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Investigation of Stress and Strain of Parabolic Leaf spring using Numerical Analysis

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Abstract

A spring is an elastic object, springs are used to store mechanical energy. When a conventional spring, without stiffness variability features, is compressed or stretched from its resting position, it exerts an opposing force approximately proportional to its change in length. In this manuscript, Modeling of leaf spring is performed in Solid works 2015 and Equivalent (von mises) stress, maximum shear stress and normal shear strain is investigated by Ansys 12.1. The material used for the leaf spring analysis is spring steel (50Cr1V23). The result shows that maximum value of von mises stress is 1.02x 10^9pa and the entire von mises stress is spread all over the spring. The maximum value of maximum shear stress is 5.91x 10^8pa. However it also indicates that there is no heavy stress accumulation at any of the spring. The maximum value of normal elastic strain is 0.0013552m/m and no unusual strain developed at any stage of the spring and the entire normal elastic strain is spread all over the spring.

1. Introduction

A leaf spring is a simple type of elastic body, which are used for the suspension system of wheeled vehicles. When force is applied they return to their original position. Leaf springs (or flat springs) are made of flat plates. Engineers worked for years and made many small changes in the suspension system, mainly on the leaf springs, coil springs and many different kind of steel were used first marked improvement in spring ease came long. Great advantage gained when the positioning of the spring were made, engineers worked on each and every part of the vehicle by positioning the seats, engine, leg space inside the cars which made them try every possible position and found better results. Further they worked on the weight reduction of the suspension system which made them work on every different manufacturing processes. Which resulted in better comfort inside the car and rides of the vehicle. The benefits of leaf spring over helical spring are the ends of the spring that may be guided along a certain path as it changes direction to act as a structural member as well as an energy absorbing device. Weight diminution can be attained primarily by introducing a better material, better manufacturing processes and design analyses. The leaf spring suspension is one of the possible items for weight reduction in automobiles as it holds 10% - 20% of the unstrung weight. This achieves more efficiency and quality riding. By introducing composite materials made it possible to lower the weight of the leaf spring [1]. There are many types of springs available for vehicle suspension system. Leaf springs are predominantly used for the suspension system in vehicles. The leaf spring is an arc-shaped slender having some length of a kind of steel spring of rectangular cross-section. The vehicle axle is placed at the point that is equally distant from every point of the arc, at the end eyes are used for attaching to the machine body [2]. The heavy vehicles need a quality suspension system that can deliver good handling and a good ride. The component needs to have an excellent of fatigue life and lightweight. Exhaustion is one of the major issues in automobile element. It must withstand numbers of cycles before it can break, or never fail at all during the period of service. From engineering applications, the purpose of exhaustion research consists of the prognostication of fatigue life on structures, simplifying fatigue tests and increase in fatigue life. A spring is usually made out of hardened steel. Originally called laminated or carriage spring [3]. Leaf spring is widely used in automotive components. It consists of one or more leaves. As a common rule, the leaf spring must be considered as a safety component as failure could lead to frightful accidents. The leaf springs may carry brake torque, loads, etc. in addition to breakdown. The multi-leaf spring is made up of number of steel plates of different lengths cram together. During common operation, to absorb road shock the spring compresses. The leaf springs slide and bend on each other allowing suspension motion. Fatigue failure is the primary mode of in-service failure of many automobile elements [4]. One of the roles of suspension system is to balance the wheels in proper camber and steer attitudes to the surface of roads. It should react to all the forces that follow in dynamic condition. These forces include lateral forces (cornering forces) and longitudinal forces. It should counter the roll of the chassis. Leaf spring keep the wheels act any uneven road by separating the chassis from the surface roughness of the road [5]. Some form of springs are used to mount the chassis of the vehicle. This is done to separate the body of vehicle from the road shocks which may be in the form of pitch, roll, bounce or sway. These tendencies give rise to disagreeable ride and can cause additional stress in the automobile body and frame. All the components which perform the function to separate the vehicle from the road shocks are unitedly called a shock absorbing suspension system [6]. The evolution of a flex light suspension leaf spring is first executed. Consideration based on chipping resistance, part base and exhaustion resistance, a glass carbon hybrid fiber covered spring is fabricated. A general scrutiny on inspection and design of constant width, variable thickness, and leaf spring (composite) is accorded [7]. As the name says indirectly, stress scrutiny

