International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.5, Issue No.2, pp : 123- 126 1 Feb. 2016

Analysis of Coil Spring Used in Shock Absorber using CAE

Dr. Dhananjay. R. Dolas , Kuldeep. K. Jagtap
JNEC,Aurangabad

Abstract: Vehicle suspension system has to perform complexity requirements, which includes road holding and equality, driving pleasure, riding comfort to occupant. The objective of this paper is to analyze the performance of Shock absorber spring by varying stiffness, which is obtained by doing optimization using Genetic Algorithm as optimization tool to obtain maximum ride comfort. The Shock absorber is one of the suspension systems designed mechanically to handle shock impulse and dissipate kinetic energy. It reduces the amplitude of disturbances leading to increase in comfort and improved ride quality. The spring is compressed quickly when the wheel strikes the bump. The compressed spring rebound to its normal dimension or normal loaded length which causes the body to lift. The spring goes down below its normal height when the weight of the vehicle pushes the spring down, spring resist deformation. Modeling and analysis is done using Pro E and ANSYS respectively.

Keywords: Coil spring, Stiffness, Modelling & FEA

Introduction:

Suspension system plays an important role for a comfortable ride for passengers besides protecting the chassis and other working parts from getting damaged due to road shocks. If in a vehicle both front and rear axles are rigidly fixed to the frame, while vehicle is moving on the road, the wheels will be thrown up and down due to the irregularities of road, as such there will be much strain on the component as well as the journey for the passengers in the vehicle will also be very uncomfortable. This is the system that provide comfortable ride and also prevent damage to the working parts.

Literature Review

In this section, literatures survey study gathered regarding the information about the stress for the helical compression spring. Springs are mechanical shock absorber system. A mechanical spring is defined as an elastic body which has the primary function to deflect or distort under load, and to return to its original shape when the load is removed. The researchers throughout the years had given various research methods such as Theoretical, Numerical and Experimental. Researchers employ the Theoretical, Numerical and FEM methods. Study concludes Finite Element method is the best method for numerical solution and calculating the stress, life cycle and shear stress of helical compression spring Lavanya et al. [1] presented the work to analyze the safe load of the light vehicle suspension spring with different materials and investigation includes comparison of modeling and analyses of primary suspension spring made of low carbon-structural steel and chrome vanadium steel and suggested the suitability for optimum design. The results showed that reduction in overall stress and deflection of spring for chosen materials. Youli Zhu et al.[2] analyzed compression coil spring fractured at the transition position from the bearing coil to the first active coil in service, Visual observations indicated that a wear scar was formed on the first active coil and the fracture surface showed radiating ridges emanating from the wear scar. Scanning electron microscopy examination showed crescent shaped region and beach marks, typical of fatigue failure. Chavan et al. [3] determine the fatigue life of the existing coil spring on the car and identify areas of improvement over the fatigue life. Finite Element Analysis would be deployed for the structural analysis using NASTRAN or suitable solver while the fatigue life would be predicted using `MSC Fatigue' or suitable. For this work, experimentation shall be performed for validating the performance parameter identified as `Stiffness' of the spring. The load vs. displacement shall be recorded using load cells with data logger to display results. Kannan et al. [4] presented shock absorber modeling using SOLID WORKS and analysis done in ANSYS. Structural analysis is done on the shock absorber for various material, Spring Steel and Carbon fiber. Suryawanshi et al. [5] considered the four variants of spring as its application is in the dies to hold the metal sheet during blanking (stamping) operation. One of the variant is considered as standard specimen and accordingly study and design analysis of standard specimen is done (In Hypermesh, NASTRAN and MSC Fatigue), by finding the both static force and dynamic forces in terms of fatigue life. Mehdi et al.[6] worked on optimum design of steel helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution. The spring has been replaced by three different composite helical springs which are made of Eglass/Epoxy, Carbon/Epoxy and Kevlar/Epoxy. The optimum design based on the parameters of weight, maximum stress and deflection and has been compared with steel helical springs. It has been shown that spring optimization by material spring changing causes reduction of spring weight and maximum stress considerably. Mulla et al. [7] presented the static stress analysis using finite element method has been done in order to find out the detailed stress distribution of the spring. Pharne et al. [8] study under fatigue loading condition. Fatigue analysis is done in ANSYS 14.0 software. The results are compared with the experimental observations. A new design modification is done by introducing another spring coaxially. Gaikwad et al. [9] presented the analysis of safe load of the helical compression spring. A typical helical compression spring configuration of two wheeler horn is chosen for study. This work describes static analysis of the helical compression spring is performed using NASTRAN solver and compared with analytical results. The pre processing of the spring model is done by using HYPERMESH software. Achyut et al. [10] worked on the shock absorber designed and a 3D model is created using Pro/Engineer. Structural analysis and modal analysis are done on the shock absorber by varying material for spring, Spring Steel and Phosphor Bronze. Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different

