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Finite Element Analysis of Shock Absorber for Spring Steel and Carbon Fibre

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Abstract

In this project a shock absorber is designed and a 3D model is created using Solid works . Structural analysis are done on the shock absorber for various material, Spring Steel and Carbon fiber. The analysis is done by various factors loads, weight, for single person and double person. Modeling is done in SOLID WORKS and analysis is done in ANSYS

Keywords: deformation ,stress, spring steel ,carbon fiber.

Introduction

The current world-wide production of shock absorbers, is difficult to estimate with accuracy, but is probably around 50–100 million units per annum with a retail value well in excess of one billion dollars per annum. A typical European country has a demand for over 5 million units per year on new cars and over 1 million replacement units.

The US market is several times that and India is not behind these countries for demand and consumption of shock absorbers. If all is well, these shock absorbers do their work quietly and without fail. Drivers and passengers simply want the dampers to be trouble free. In contrast, for the designer they are a constant interest and challenge. The need for dampers arises because of the roll and pitches associated with vehicle/bike maneuvering and from the roughness of roads.

In India, road quality is generally below average and poor for smaller towns. As there is growing demand for quality shock absorbers in India, design and construction of shock absorbers are demanding tasks that require advanced calculations and theoretical knowledge . There are two basic shock absorber designs in use today: the two-tube design and the mono-tube design .

Main components of shock absorber consist of following part

Piston rod: It is made of high tensile steel harden and corrosion resistant.

Piston ring: It is hardened for long life.

Pressure chamber: It is made from hardened alloy steel machined from solid with closed rear end to with stand internal pressure up to 1000 bar.

Outer body: It is heavy duty one piece fully machined from solid steel to ensure total reliability.

Vehicle suspension

In a vehicle, it reduces the effect of travelling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement. Control of excessive suspension movement without shock absorption requires stiffer (higher rate) springs, which would in turn give a harsh ride. Shock absorbers allow the use of soft (lower rate) springs while controlling the rate of suspension movement in response to bumps. They also, along with hysteresis in the tire itself, damp the motion of the unspring weight up and down on the springiness of the tire. Since the tire is not as soft as the springs, effective wheel bounce damping may require stiffer shocks than would be ideal for the vehicle motion alone. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars can be used in tensional shocks as well. Ideal springs alone, however, are not shock absorbers as springs only store and do not dissipate or absorb energy. Vehicles typically employ springs and torsion bars as well as hydraulic shock absorbers. In this combination,

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"shock absorber" is reserved specifically for the hydraulic piston that absorbs and dissipates vibration.

Types of Shock Absorber

Basic twin-tube

Also known as a "two-tube" shock absorber, this device consists of two nested cylindrical tubes, an inner tube that is called the "working tube" or the "pressure tube", and an outer tube called the "reserve tube". At the bottom of the device on the inside is a compression valve or base valve. When the piston is forced up or down by bumps in the road, hydraulic fluid moves between different chambers via small holes or "orifices" in the piston and via the valve, converting the "shock" energy into heat which must then be dissipated.

Twin-tube gas charged

Variously known as a "gas cell two-tube" or similarly-named design, this variation represented a significant advancement over the basic twin-tube form. Its overall structure is very similar to the twin-tube, but a low-pressure charge of nitrogen gas is added to the reserve tube. The result of this alteration is a dramatic reduction in "foaming" or "aeration", the undesirable outcome of a twin-tube overheating and failing which presents as foaming hydraulic fluid dripping out of the assembly. Twin-tube gas charged shock absorbers represent the vast majority of original modern vehicle suspensions installations.

