STRESS ANALYSIS OF AN AUTOMOTIVE HELICAL SPRING

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Abstract

Design is very essential in engineering, in order to ascertain the good quality of services. The need to ascertain the strength of the helical spring used in automobile vehicles, led to this research. This was achieved through the aid of a design software, known as Autodesk Inventor and helped in the analysis of the designed material. . The material type selected for the spring, was galvanized steel and the necessary parameters were selected to suit the condition of the automotive. Helical compression springs have for long been in implementation in mechanical devices. Automotive industry employs compression springs in drivetrains and suspension devices, making it easy for the application of axial based on kinematic inputs. Hence, the research carried out, showed a result of the best loading condition for the helical spring and the factor safety in order to have a good design.

Keywords: *Autodesk, Automobile, Design, Engineering, Helical, Software, Springs*

Introduction

Helical compression springs have for long been in implementation in mechanical devices. Automotive industry employs compression springs in drivetrains and suspension devices, making it easy for the application of axial based on kinematic inputs. Hence, spring designers are able to tailor the shape and size of axial compression springs to meet the design requirements without accounting for non-negligible off-axis or multiaxial loading (Imaizumi, 1993). The stress snd strain analysis of helical compression has been a vital factor in machine design. The spring design involve helical spring, either tensile or compressive, to uniaxial loads. Multi-axial loading has recently become common with devices such as flexible shaft coupleings. The equivalent stress distribution in uniformly deformed springs is developed through static mechanical experiments and finite element analysis based solely upon visual inspection of the bent helix. Equivalent strains are also approximated, with satisfactory comparison and correlation between the predicted and observed strains (Keller, 2011). Particularly, numerical models were compared to existing analytical models that employ the critical plane approaches to predict multiaxial crack initiation (Vizcaya, 2006). Crack initiation locations can be predicted by locating regions of the largest stress (Scott, 2010).

Based on past research, when a spring is subjected to bending, the wire undergoes both torsion and flexure; the values of the flexural and torsional stresses are reported as one-half of the commonly accepted values in engineering texts (Wolansky, 2000). In order to have high and good resolution of stress distribution , two coils were extracted from the whole model and ansalysed seperately. These coils were meshed, making use of quadratic tetrahedral elements with nodes that were unconstrained in all degrees of freedom and from the model, the effective stress trajectories were extracted for comparison (Fakhreddine, 2005). ANSYS software was used to analyze an helical steel spring used in the rear suspension of light vehicles (Hou, 2004). The result obtained, showed the minimum and maximum weight that it is caoable of carrying given static external forceswithout failure. Stress analysis was also carried out on composite of an helical spring, in order to reduce the weight of the suspension spring and thereby to improve the overall performance of the vehicle (Mahadevan, 2018). Hence it was observed that, the weight of the suspension system is to be reduced by changing the helical spring material. Stress analysis in helical springs with closed ends coils machined from cylindrical sleeves showed that the smaller the relative radius of curvature, the bigger inequality of stress distribution in section and higher maximum stresses (Salwinski, 2006). The spring is expected to be linear, elastic material with a uniform symmetric cross section and the load imposed does not induce yielding of a material (Jiang, 2000).

METHODOLOGY

The software used for the simulation process was Autodesk Inventor design software. The material type selected for the spring, was galvanized steel with a yield strength of 207 MPa, young's modulus of 200GPa, poisson's ratio of 0.3 and shear modulus of 76.9231 GPa. It also had a mass of 0.001127178 kg, an area of 0.002555642 m^2 and a volume of 0.00000127178m^3. The spring was subjected to a load of magnitude 2000.00N, and a load vector of -1969.616N was applied towards the X-direction or horizontal axis, 338.808N was applied towards the Y-direction or vertical axis, and -76.31N was applied towards the Z-direction. The top faces or edges were selected, and a fixed constraint was applied at both ends. Then it was simulated to observe the behaviour under loading and constraints.