frequencies for number of modes. Comparison is done for two materials to verify best material for spring in Shock absorber. Modeling is done in Pro/ENGINEER and analysis is done in ANSYS. Madan et al. [11] carried out on modeling, analysis and testing of suspension spring is to replace the existed steel helical spring used in popular two wheeler vehicle. The stress and deflections of the helical spring is going to be reduced by using the new material. The comparative study is carried out between existed spring and new material spring. Static analysis determines the stress and deflections of the helical compression spring in finite element analysis. Pinjarla et al. [12] presented the work on Design and Analysis of a Shock absorber. Modeling is done in Pro/ENGINEER and analysis is done in ANSYS. Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design. ANSYS is general-purpose finite element analysis (FEA) software package. Jagtap & Dolas [13] worked on the geometric parameters of suspension system are optimized using Matlab as an optimization tool Jagtap et al. [14] worked on minimize the TDF by optimum suspension design so that minimum vertical accelerations would be experienced by the passengers. To minimize the vertical acceleration, mathematical model of 2-DOF Quarter car model is considered for passive suspension system. Its equation of motion is formed with correlating objective function.

The mechanical properties of the suspension spring along with the configuration of the geometry like the diameter of the wire, the pitch, number of turns, etc affect the performance of the spring in a favorable or adverse manner. Simulation using Finite Element Modelling techniques offer insight into the nature of the stresses, deflection or any other response parameter responsible for the performance of the spring. Experimentation for fatigue life is not feasible in most of the cases.

According to the literature review presents that the Coil springs becomes quite necessary to do the complete stress analysis of the spring. These springs undergo the fluctuating loading over the service life. In addition, FEM software has been use for performing meshing simulation.

METHODOLOGY

In this work modeling and analysis has been carried out on spring. The design variables of suspension coil spring are as follows.

Table No 1 Design Variables

Parameter	Original	GA Value
Spring Stiffness	18760	12265
Damping Coefficient	900	536

With the optimized values the new strut is manufactured from the supplier and is used for the analysis. As per the optimized values the new strut is manufactured for the testing. The spring stiffness has been optimized to obtain ride comfort. It was observed in Matlab and on Quarter Car Test rig that the reduced spring stiffness has reduced the vertical accelerations experienced by the passengers. The initial spring stiffness was 18,760N/m which was optimized to 12,236 N/m using the Genetic Algorithm as optimization Tool. An attempt is done to analysis the spring using CAE software's. The Modeling of the spring is done in Pro E and Analysis in ANSYS.

Fig 1: Original Strut

Fig.2: Optimized Strut

Model of the spring applying load of 60Kg and Stiffness-18,760 N/m

Fig 3: Isometric View of spring

ISSN:2319-6890)(online),2347-5013(print)
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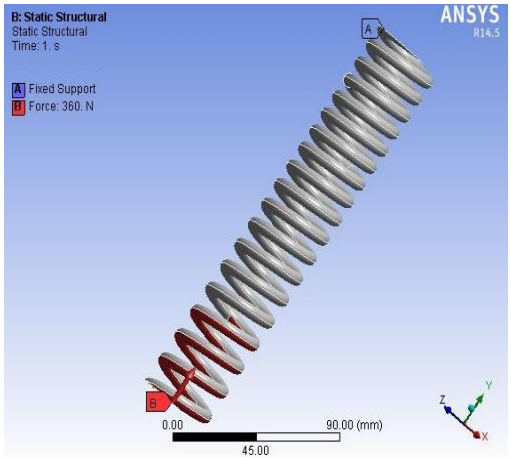