Position sensitive damping

Often abbreviated simply as "PSD", this design is another evolution of the twin-tube shock. In a PSD shock absorber, which still consists of two nested tubes and still contains nitrogen gas, a set of grooves has been added to the pressure tube. These grooves allow the piston to move relatively freely in the middle range of travel (i.e., the most common street or highway use, called by engineers the "comfort zone") and to move with significantly less freedom in response to shifts to more irregular surfaces when upward and downward movement of the piston starts to occur with greater intensity (i.e., on bumpy sections of roads— the stiffening gives the driver greater control of movement over the vehicle so its range on either side of the comfort zone is called the "control zone"). This advance allowed car designers to make a shock absorber tailored to specific makes and models of vehicles and to take into account a given vehicle's size and weight, its maneuverability, its horsepower, etc. in creating a correspondingly effective shock.

Acceleration sensitive damping

The next phase in shock absorber evolution was the development of a shock absorber that could sense and respond to not just situational changes from "bumpy" to "smooth" but to individual bumps in the road in a near instantaneous reaction. This was achieved through a change in the design of the compression valve, and has been termed "acceleration sensitive damping" or "ASD". Not only does this result in a complete disappearance of the "comfort vs. control" tradeoff, it also reduced pitch during vehicle braking and roll during turns. However, ASD shocks are usually only available as aftermarket changes to a vehicle and are only available from a limited number of manufacturers.

Coil over

Coil over shock absorbers are usually a kind of twin-tube gas charged shock absorber around which has been mounted a large metal coil. Though common on motorcycle and scooter rear suspensions, coil over shocks are uncommon in original equipment designs for vehicles, though they have become widely available as aftermarket add-ons. Coil over shocks for cars have been considered specialty items for high performance and racing applications where they allow for significant reductions in overall vehicle height, and though high-quality aftermarket options with wide sturdy springs may provide improvements in vehicle performance, there is dispute over whether or not most aftermarket coil over shocks confer any material benefits to most drivers and may in fact reduce performance over original equipment installations.

Design Calculation

Mean diameter of a coil D=62mm

Diameter of wire d = 8mm

Total no. of coils n1= 18

Height h = 260mm

Outer diameter of spring coil D_0 = D +d =70mm

No. of active turns n= 14

Weight of bike = 125kgs

Weight of 1 person = 75Kgs

Weight of 2 persons = 75×2=150Kgs

Weight of bike + persons = 275Kgs

Rear suspension Weight = 65%

Overall weight = 178.75Kgs

Considering dynamic loads 357.5Kgs = 3507N

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For single shock absorber weight = 1753N
C = spring index = D/d=62/8= 7.75 =8

Shear stress=K_s ×(8PD/3.14×d^3)
Deflection of spring=(8PD^3n/Gd^4)
Wahl stress factor=(4C-1/4C-4)+(0.615/C)
Material: Spring Steel (modulus of rigidity)
G = 41000
Shear stress= 764N/mm^2(1 person)
Shear stress= 1529N/mm^2(2 person)
Deflection= 2229mm(1 person)
Deflection= 4459mm(2 person)
Material: Carbon fiber G=33000
Deflection= 2769mm(1 person)
Deflection= 5538mm(2 person)

Solid Works Models

Solid Works is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and is being developed by Dassault Systèmes Solid Works Corp., a subsidiary of Dassault Systèmes, S. A. (Vélizy, France). SolidWorks is currently used by over 2 million engineers and designers at more than 165,000 companies worldwide. FY2011 revenue for SolidWorks was 483 million dollars.

Fig.1 Shock absorber

Finite Element Analysis

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

Material: Spring steel

load =1753N(1 person)

