DESIGN AND ANALYSIS OF VALVE SPRING USED INCOMMERCIAL VEHICLE

[1]Amit Singh, [2]Dr.Pradeep patil,[3]Vishal Wankhade,[4]Rahul Joshi

[1]ME student,[2]Associate Professor and HOD,[3]Assistant professor,[4]Assistant professor,
[1]Mechanical,
[1]Swami Vivekanand College ofEngineering,Indore, India

*Abstract :*Valve helical spring is a critical part in valve train of the IC engine. It absorbs energy while opening of the valves and release energy during closing of the valves. It is basically a compression types of helical spring used in commercial vehicles. Spring stiffness plays a vital role in design of helical valve spring. The primary part of designing of valve helical spring is to define the stiffness of spring as per requirement of engine design. Then todesign for space constraints, to design for high fatigue strength, and to design for reliability.

***Index Terms*– valve spring, stiffness, fatigue strength.**

I. INTRODUCTION

A reciprocating internal combustion engine uses valves to control air and fuel flow into and out of the cylinders. All cylinders have two valves, first intake valve and second exhaust valve. Intake valve opens just before the intake stroke start. In the petrol engine this allows the air-fuel mixture to enter the cylinder or in case of diesel engine it is only air is allows to enter into the cylinder. Exhaust valve open before the exhaust stroke begins start so that the burned gases can easily escape. The valves are operated by the valve train. We have two types of valve train used for a reciprocating engine depends on the engine ,first on is overhead camshaft with rocker arms, and second one is camshaft in a block with a pushrod. The valve train consists of valves, rocker arms, pushrods, and camshaft and helical springs and the combination of all. If we analysis the data we found the critical component in the valve train is helical spring. Valve springs plays an important role in the controlling of breathing of internal combustion engine, also provide a resisting force that returns displaced valves to their closed position and seal the combustion chamber during compression and combustion. Spring is used to store energy and to absorb shock, or to maintain a force between contacting surfaces. They are generally made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded.

II. METHODOLOGY

Firstly we take design requirement from the engine manufacturer, then we design the component using CAD software after that we performed CAE analysis using HYPERWORKS tools. If there is mismatch between the design requirements and results then make modification as per condition, then manufacture a final product. After that we perform some physical, then again perform fatigue life cycle analysis using CAE software for its sustainability.

III. DESIGN REQUIREMENTS

The reciprocating internal combustion engine is that engine in which the combustion is take place inside the engine cylinder. They are differentiate in manly two categories, first one is as per fuel is used and second one a type of stroke is used. Our research is fully based on four stroke engines in which valve train mechanism is used to control breathing of internal combustion engine. The valve train mechanism is consisting of those parts which actuate the inlet and exhaust valve at the required time with respect to position of piston and crankshaft. In this mechanism the most cruises part is helical spring, may be it is cheapest than all other parts but if this part is disturbed in functioning all engine work and efficiency will disturbed.so the focus of our research is design of valve spring there are some basic requirements followed.

Performance			
	Length of spring	On load	
Free length	58.5 mm	0	Newton's
Installed length	45.5mm	274 ± 1.4	Newton's
required length	41.9mm	850 ± 1.4	Newton's

IV. COMPUTER AIDED DESIGN

CAD stands for Computer-Aided Design; with the help of computer aided design software we can create new design, modified it or may analysis it also. There are so many cad software are used in industries currently like pro-e, cre-o, catia, solid works etc.CAD software are used to increase the productivity, improve the quality of design, improve communication between deign and requirement virtually. That is not only for mechanical engineering but it is also useful for other engineering's also. That's

software are very useful in automobile industries for making virtual prototype. In our case we use creo parametric 2.0 as a CAD software, and design our model as per given dimensions.

