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Structural Analysis of Helical Compression Spring

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ABSTRACT

The die set system used in the wire straightening and cutting system is comprises of die plate, bolster plate and guides with mutually helped by helical compression spring. This spring plays an important role in smooth movement of the die set by supplying energy stored in it as well as keeps sufficient pressure on the plate provided at the bottom of the rod. It acts as suspension system to absorb the shocks and stores the mechanical energy. It is made up of elastic materials such that it can twist, pulled or stretched by the application of force and regain its original shape when the force is released due to this the stress are produced along the length of the helical compression coil spring. On account of these stresses coil springs have been undergone the failure prematurely before its service life. The present work is investigation on reduction of the premature failure and improves the service life of helical compression spring. The life of spring is improved by optimum design and analysis by variation of wire diameter. Results indicate that the maximum shear stresses are decreased for increase values of wire diameter and number of turns of coil spring. Due to this, deflection of spring as required is achieved hence reduction of the premature failure of coil spring is attained.

Keywords: Helical Spring, Suspension System, Deformation, Ansys

I. INTRODUCTION

A spring is a resilient member capable of providing large elastic deformation. A spring is basically defined as an elastic body whose function is to distort when loaded and to recover its original shape when the load is removed. Mechanical springs are used in machines and other applications mainly to exert force, to provide flexibility, to store or absorb energy. Springs are elastic bodies that can be twisted, pulled, or stretched by some force. They can return to their original shape when the force is released. In other words it is also termed as a resilient member[3].

Spring material and its quality can be normally taken into consideration or highlighted in such cases as (i) spring installed in mechanical products failed either by fracture or by significant deformation in use. Here the quality requirements set up in the initial quality design stage were not achieved in the actual product (ii) a mechanical product newly designed or improved where a new design of spring is required of higher quality (iii) a cost reduction requested for the spring have been used without any difference of the quality. Here although the quality requirements at the design stage were satisfied in use the springs were used in the severer condition than the initially expected or some important quality requirement failed to be included in the initial quality requirements in the design stage[5].

When a spring has failed due to the above reasons an investigation is need to be carried out to find out the quality of the material used for the spring and manufacturing process used to make it. Considering the availability, quality level, price and the matching with working processes, the most suitable material can be chosen.

II. LITERATURE REVIEW

Rathore Gajendra Singh et al. [1] studied that the helical compression 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. Almost in all of the above cases, fatigue stress, shear stress calculation play more significant role in the design of helical compression springs. authoralso showed that shear stress and deflection equation is used for calculating the number of active turns and mean diameter in helical compression springs. Comparison of the theoretical obtained result by the shear stress equation to the Finite Element Analysis result of helical compression springs is the mode of our present work, by this analysis it will possible in future to provide help to designers for design of spring against fatigue condition. Tauseef Shaikh et al. [2] observed that failure of valve spring on any of the cylinder may result in sudden depreciation of the engine power and consequently may lead to threat of life and property due to a potential accident. Hence the spring must be designed for reliability and to withstand the cyclic loading during operation over its life time. author also proposed to carry out the design and fatigue analysis of compression spring used in the engine valve of high speed (racing car) so as to ensure minimum fatigue life of the spring. author done analysis on original spring and we got fatigue life 6.56x104Then by modifying the original spring i.e. changing its wire diameter and by changing the pitch and also we had done analysis on modified springs. Then we got maximum fatigue life 4.32x105for modified spring II (by changing wire diameter 4.5) so got the best suitable spring for our application of valve spring i.e. modified spring II (by changing wire diameter 4.5).Since the impact of cost and the process of manufacturing are negligible for the proposed variant, the same is recommended for implementation over the application studied. Pattar Sangmesh et al. [3] observed that maximum stress is developed at the inner side of the coil. From the ANSYS and theoretical, the allowable design stress is found between the corresponding Loads 2 to 5 N. It is seen that at 7N load, it crosses the yield stress (yield stress is 903 N/mm2). By considering the factor of safety 1.5 to 2. It is obvious that the allowable design stress is 419 to 838 N/mm2. So the corresponding loads are2 to 5 N. Therefore it is concluded that the maximum safe payload for the given specification of the helical compression spring is 4 N. At lower loads both theoretical and ANSYS results are within the range, but when load increases the ANSYS results are uniformly reduced compared to theoretical results. Christopher Prince Jerome[4] designed shock absorber and modified by reducing the diameter and stress analysis is performed. The stress value is lesser in our designed spring than in original which adds an advantage to our design. By comparing the results in the table we could analyse that our modified spring has reduced in weight and it is safe. Kumar B. Ravi[5] studied Microstructural analysis and hardness measurements did not show any degradation of the spring material. Surface corrosion product was analysed by XRD and SEM–EDS. Sulphur and chlorine bearing compounds were detected. Macrofractography of the fracture surface revealed beach marks, indicating fatigue as the mode of fracture and surface pits. It was established that the spring failed due to corrosion fatigue. Todinov M.T.[6] concluded that location of the fatigue crack origin is dependent upon the uniformity of the residual stress. If shot-peening is not uniform, the likely location of the fatigue crack origin is shifted towards regions with small magnitude of the residual compressive stress. For relatively wide range of loads, spring designs characterised by a large helix angle can tolerate a certain degree of non-uniformity of the residual stresses from shot peening since the likely fatigue crack origin for these springs is close to the best peened outermost part of the helix.