is the complete, intact and comprehensive examination of stress distribution of sample under study. The most important job before design engineering is to balance the working stresses within pre-decided specific limits, in order to avoid the fail. The design has to be inexpensive with adequate inertia and mass. To upgrade the quality of product, it is important to examine the stresses in the components. It is also necessary to know the distribution of stresses in order to assume the failure of elements. The design engineer has to indispensably perform the stress analysis [8].

2. Leaf Spring Design Calculation

A suspension system (leaf spring) generally used in automobiles vehicles of semi-elliptical structure as in figure. The spring built up of a numerous plates (leaf shaped). The plates are commonly given primary curvature or cambered so that they would straighten (without any failure) under the applied load. The leaves (plate) are held continuously by a method of a shrunk that is banded around them at the midpoint or by a nut and bolt crossing through the midpoint. The longest (base) leaf known as master leaf has its ends manufactured like a shape of eye through which the nuts and bolts are passed to lock the spring to its supports. Generally the eyes, by which the spring is fixed to the shackle, are supported with bushings of some material (antifriction) such as bronze or polymer (rubber). The other plates (leaves) of the leaf spring suspension system are called as graduated leaves or plates. To prevent digging of the adjacent plates, the ends of the progressive plates are trimmed by various forms as in diagram. Since the master or main leaf has to confront bending vertical applied loads as well as loads due to crabwise of the vehicle, therefore due to the stresses caused by these bending vertical loads, it is important to provide two full length plates and the rest progressive leaves as shown in figure. Special rebound clips are located at intermediary locations in the length of the leaf spring, so that the progressive leaves also share the loads influenced in the full length plates when the spring is rebound. Design methods (conventional) of leaf springs are dependent on the application of semi-empirical rules as well as empirical rules along with the use of accessible data in the literature existing. The features of springs are absorbing enthalpy and release this energy or enthalpy according to the required functions to be presented. So leaf springs structure and design is dependent on the load resisting deflection and capacity. Modeling of leaf spring is performed in Solid works 2015. There are different convenient methods to manufacturing a leaf spring. Here we utilize method (divisional) of generation of leaf spring parabolic.