V. FINITE ELEMENT ANALYSIS

Generally we have three types of technique to solve any engineering problem, first one is Analytical method in which we reached to our solution through formulas and hand calculations, it is a classical approach , it is assumed to 100 % accurate , but this solution only applicable for simple problems . A second technique is numerical method; it is basically a mathematical presentation of a problem in which we use matrix to solve any engineering problem using CAE software, in this technique we does not need to make prototype , it is a simple technique in which we design and analysis our product using computer system. Using this technique we can easily test our product, or make changes according to requirements, but the results cannot be believed blindly, we need to verify our results by other any techniques. A third one technique is physical experiments, in this technique we need to make a real product prototype and test it, if the test will goes failed need to design and modify, and again test is so we can see it was very long term process and very costly also, along with that, we needed an experienced workers for this work. So finally we solved our problem through numerical method, the numerical method basically based on discretization to convert our model from infinite to finite one, assume we have a geometry have infinite number of points, so if we want to analysis it , we have to solve infinite number of equations means we can't achieve the exact solution of our problem. So with the help of discretization, divide our model into countable number of nodes and elements, at the end we got final and exact answer of our equation.

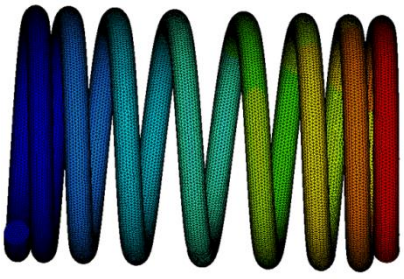
5.1 Meshing

Meshing is process to generate elements in our model or in other term to replace surface or volume by element generation. Basically it is a process of subdivision of geometry in to discrete geometry. There are four types of elements used in mesh generation according to cad model geometry. The followings are described bellowed.

1 D Element – 1 D element are used in one dimensional type of meshing, there are manly three type of 1D elements are used in industries and they are rod , bar and beam.
Rod- used where only axial load is applicable, no twisting in the elements like- civil truss members.
Bar- Used where element subjected to multiracial loading like- bolt joint, weld join etc.
Beam- It is same as bar but also support unsymmetrical cross section.

2 D Element – Two dimensional elements are used where two of the dimensions are very large as compared to third one. This type of mashing is used widely in the industries, because it is very simple to manage other than 3 D meshing. There are two types of elements are used in the industries, tria and quad elements.

3 D Element- This type of meshing is used where, there is an no possibility for 2D type of meshing, manly a geometry has variable thickness in shape and have to small curvatures, there are two types of 3D meshing is used in the industries, hex and tetra.
In our case we used tetra type of meshing because our geometry is in 3D , there is a no possibility of 2D meshing and has small curvatures , which need to be cover very carefully.

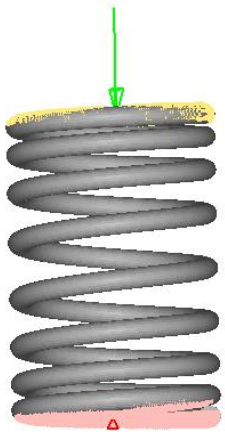


5.2 Meshing Quality

Modelling with Different types of element provides probability to introduce numerical incompatibilities in your model. Incompatibilities arise due to element degrees of freedom do not match at a common node. And mechanisms occur due to some forms of incompatibility or incomplete connectivity.

5.3 Boundary Condition

At our first condition we have to fix one end in all degree of freedom, and applied force at the other end for static structural analysis.