Kaiser et al. [7] reported on procedure and preliminary research results of long-term fatigue tests up to a number of 109 cycles on shot peened helical compression springs with two basic dimensions, made of three different spring materials (oil hardened and tempered SiCr- and SiCrV-alloy steel). Their result shows that the various spring types in test exhibit different fatigue properties and also different failure mechanisms in the VHCF regime. Pollanen et al. [8] proposed optimum design of the spring which minimize of wire volume, space restriction, desired spring rate, avoidance of surging frequency and achieving reliably long fatigue life. Their result was verified by using full 3D solid FEM analysis with MSC Nastran by which the stresses and also strains, deformations and natural frequencies and modes are obtained. Prawoto et al. [9] discussed about automotive suspension coil springs, their fundamental stress distribution, materials characteristic, manufacturing and common failures. An in depth discussion on the parameters influencing the quality of coil springs is also presented. This paper discussed several case studies of suspension spring failures. FEA of stress distributions around typical failure initiation sites are also presented. Berger and Kaiser [10] reported that the results of very high cycle fatigue tests on helical compression springs which respond to external compressive forces with torsional stresses. The results of these investigations can add an important contribution to the experience of fatigue behaviour in the very high cycle regime. Ronald E. Giachetti [11] stated that the material and manufacturing process selection problem is a multi-attribute decision making problem. These decisions are made during the preliminary design stages in an environment characterized by imprecise and uncertain requirements, parameters, and relationships.

III. METHODOLOGY

Ansys is for getting the required geometry read into the software. Analysis of existing spring deatils
Material : A286 Alloy, Rockwell hardness: C35-42, E = 200000Mpa, G = 71.7 X 103Mpa, Number of turns: 5.5, Wire Diameter: 6 mm, Free Length:- 90 mm

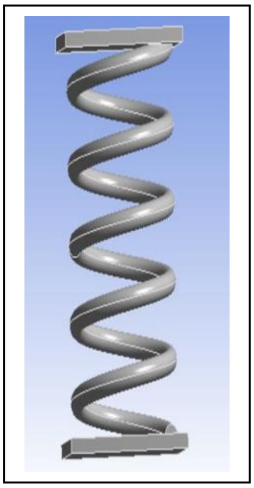


Figure 1:-Geometry

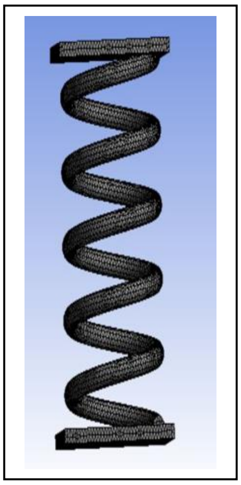


Figure 2:- Meshing

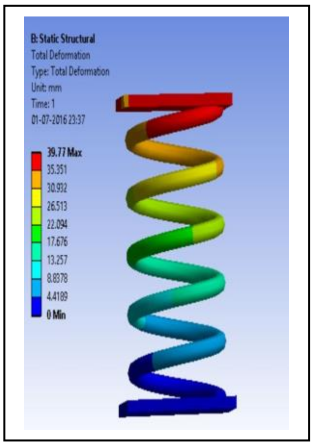


Figure 3:- Deformation 1000 N Load

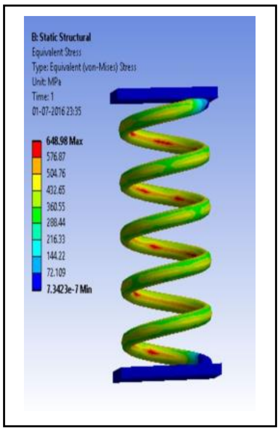
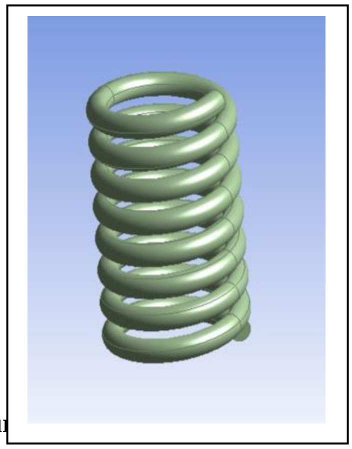


Figure 4:- Von Mises Stress 1000 N Load

Analysis of new spring details
Material : Chrome Vanadium, Rockwell hardness: C41-45, E = 207000Mpa, G = 79 X 103, Number of turns: 8
Wire Diameter: 8 mm