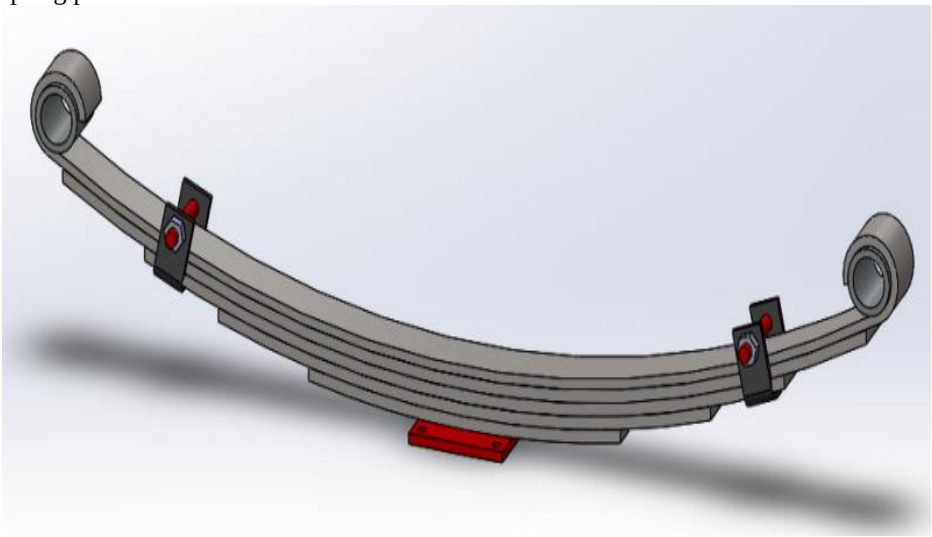

Figure 1: Leaf Spring Design

Figure 1 shows the design of the leaf spring which is designed by using solid works. The leaf spring is made of five flat leaves which includes 2 full length laves clamped together to make leaf spring. Total Length of the spring (Eye to Eye) is 1340mm, Distance between U bolts is 80mm, Free Camber (At no load condition) is 96mm, Thickness of each leaf is 8mm and the Width of each leaf spring is 60mm.

3. Analysis of Leaf Spring

In most structural analysis applications it is necessary to compute displacements and stresses at various points of interest. The finite element method is a very valuable tool for studying the behavior of structures. Software to be used for ANSYS 12.1. Material used for steel leaf spring analysis is spring steel (50Cr1V23) which is isotropic having 2000 MPa ultimate Tensile strength, 1800 MPa yield strength and 7850 Kg/m^3 Density. Design Load given on the spring is 6kN and the Maximum Load (Metal to Metal Position) is 10kN.

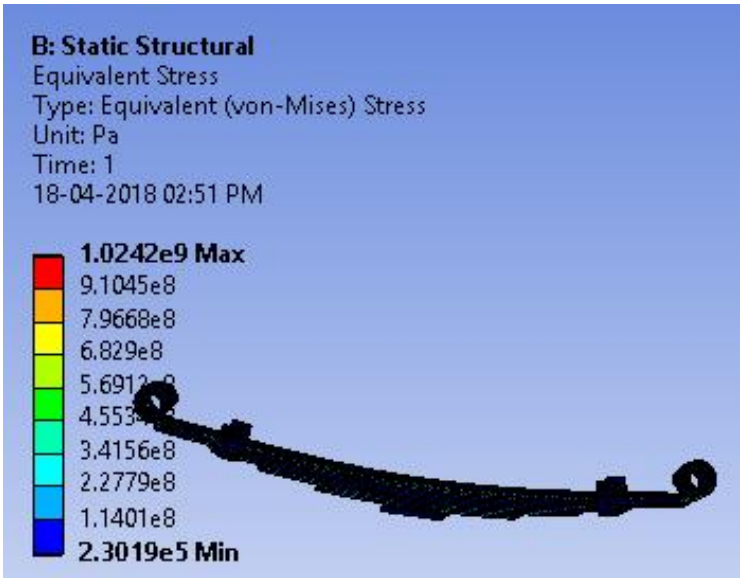

Figure 2: Equivalent (Von Mises) Stress

Figure 2 shows the Equivalent (Von Mises) Stress of the leaf spring by Ansys analysis. The result shows that the minimum value of 2.30x 10^5pa and the maximum value of 1.02x 10^9pa. However it also indicates that there is no heavy stress accumulation at any of the spring and the entire von mises stress is spread all over the spring.