Fig 4: Load applied on Tetra Mesh Mode

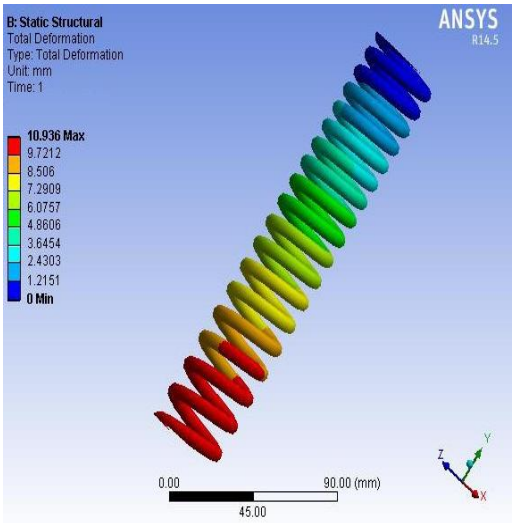

Fig 5: Displacement of Spring

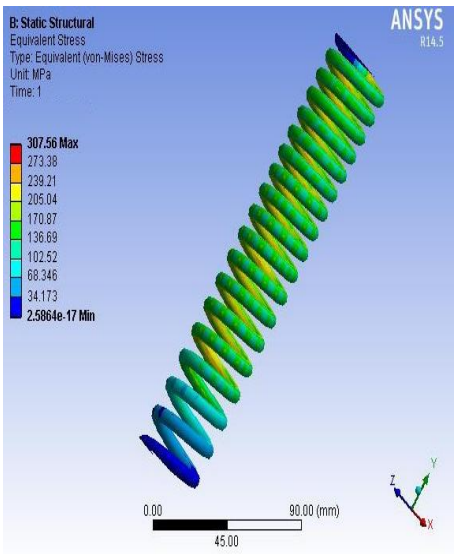

Fig 6: Von Misses Stress

Applying load of 60 kg and Stiffness-12,236 N/m on New Spring

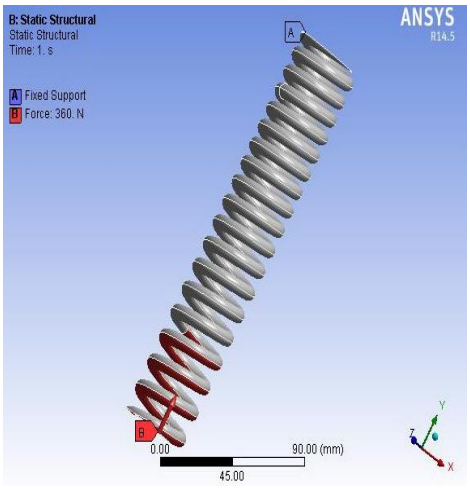

Fig 7: Displacement of New Spring

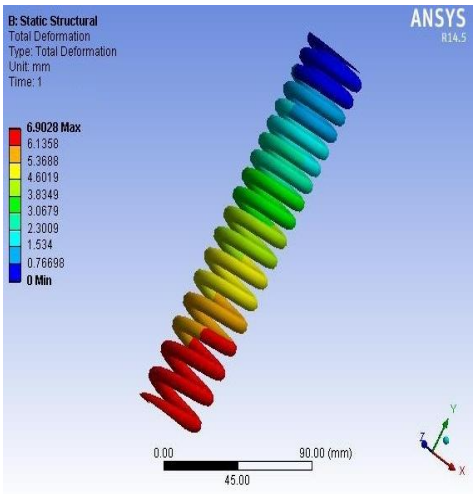

Fig 8: Load applied on Tetra Mesh Model

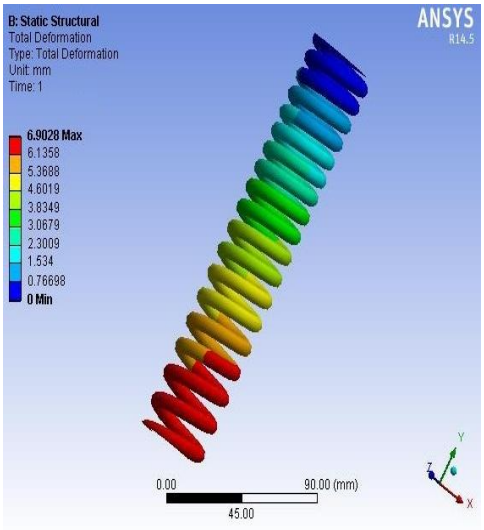

Fig 9:Von Misses Stress for New Spring

RESULTS AND DISCUSSION

The static analysis of suspension coil spring is carried out in ANSYS

Table No 02 Compression Parameters of spring

Load	Stress in Spring		Deflection of Spring	
	Present	Optimized	Present	Optimized
60 Kg	750.45 MPa	600.36 MPa	24.988mm	18.234mm

As we can analyze from Table1, as the spring stiffness is reduced from 18,760 M/m to 12,236 N/m, the stress level has also been reduced from 750.45 MPa to 600.36 MPa. The stress level is low in the modified spring, so it's safe and the weight is also reduced which adds an advantage to the analysis.

CONCLUSION

The CAE software's are an important tool to analysis the system and to check its feasibility.

1. By observing the analysis results, the analyzed stress values are less than their respective yield stress values. So design is safe.
2. By comparing the results for present design and modified design, the stress and displacement values are less for modified design.
3. The weight of the spring has also been reduced and it is safe.

ACKNOWLEDGEMENT

We would like to thank our mentor Dr. Sudhir Deshmukh, Principal MGM's JNEC for their valuable co-operation and support; also we wish to thank all faculty members of Mechanical Engineering Department.

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