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DESIGN AND ANALYSIS OF COMPRESSION SPRING USED IN AUTOMOTIVES

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ABSTRACT

Springs are mainly used as members absorbing shock energy as well as for restoring the initial position of a part upon displacement for initiating a given function. Compression springs are helical coil springs that resist a compressive force applied axially.Compression springs may be cylindrical, conical, tapered, concave or convex in shape. Consider the life of a race car nearly 10 years then the valve spring present in the car engine should withstand cyclic loading approximately infinite number of times.It has been reported by the warranty/ maintenance department that frequent complaints are being received over the failures of these springs well within their intended life span.For a high speed car, the 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.Therefore in this dissertation work, it is 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.

KEYWORDS:Compression spring,FEM Analysis,Static Structural Analysis

INTRODUCTION

A spring is defined as an elastic machine element, which deflects under the action of loading and returns to its original shape when the load is removed. It can take any shape and form depending upon its application. The important functions and applications of springs are as follows:

(1) Springs are used to absorb shocks and vibrations, e.g. vehicle suspension springs, railway buffer springs.

(2) Springs are used to store energy, e.g. springs used in clocks, toys, circuit breakers and starters

(3) Springs are used to measure the force e.g. springs used in weighing balances and scales.

(4) Springs are used to apply force and control motion.

LITERATURE REVIEW

• Heikki martikka ilkka pöllänen, the aim of this paper is to present results of using fundamental machine element design principles into re-designing optimally heavy duty springs used in terrain machinery and in industry. Background for this study is observation that conventionally designed helical springs did not have the expected long fatigue life time promised by standards.

• Reza Mirzaeifar a, Reginald DesRoches b, Arash Yavari b,a George W, In this paper, the pseudoelastic response of shape memory alloy (SMA) helical springs under axial force is studied both analytically and numerically.In the analytical solution two different approximations are considered.

• Koutaro Watanabe, Hideo Yamamoto, Yuichi Ito, Hisao Isobe, in order to solve this problem, a simplified calculation formula and a chart of the maximum shear stress and maximum principal stress that take initial pitch angles into consideration were devised using the design of experiments and FEM analysis.This paper is a summary of activities in the collaboration research committee of the Japan Society of Spring Engineers.

• Abdul Rahim Abu Talib, Aidy Ali, G. Goudah, Nur Azida Che Lah, A.F. Golestaneh,in this study, finite element models were developed to optimize the material and geometry of the composite elliptical spring based on the spring rate, log life and shear stress parameters. The influence of the ellipticity ratio on the performance of woven roving–wrapped composite elliptical springs was investigated both experimentall and numerically.Thestudy demonstrated that composite elliptical springs can be used for light and heavy trucks with substantial weight reduction.

• Y. Prawoto, M. Ikeda, S.K. Manville, A.Nishikawa, NHK International, this paper is a discussion 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

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also presented. Failure analyses of suspension coil springs were performed and summarized in this paper.

PROBLEM DEFINITION

Objective of the Work :

The Valve spring in a car engine needs to withstand high number of cyclic loading; typically infinite number of times. The replacement for the spring calls for downtime of the machine with high overheads due to idle time for maintenance.

The problem for the proposed work is to design a spring for lasting the needful number of cycles without failure. The same to be ensure through `Fatigue Analysis' using suitable FEA software for predicting the life.

So Objective or our Goal is to,

- Design the spring using Fatigue analysis for life enhancement of spring.
- To reduce the incidence of fatigue failure for the working life of the component.

