Optimization of Cross Section in spring design for Two Wheeler Shock Absorber

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Article History: Received: 11 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 4 June 2021

Abstract:

The vehicle suspension system connects to the vehicle at its wheels and contributes to the vehicle's road handling and braking for better safety, driving pleasure andoffers comfortable ride well isolated from road noise, bumps and vibrations [1].The basic element of a suspension system is the spring and the material used for the helical coil spring is of great importance.In this work the shock absorber with spring is modelled in SOLIDWORKS and analysis is carried out on ANSYS by varying different cross sections for the spring. The comparative study is carried out between existing spring and new spring materials. Static analysis determines the stress and deflection of the compression spring

Keywords: Inconel x750, Monel K500, ANSYS, Static analysis

1. Introduction

A suspension system contains springs, dampers, shock absorbers, tyres linkages that connect the vehicle system. Each of the following has its own working, by combining which we get the total working of the suspension system. It allows the vehicle to bounce up and down on rough roads while the rest remains fairly steady. It allows the vehicle to corner with minimum roll or tendency to lose traction between the tyres and the road surface. Shock absorber is the crucial part in vibration handling and provides comfort. Shock absorber is the combination of spring and the damper. Spring is the unit which absorbs potential energy, whenever a vehicle hits a bump, and dissipates it as heat. When the vehicle is travelling on a level road, the spring is compressed quickly when the wheel strikes the bump. The compressed spring rebound to its normal dimensions or normal loaded length which causes the body to be lifted. The spring goes down below its normal height when the weight of the vehicle pushes the spring down. This, in turn, causes the spring to rebound again. The spring bouncing process occurs over and over resulting in lessening of vibrations each time, until the upand down space finally stop. The vehicle handling becomes very difficult and lead to uncomfortable ride when bouncing is allowed. To control this bouncing dampers or dashpots are used. Dampers are used to absorb this vibration energy and dissipate as heat. Suspension systems are used in automobile industries, in all type of road transportation. Suspension systems are also used in aerospace applications. It is also used in supporting many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of the structures to earth quake damage and resonance [6].

The structural simulation is used to determine the strength and stiffness of a product by reporting component stress and deformations. The type of structural analysis performs depends on the product being tested, the nature of the loads, and the expected failure mode[2]. If the yield stress is exceeded the structure will fail due to material failure. The Analysis involves discretization called meshing, boundary conditions and loading.

In the present work, the materials for spring are Stainless Steel, Inconel x750, and Monel K500 are used for analysing vonmises stress and deformation in each case with a constant design load .after selecting the best among these materials the analysis is done with different cross sections like circular, square, triangular, and hexagonal cross section for maximum stress and deformation in the spring with the constant design load. The main objective is to design the shock absorber spring for two wheeler vehicle and to optimize the cross section.

2. Material Properties

INCONEL x750 is a precipitation hardenable nickel-chromium alloy used for its corrosion and oxidation resistance and high strength at temperatures to 1300°F.It is used in various applications like rocket-engine thrust chambers, heat-treating fixtures, forming tools, extrusion dies, springs and fasteners. Its composition is shown in table1.

MONEL alloy K-500 is a nickel-copper alloy which combines the excellent corrosion resistance with the added advantages of greater strength and hardness. The composition of the alloy is given in Table 2. Its typical applications are chains and cables, fasteners and springs for marine service, pump and valve components for chemical processing oil well drill collars and instruments. It also has exceptionally good dimensional stability, both in long-time exposure tests and in cyclic tests. This property of the alloy has led to its use in high-precision devices. The allowable yield strengths of Stainless Steel, Inconel x750, Monel K500 are 40MPa, 37.5MPa, 43.5MPa respectively.

Table1 INCONEL x750

Nickel (plus Cobalt)	70.00 min
Chromium	14.0-17.0
Iron	5.0-9.0
Titanium	2.25-2.75
Aluminium	0.40-1.00
Niobium (plus Tantalum)	0.70-1.20
Manganese	1.00 max
Silicon	0.50 max
Sulphur	0.01 max
Copper	0.50 max
Carbon	0.08 max
Cobalt	1.00 max

Table2.MONEL K-500

Nickel (plus Cobalt)	63.0 min
Carbon	0.25 max.
Manganese	1.5 max
Iron	2.0 max
Sulphur	0.01 max
Silicon	0.5 max
Copper	27.0 - 33.0
Aluminum	2.30 - 3.15
Titanium	0.35 - 0.85

3 Methodology

3.1. Design calculations

Design Calculation for Helical Coil Spring of Shock Absorber made with Stain less Steel are calculated which includes its load and deflection.