RESULTS

An animation of the behaviour of the spring, was obtained from the simulation process. The minimal to critical situation was expressed in terms of the colour each animation. When the material situation is critical, it shows orange display of the material. When it is moderate; it shows green colour display of the spring. When it has a very good condition, it displays sky blue colour of the spring. When it is in an excellent condition, it displays the blue colour.

Safety Factor of Helical Spring

Figure 1 shows a display of the strain safety factor of the helical spring; in such a way that the minimal and maximum points must not be exceeded in order for the spring not to reach a critical situation of failing. Hence it shows a minimum of 0.01 strain displacement to a maximum strain displacement of 15. The orange colour display shows that any strain displacement bellow 15 will be in an unsafe condition for the helical spring.

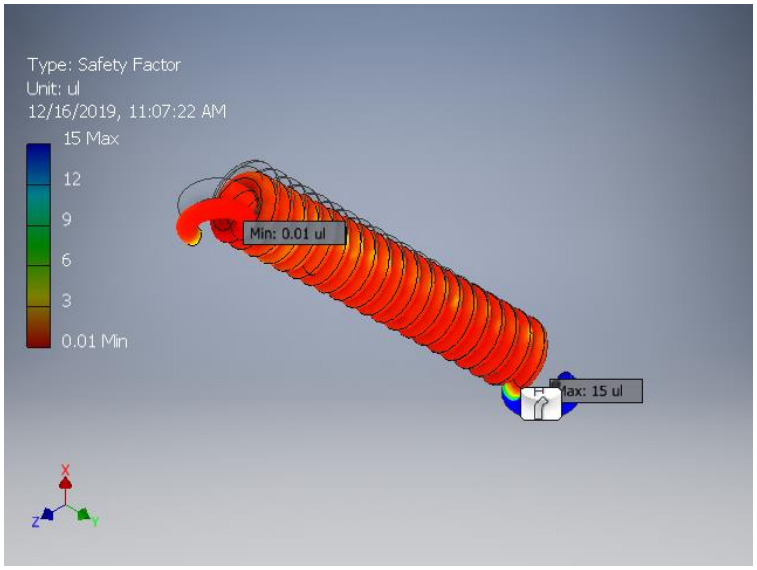


Figure 1:- Safety factor of the Helical Spring

Stress xx-Displacement of the Helical Spring

Figure 2 shows the safe condition of the helical spring which is displaced in the xx-axis. The blue colour animated shows an excellent condition of the helical spring. It showed a maximum stress of 45383MPa and a minimum of -16021MPa.

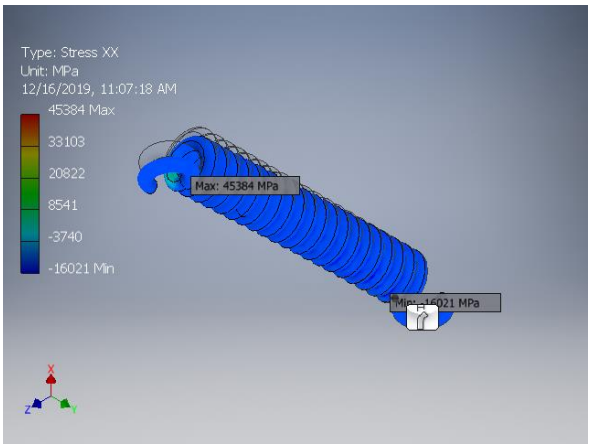


Figure 2:- Stress xx-Displacement of the Helical Spring

Stress xz-Displacement of the Helical Spring

Figure 3 shows the safe condition of the helical spring which is displaced in the xz-axis of the three dimensional body. The green colour animated shows a moderately good condition of the helical spring. It showed a maximum stress of 8014MPa and a minimum of -120MPa.

