithography, etc.), use of the SLA part in hands -on verification of fit, form, and function, and then export of an IGES file to the molder or toolmaker. A toolmaker will then use the IGES file to program the NC machines which will directly create the mold for the parts. In many such design cycles, the only print created will be an inspection drawing with critical and envelope dimensions shown.

2.1.1. MODELLING:



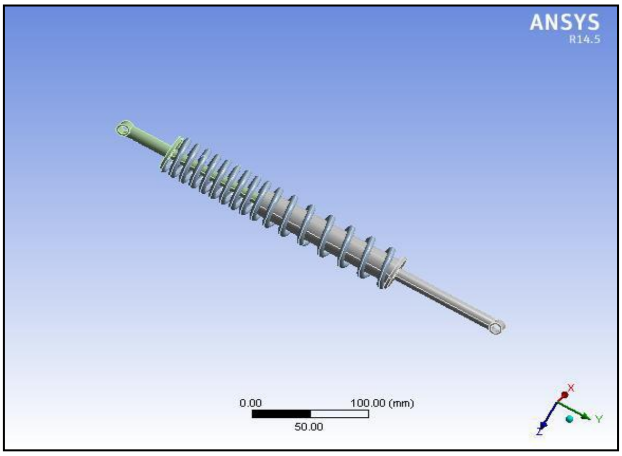


*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-6 Assembly in CREO*
*Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-7 Model of shock absorber in ANSYS*

Element Type: Solid 20 node 95

Material: Structural Steel Material

Properties: Young's Modulus (EX): 210000N/mm^2

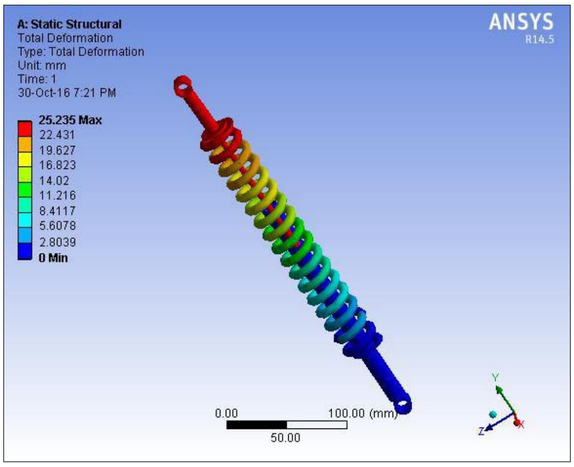
Poisson's Ratio (PRXY): 0.29

Density: 0.000007850kg/mm^3

Modeling of a suspension system is done in CREO and Analysis is done in ANSYS. model is imported from CREO and meshing is done. Load has been applied on top part. Bottom part has been taken as fixed support.

2.2 ANSYS:

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software Implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. Like solving any problem analytically, you need to define (1) your solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation.



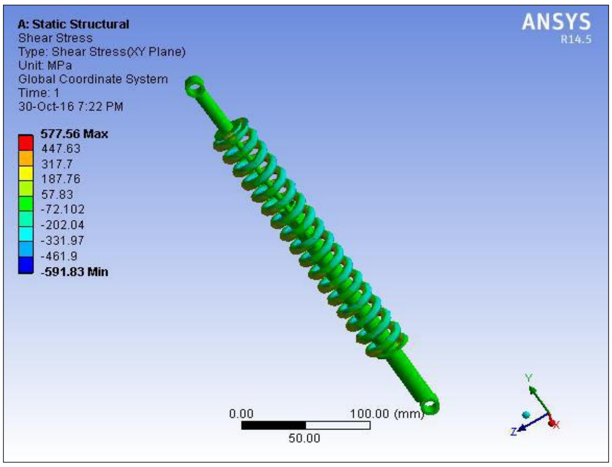


Figure ***Fehler! Kein Text mit angegebener Formatvorlage im Dokument.****-8 Deformation*
Figure ***Fehler! Kein Text mit angegebener Formatvorlage im Dokument.****-9 Shear Stress*

3. CONCLUSION:

In above section we observe the Deformation and Von Misses Stress by using software (ANSYS). Suspension system is also checked under variable loading condition. From above Analysis We show that The Deformation And Shear Stress increases while increasing the Load. Vibration Analysis of Suspension system was carried out under various road conditions. Acceleration of the different suspension system was evaluated at different road conditions by using varying road conditions. From The Analysis we conclude that Stiffer suspensions have higher road holding (traction, braking and cornering) capabilities. Road holding depends on the forces generated by the tyre which are frictional forces in nature. Stiffer suspensions have higher sprung mass accelerations. Sprung mass acceleration quantifies human comfort. This is because, when a body accelerates, inertia forces will act upon it, which is the cause of discomfort. For softer suspensions, sprung mass accelerations are less thereby improving suspension. This is because, softer springs absorbs the excitations given to the base.

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