Modulus of rigidity G = 79300N/mm2

Mean diameter of a coil, D=30mm, Diameter of wire, d = 7.25mm

Total no of coils, n_1= 6, Height, h = 99.9mm

Outer diameter of spring coil, D_0 = D +d =37.25mm, No of active turns, n= 5

Weight of bike = 143kg, Weight of 2 persons = 60×2=120Kg

Weight of bike +2 persons = 263Kg,

We Know that, compression of spring (δ) = WD^3 n/ G.d4 =1.589mm.

The stress calculations for different materials are different. They depend on material of the spring and its young's modulus. It lies in the safety limits for a safe shock absorber. Thus, the stress values are validated as their yield values as the safety limit and compared accordingly.

3.2Modelling of shock absorber:-

Suspension system is designed using SOLIDWORKS software. The suspension system is designed by measuring the dimensions of the bike model HERO HONDA CD100, in the garage. The components are disassembled and the individual measurements are noted. By using the dimensions measured, the 3D model is created in SOLIDWORKS. The components modelled are top rod, base, nut and springs. The components are assembled in SOLIDWORKS ASSEMBLY. This model is imported to Hyper mesh for meshing and the analysis is done with ANSYS for various cross sections of the spring on this assembly.


Figure1 Top Rod

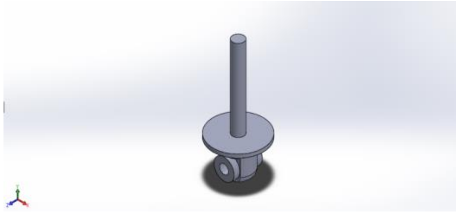
Figure2 Base

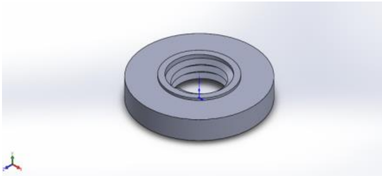
Figure3 Nut


Figure4 Circular Spring


Figure5 Hexagonal Spring


Figure6 Triangular Spring

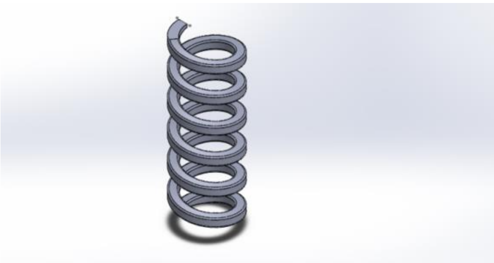
Figure7 Square Spring

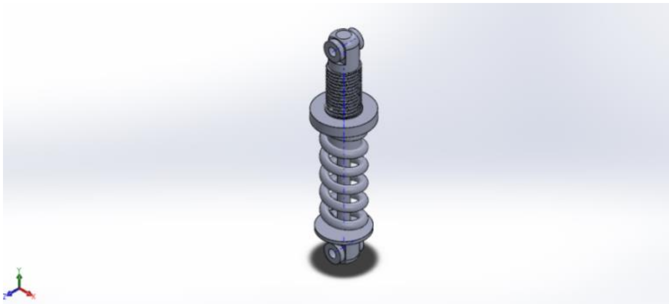
Figure8 Assembly

3.3Finite Element Analysis:

The different materials that are assigned to the spring are Stainless Steel, Inconel x750 and Monel K500. These materials have some properties that are in favour for the manufacture of spring materials such as shear modulus, corrosion resistance, and temperature withstanding capability. Spring stiffness not only depends upon material of spring but also the cross section of spring. Thus cross section of spring also plays a vital role in analysis of shock absorbers. Finite Element Analysis is done on the working model of shock absorber with the above spring material and best one is selected based on the results of stress and deformations. With this spring material the cross sections are varied with circular, hexagonal, triangular and square cross sections under constant load factor and results are observed

4 Results and Discussions

4.1 Analysis of shock absorber with various materials

The results of **s**tatic analysis of shock absorber with the spring materials as stainless steel, Inconel x750 and Monel K500 at the design load are shown in figures 9 to 14 by using ANSYS 15.0 and the stresses and deformations are noted in the tale3.

It is observed from table 3 that that the springs with the change of materials are within the safety limit under a load of 2500N. It is also found that **Monel K500** has high capacity of absorbing shocks and stress resistant, having 0.025763mm deformation which is more than other two materials. Hence it is the best material for spring manufacturing compared to Inconel x750 and Stainless Steel.