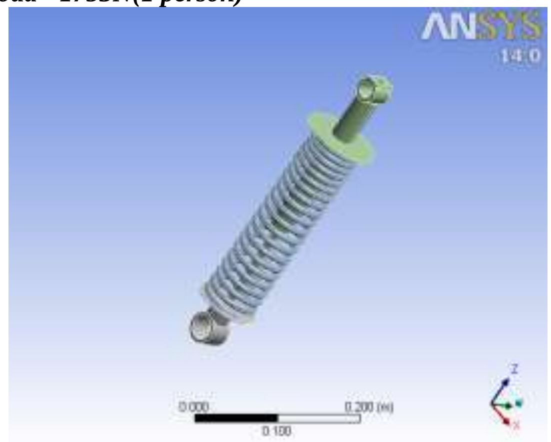

Fig.2 Shock absorber

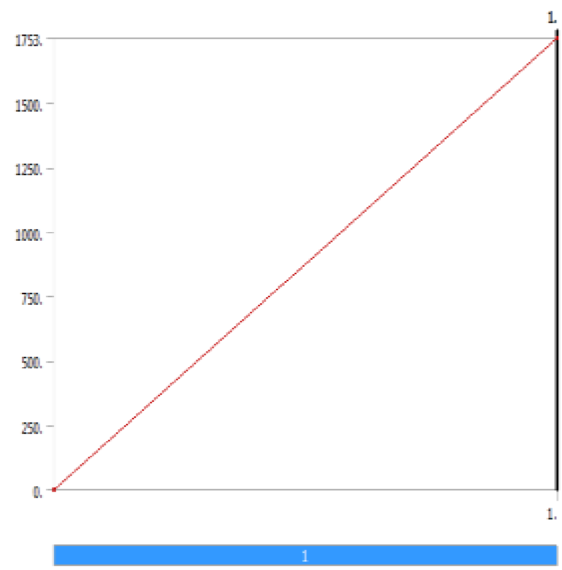

Fig.3 Applied load

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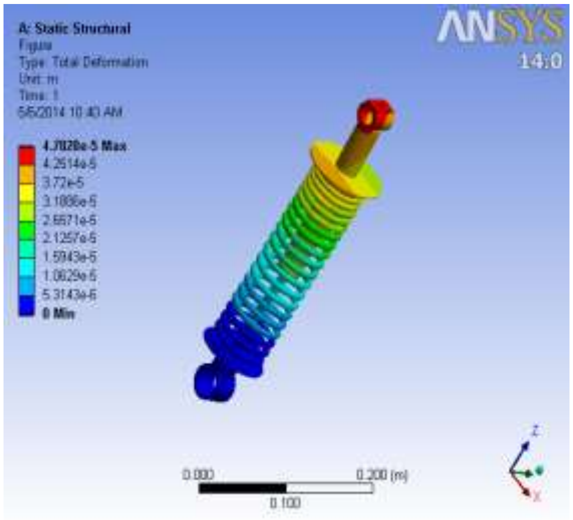

Fig.4 Deformation diagram

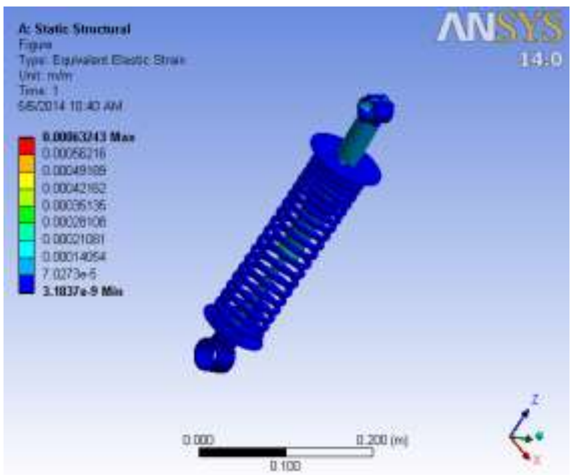

Fig.5 Strain diagram

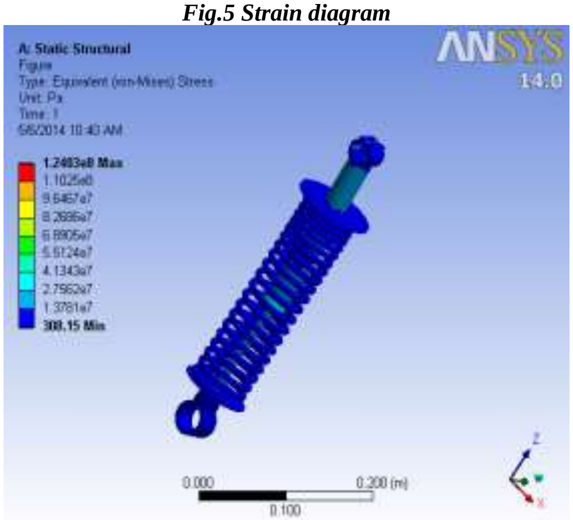

Fig.6 Stress diagram

Material : Spring steel

Load=3507 N (2 person)