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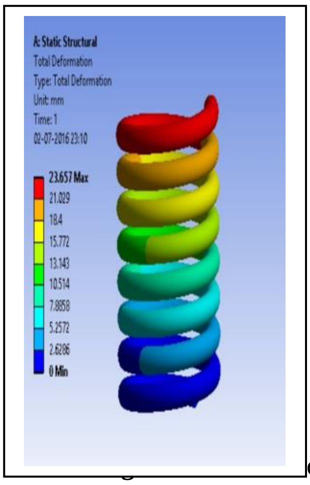

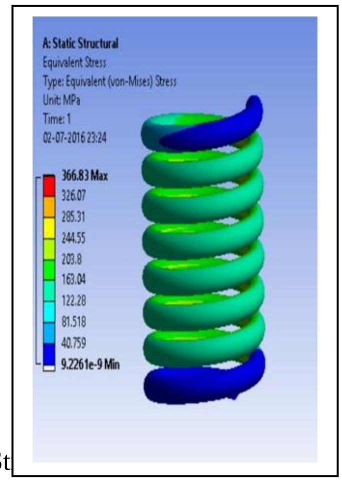

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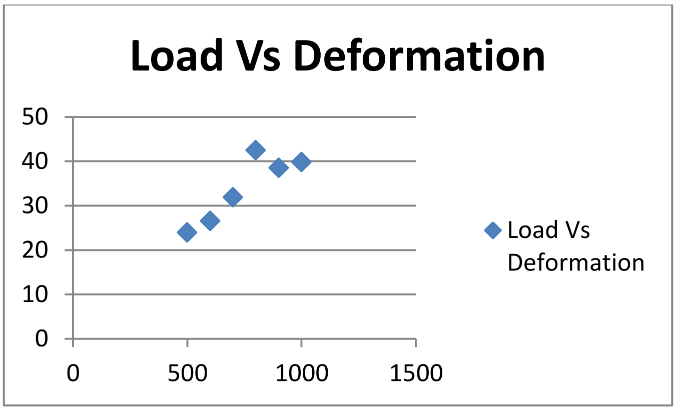
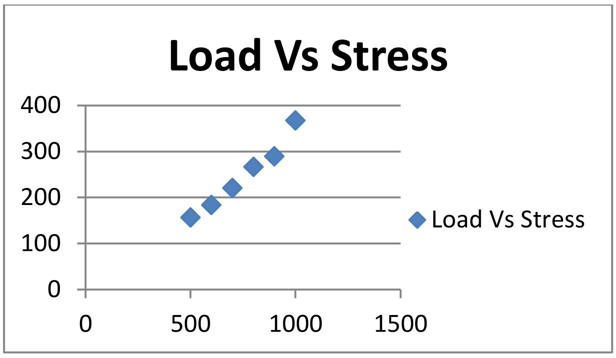
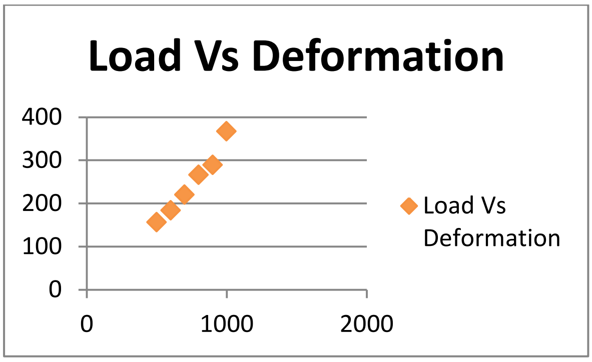
IV. RESULT AND DISCUSSION



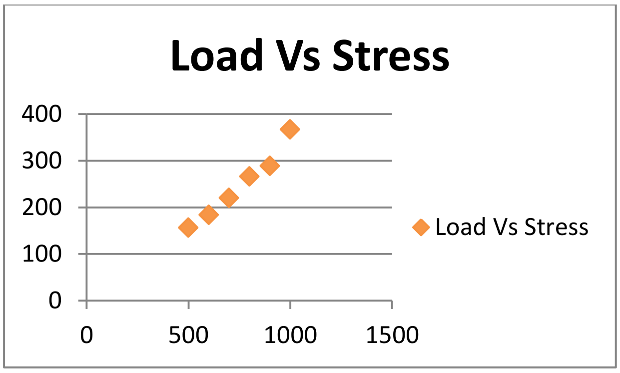
Graph 1: Load Vs. Deflection for Existing Spring



Graph 2: Load Vs. Stress for Existing Spring



Graph 3: Load Vs. Deflection for New Spring



Graph 4: Load Vs. Stress for New Spring

As the wire diameter increases the deflection and shear stress decreases. This happens due to the better spring index achievement for that application. As wire diameter increases the spring index decreases which provides better design of curvature of the spring and hence shear stresses decreases. But too low spring index results into design failure.

V. CONCLUDING REMARK

The above calculations shows that the deflection in the spring decreases with reduction in the shear stresses when change in certain parameters. The number of turns affects the deflection and shear stress adversely. As the number of turns increases the deflection decreases and shear stress also decreases. This effect is impossible without change in wire diameter as wire diameter has the influence on the deflection and the stresses. This happens due to the better spring index achievement.

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