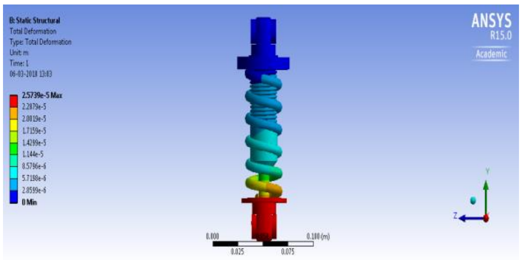

Figure9: Deformation for stainless steel

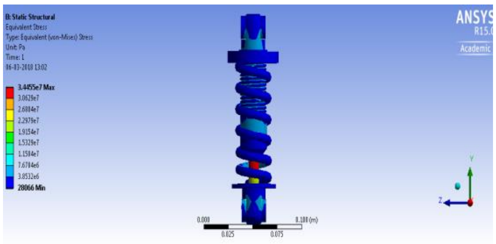

Figure10:Stresses for stainless steel

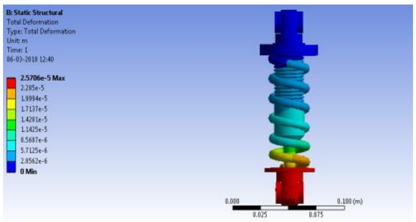

Figure11: Deformation for Inconel x750

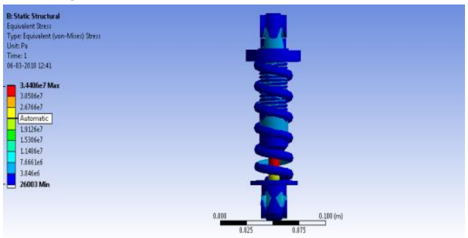

Figure12: Stresses for Inconel x750

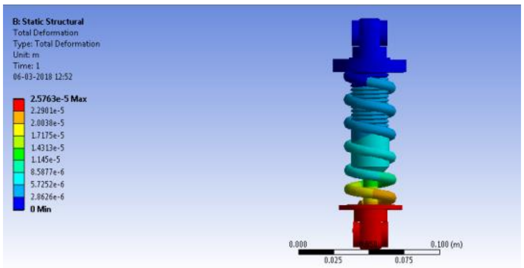

Figure13:Deformation for Monel K500

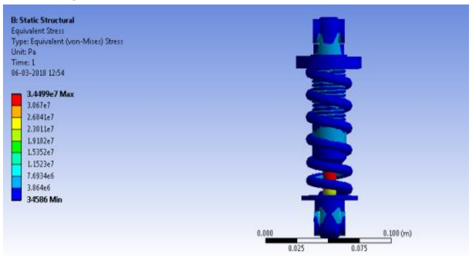

Figure14: Stresses for Monel K500

Table3: Comparison of stresses and deformation for different Materials

Sno	**Material**	**Deformation**(mm)	**Stress**(MPa)
1	Stainless Steel	0.025739	34.455
2	Inconel x750	0.025706	34.406
3	Monel K500	0.025763	34.499

4.2 Finite Element Analysis of Shock Absorber with the Monel K500 springs Static Analysis have been done on shock absorber with the Monel K500 material springs made up of circular, hexagonal, triangular and square cross sections .The stresses and deformations are shown in the figures from figure 15 to 22. The values of equivalent vonmises stress and deformations are tabulated in table 4.

From the table4, it can be observed that the square cross section is best when it is considered stress as main criteria as it resists maximum stress (38.294MPa) and triangular cross section spring is best when considered deformation as main criteria as it resists maximum deformation (0.026162mm).