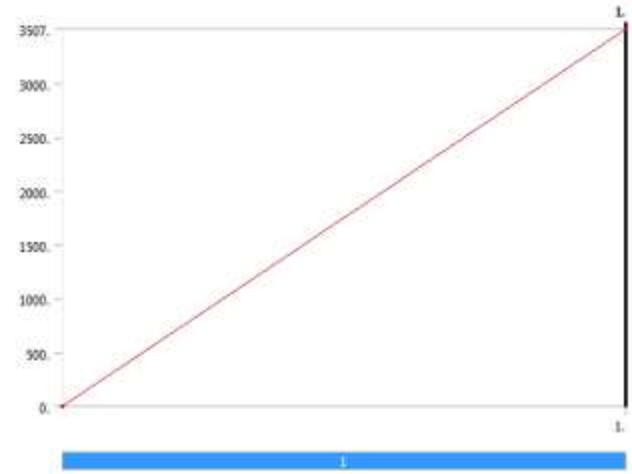

Fig.7 Applied load p=3507N

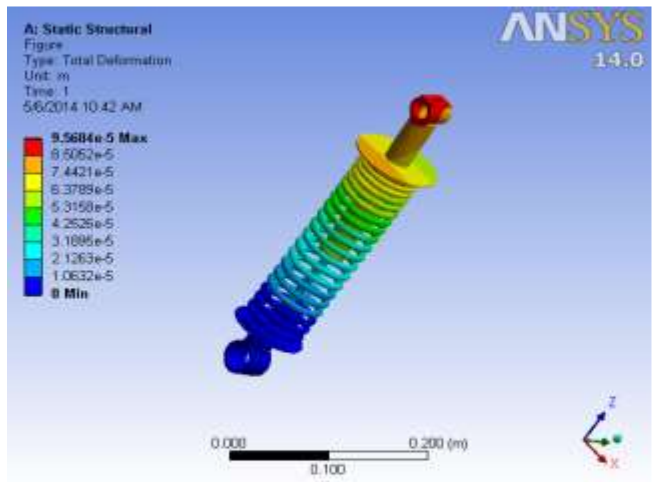

Fig.8 Deformation diagram

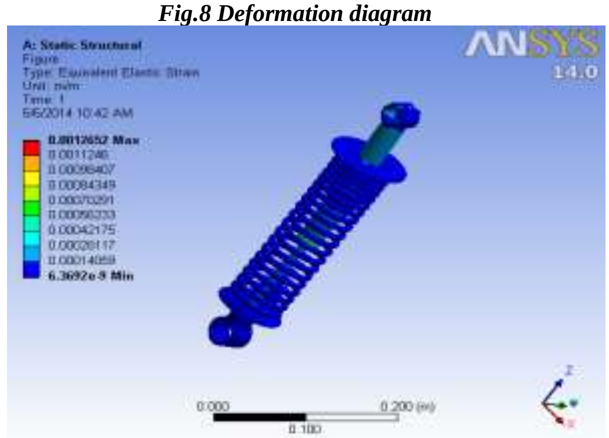

Fig.9 Strain diagram

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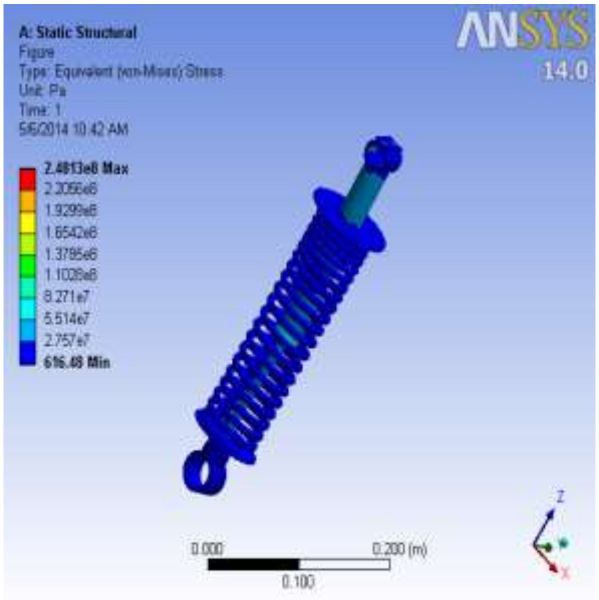