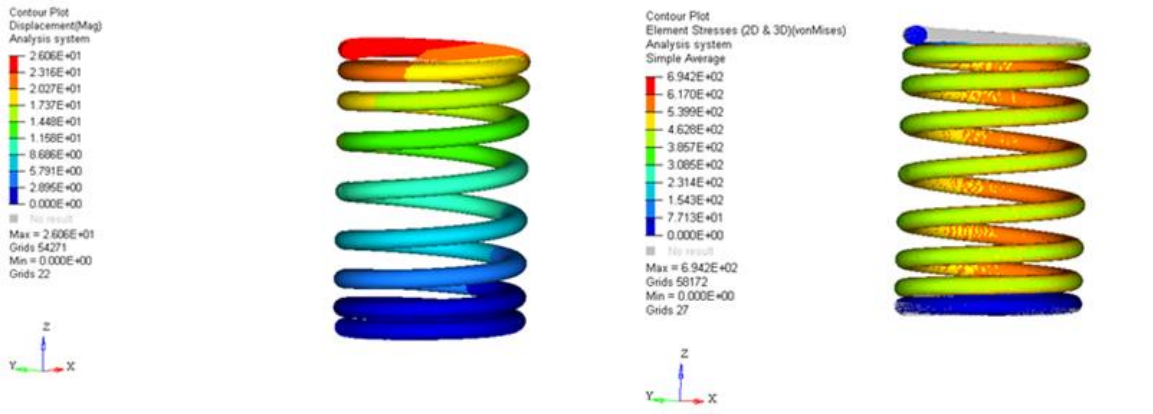


5.4 Analysis

We used optistruct as a solver for this equation, because optistruct considered as a implicit type of solver in which time steps are very large that's why it needs less time as compared to explicit type of solver. In industries mostly all type of static structural analysis solved by optistruct solver.

VI. FINITE ELEMENT ANALYSIS

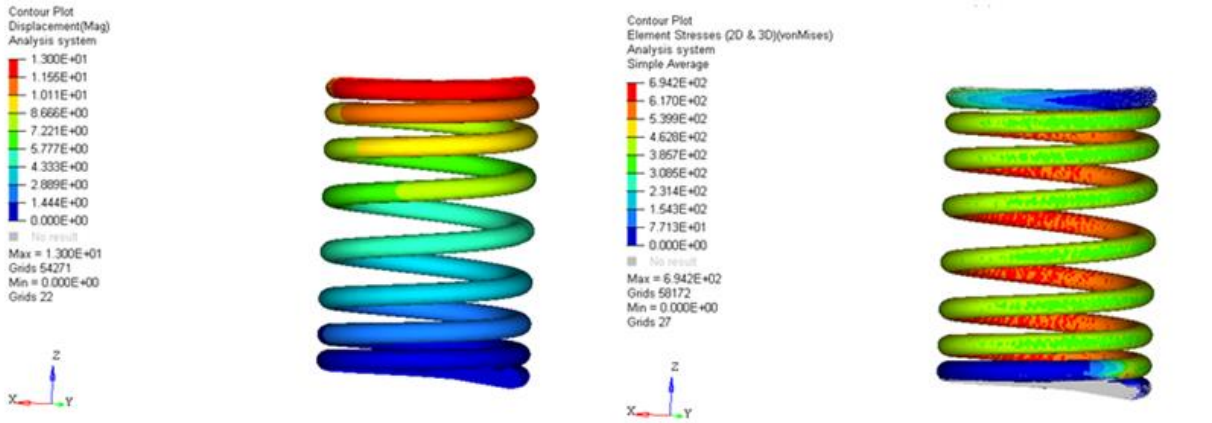
As the results shows the maximum displacement is 26.06mm and the maximum stress is 694.2 mp, that displacement is not meet the design requirement and it will failed with respect to safety of factor.