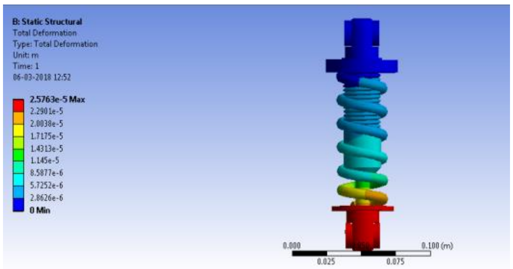

Figure15: Deformation for circular spring

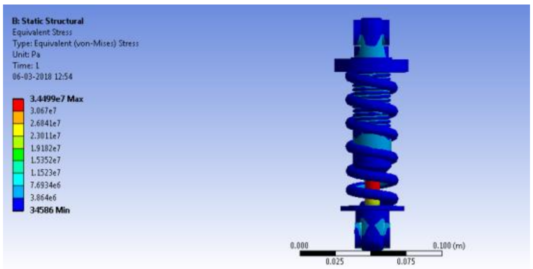

Figure 16:Stresses for circular spring

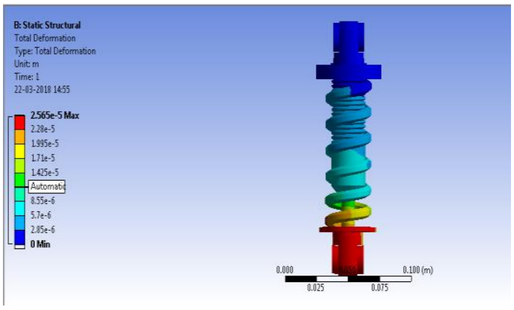

Figure17:Deformation for hexagonal spring

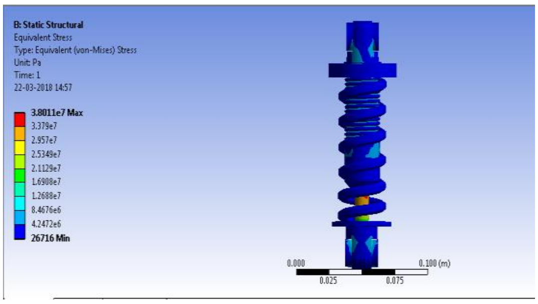

Figure18:Stresses for hexagonal spring

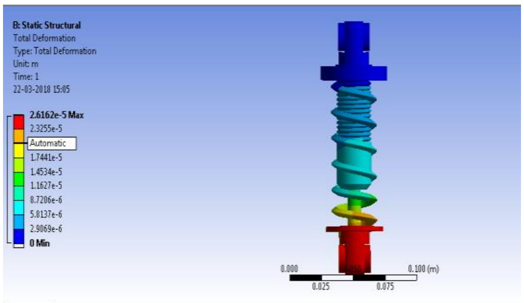

Figure19: Deformation for triangular spring

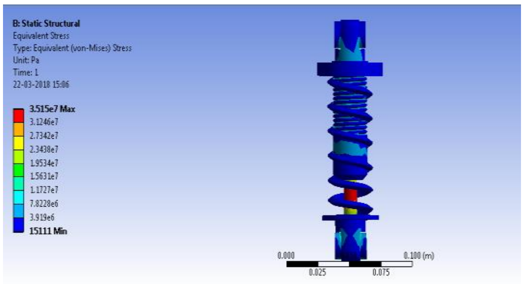

Figure20:Stresses for triangular spring

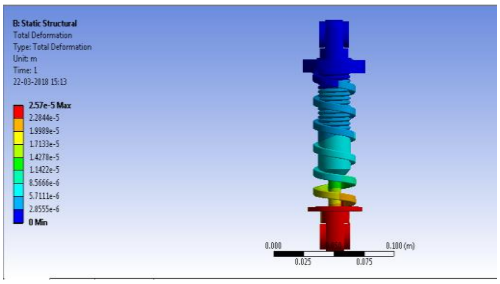

Figure21:Deformation for square spring

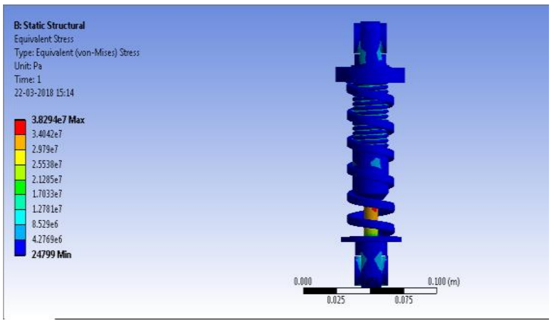

Figure22:Stresses for square spring

Table4 : Comparison of stresses and deformations for various cross sections

Sno	Cross Sections of Spring	Deformation (mm)	Stress (MPa)
1	Circular spring	0.025763	34.499
2	Hexagonal spring	0.02565	38.011
3	Triangular spring	0.026162	35.511
4	Square spring	0.0257	38.294

For shock absorbers, deformation is given more preference than the stress, as all the stress values are within the safety limit. The best spring cross section for shock absorber is triangular cross section.

5. Conclusions

The following conclusions are made from this work

1) Monel K500 has maximum deformation of 0.025763mmwhich is more than Inconel 750 and Stainless Steel material. Hence it is more stress resistant and the best material for spring manufacturing in a shock absorber.

2) After analysing the Monel K500 Spring material with different cross sections, Triangular cross section spring is having 0.026162mm deformation which is more than the circular, square and hexagonal cross sectional springs. Hence triangular spring is the optimum section.

3) From the results shown in table4 with equivalent stress and deformation, Monel spring with triangular cross section is considered as optimum for spring in shock absorber.

6.References

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