Specification of Spring :

Specification	Dimension
Length	51.5
Outer Dia.	33
Inner Dia.	25
Pitch	8
Wire Dia.	4

Table.1: Specification of Spring

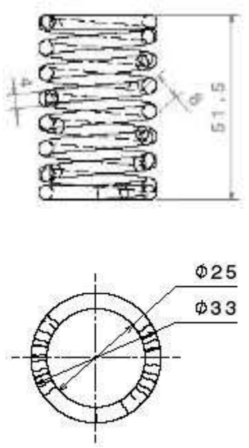

Figure.1 Original valve spring

Finite element analysis

The finite element method (FEM) (its practical application often known as finite element analysis (FEA)) is a numerical technique for finding approximate solution of partial differential equation (PDE) as well as of integral equations. Finite Element Analysis is a simulation technique which evaluates the behavior of components, equipment's and structures for various loading conditions including applied forces, pressures and temperatures. Thus, a complex engineering problem with non-standard shape and geometry can be solved using finite element analysis where a closed form solution is not available. The finite element analysis methods result in the stress distribution, displacements and reaction loads at supports etc. for the model

FEA for Original compression Spring :

CATIA V5 model :Spring model is drawn in CATIA V5 modeling software and saved as ".CATPart "

Figure.2 CATIA V5 spring model

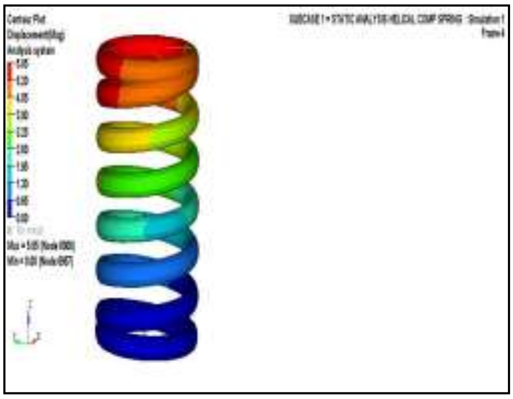

Figure.3 Maximum deflection of valve spring

Static structural analysis result:

A static structural analysis is carried out with the given loading condition in the NASTRAN solver. Preprocessing of helical compression spring is done by using HYPERMESH software. Where the 3D hexahedral mesh is done and the input deck is prepared for NASTRAN solver. The result is shown in the following,

RESULT AND DISCUSSION

Spring	Displacement mm	Shear Stress N/mm2	Von mess Stress N/mm2	Fatigue Life
Original	5.85	148.73	257.96	$6.5x10^4$
Modified I (by changing wire dia 3.5)	9.72	218.55	386.29	$3.10x10^3$
Modified II (by changing wire dia 4.5)	3.19	97.89	176.92	$4.32x10^3$
Modified III (by changing pitch 7)	6.03	145.05	257.29	$4.63x10^4$
Modified IV (by changing pitch 9)	4.93	144.15	268.44	$4.63x10^4$

1) Original spring has displacement 5.85 mm, shear stress 148.73 N/mm^2, von mises stress 257.96 N/mm^2 and fatigue life $6.56x10^4$.
2) Modified spring I (by changing wire diameter 3.5) has displacement 9.72 mm, shear stress 218.55 N/mm^2, von mises stress 386.29 N/mm^2 and fatigue life $3.10x10^3$.
3) Modified spring II (by changing wire diameter 4.5) has displacement 3.19 mm, shear stress 97.89 N/mm^2, von mises stress 176.92 N/mm^2 and fatigue life $4.32x10^5$.
4) Modified spring III (by changing pitch 7) has displacement 6.03 mm, shear stress 145.05 N/mm^2, von mises stress 257.29 N/mm^2 and fatigue life $4.63x10^4$.
5) Modified spring IV (by changing pitch 9) has displacement 4.93 mm, shear stress 144.15 N/mm^2, von mises stress 268.44 N/mm^2 and fatigue life $4.63x10^4$.
Out of these original and four modified spring, modified spring II (by changing wire diameter 4.5) gives the maximum fatigue life $4.32x10^5$. So modified spring II is the best suited spring for the valve spring as it has maximum fatigue life as compared to original and other three springs.
6) By making the experimentation of the original valve spring we get displacement as 5.93 mm and maximum cycles completed are 20 lac cycles still valve spring is not failed.

CONCLUSION

In this work we have done analysis on original spring and we got fatigue life $6.56x10^4$. Then 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 $4.32x10^5$ for modified spring II (by changing wire diameter 4.5). So we get 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.

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