Fig.10 Stress diagram

Material : Carbon fiber
Load=1753N

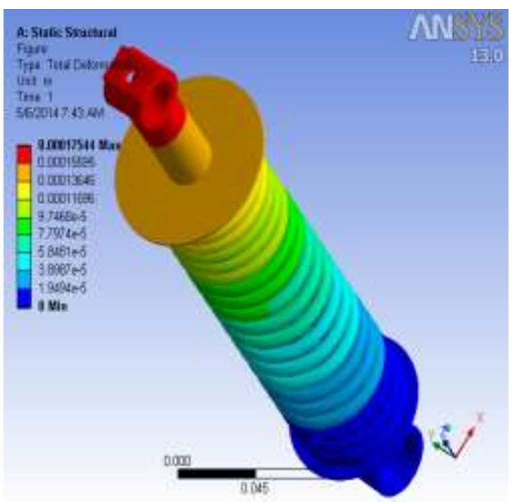

Fig.11 Deformation diagram

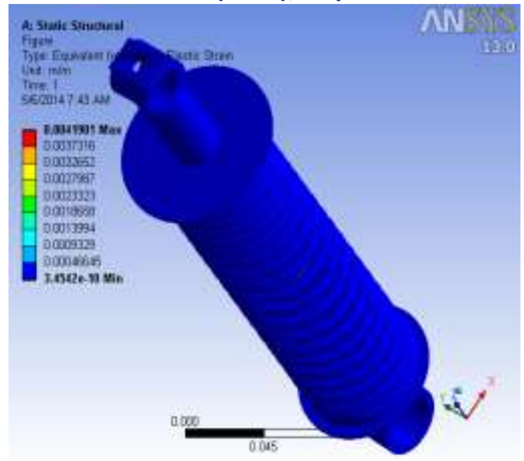

Fig.12 Strain diagram

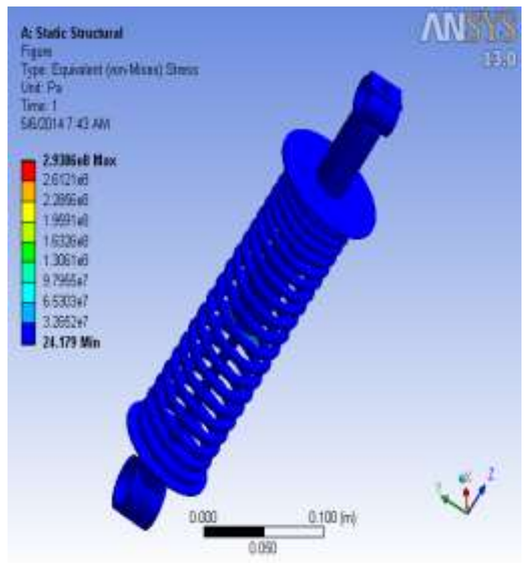

Fig.13 Stress diagram

Material: Carbon fiber
Load=3507N

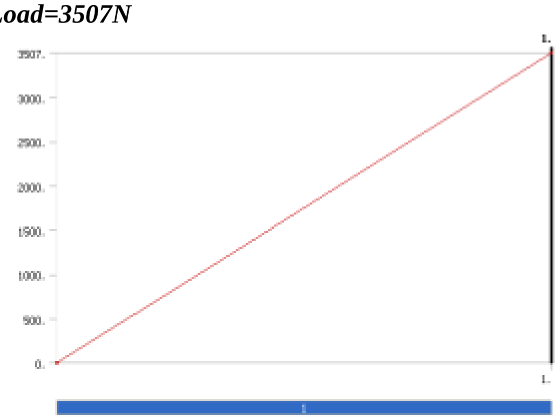

Fig.14 Applied load diagram =3507N

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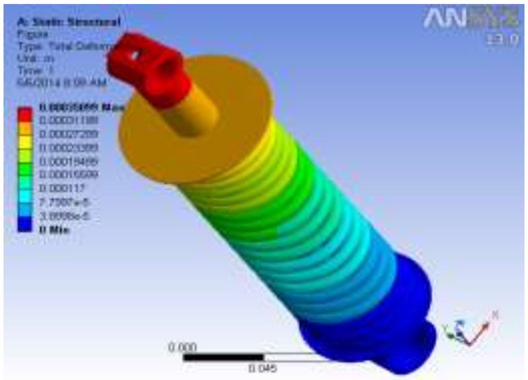

Fig.15 Deformation diagram

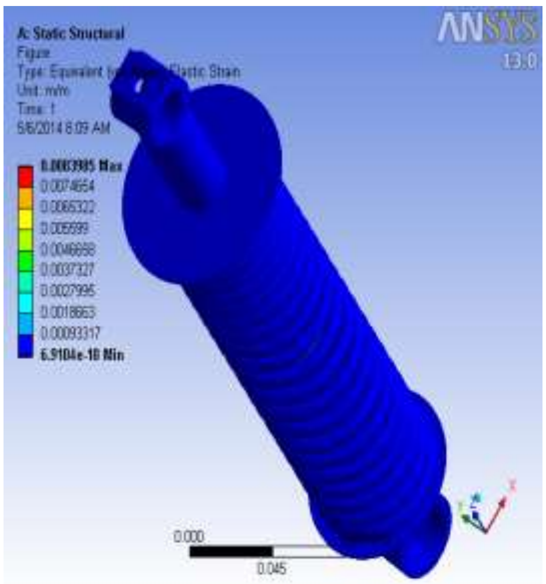

Fig.16 Strain diagram