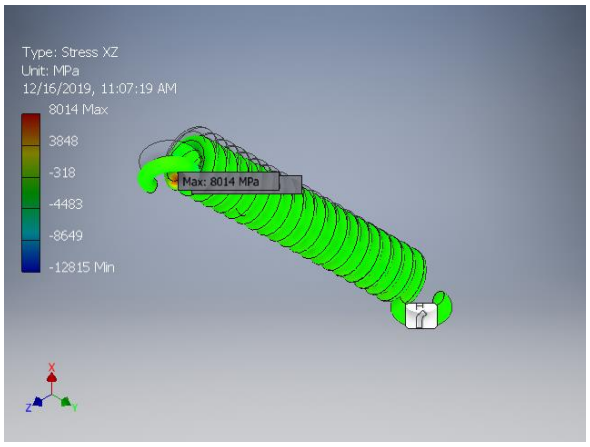


Figure 3:- Stress xz-Displacement of the helical spring

Stress yy-Displacement of the Helical Spring

Figure 4 shows the safe condition of the helical spring which is displaced in the xx-axis. The sky blue colour animated shows a very good condition of the helical spring in three dimensional form. It showed a maximum stress of 53871MPa and a minimum of -36294MPa.

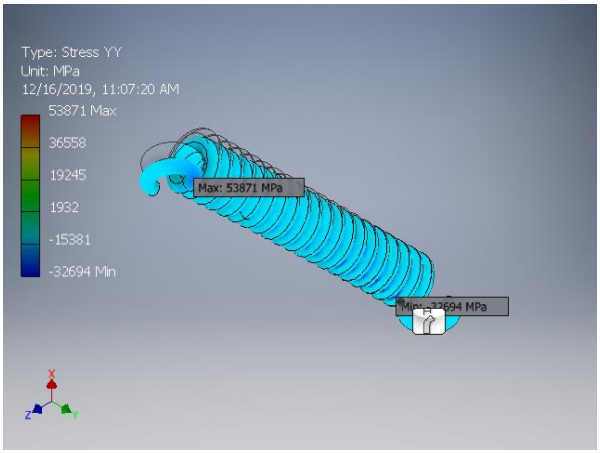


Figure 4:- Stress yy-Displacement of the Helical Spring

CONCLUSION

The research has proven its relevance in automotive, to ascertain the good quality and strength of the material to be used in engine part to avoid failure in service. The result of the analysis showed the maximum loads the material can withheld in operation and indeed will be a good criteria for the selection of the best design conditions for the production process.

REFERENCES

Fakhreddine, D. M. (2005). Finite Element Method for the Stress Analysis of Isotropic Cylindrical Helical Spring . *European Journal of mechanics and solids*, 1068-1078.

Hou, J. P. (2004). Evolution of the eye-end design of a composite helical springs for heavy axle loads. *Composite Structures*, 351-358.

Imaizumi, T. O. (1993). Shape of wire with a holeoptimization of the wire cross section of helical springs(study of shapes and outer bounderies). *JSME international Journal of Ser. C, Dynamics, Control, Robotics, Des. Mfg, 36*(4), 507-514.

Jiang, W. H. (2000). A Novel Finite Element Model for Helical Springs. *Finite Elements in Analysis & Design, 35*, 363-377.

Keller, S. G. (2011). Equivalent Stress and Strain Distribution in Hellical Compression Springs Subjected to Bending. *The Journal of Strain Analysis for Engineering Design*, 405-415.

Mahadevan, K. N. (2018). stress analysis of composite helical spring. *International journal of pure and applied mathematics*, 15855-15868.

Salwinski, J. K. (2006). stress analysis in helical springs with closed end coils machined from cylindrical sleeves. *Mechanics*, 169-171.

Scott, G. K. (2010). stress approximation technique for helical compression springs subjected to lateral loading. *ASME 2010 International Mechanical Engineering Congress & Exposition.* Vancouver: ASME.

Vizcaya, D. .. (2006). Multiaxial fatigue and failure analysis of helical compression springs. *Engineering Failure Analysis, 13*, 1303-1313.

Wolansky, E. B. (2000). Bending of helical springs. *Springs, 39*(2), 62-68.