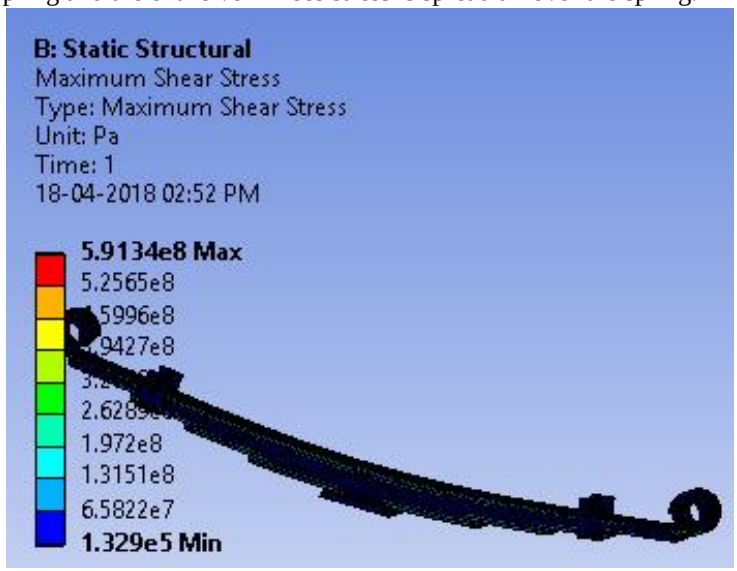

Figure 3: Maximum Shear Stress

Figure 3 shows the Maximum Shear Stress of the leaf spring by Ansys analysis. The result shows that the minimum value of 1.32x 10^5pa and the maximum value of 5.91x 10^8pa. However it also indicates that there is no heavy stress accumulation at any of the spring and the entire maximum shear stress is spread all over the spring.

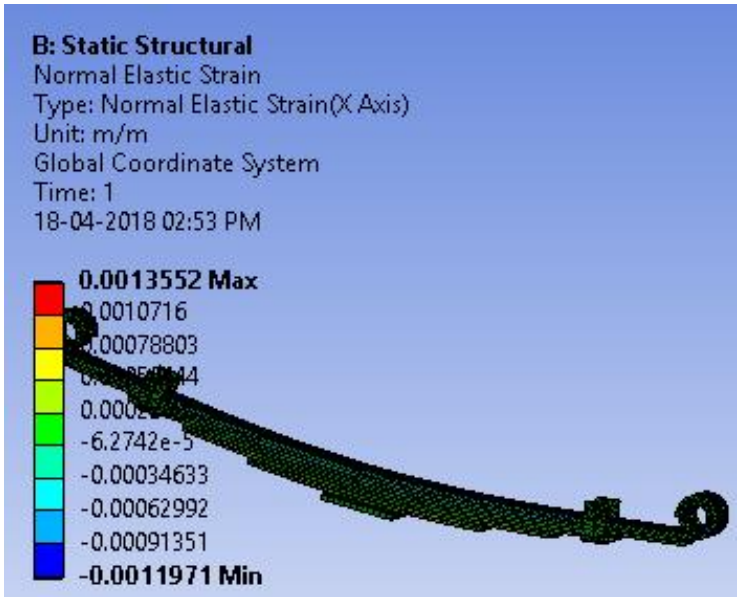

Figure 4: Normal Elastic Strain

Figure 3 shows the Normal Elastic Strain of the leaf spring by Ansys analysis. The result shows that the minimum value of -0.0011971m/m and the maximum value of 0.0013552m/m. However it also indicates that there is no unusual strain developed at any stage of the spring and the entire normal elastic strain is spread all over the spring.

4. Conclusion

The leaf spring is designed by using Solid works 2015 and Equivalent (von mises) stress, maximum shear stress and normal shear strain is investigated by Ansys 12.1. The material used for the leaf spring analysis is spring steel (50Cr1V23). The von mises stress result shows the maximum value of 1.02×10^9pa. However it also indicates that there is no heavy stress accumulation at any of the spring and the entire von mises stress is spread all over the spring. The maximum shear stress result shows that the maximum value of 5.91×10^8pa. However it also indicates that there is no heavy stress accumulation at any of the spring and the entire maximum shear stress is spread all over the spring. The normal elastic strain result shows that the maximum value of 0.0013552m/m. However it also indicates that there is no unusual strain developed at any stage of the spring and the entire normal elastic strain is spread all over the spring. From results shown by Ansys, we can say that the value of stress falls under green category. So the leaf spring design made is safe for given loading condition. Also, this particular leaf spring is suitable for application in heavy automobiles like loading trucks and tankers.

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