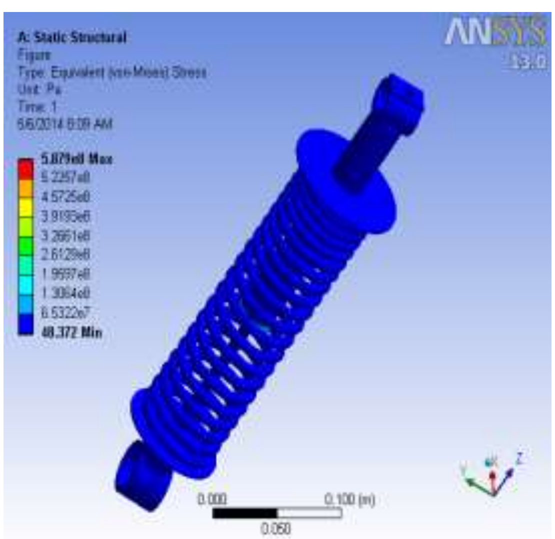

Fig.17 Stress diagram

Conclusion

Designed and Modeled a bike shock absorber by using 3D parametric software Solid works and analysed the shock absorber by using Ansys software. Analysis result [deformation,stress,strain] Shows for both materials spring steel and carbon fibers, From this results conclude spring steel is better than the carbon fiber. So future work is to analysis the different composite materials and spring steel for Different load as well as various factors.

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