Maximum Displacement- 26.06mm
Maximum Stress -694.2 mpa

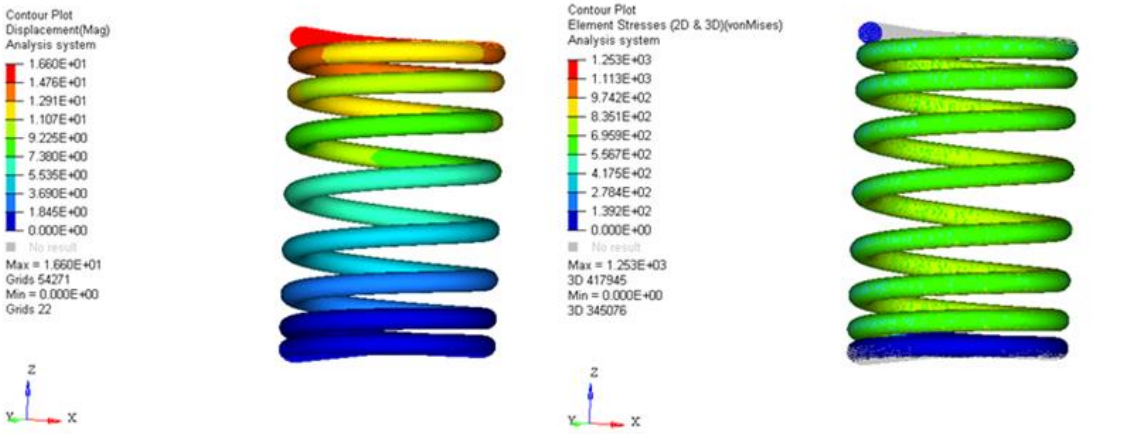
6.1 Comparison and modification

After applying installation load of 274 N we got displacement up to 26.06 and stress 694.2 mpa, we need to achieve first displacement is 13.0 mm and a permissible stress at the same load valve to meet our design requirement.
There are two ways to meet this design requirement; first one is to make modification in basic dimensions of the helical spring and second modification we can make in material properties of heliacal spring, we changed the elasticity of modular up to 4.21E+05 after that we got desired displacement and permissible stress.



Maximum Displacement- 13.0 mm
Maximum Stress - 694.2mpa

After applied load of 350 mpa required to operate valve opening.



Maximum Displacement- 16.60 mm
Maximum Stress - 1253mpa

VII. MANUFACTURING

Generally for manufacturing of valve spring we considered two methods low temperature and high temperature according to heat treatment after cooling. With the low temperature heat treatment, the spring is submitted to stress free annealing process after cooling in order to reduce internal stress; this is basically unwanted lowering component strength by this heat treatment. As the second one manly used in the industries to increase stiffness and ductility of spring material.in this process the spring is heated to a temperature above AC3 after cooling and then is quenched. Using this process we can control stiffness, ductility and internal stress of the spring.

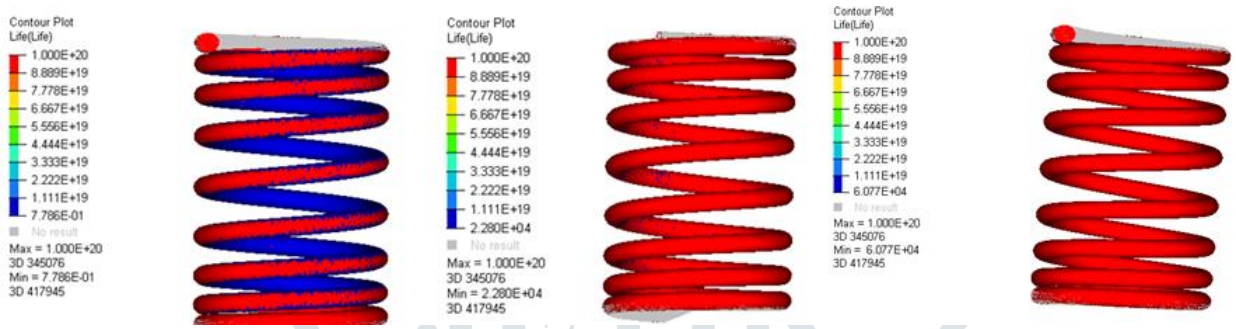
There are some conditions are described below according to stiffness –
CONDITION C - Results from heavy cold working (generally 45-50% reduction) of solution treated material.
CONDITION CH900- Heat Condition C material to 900 F (482 C), holds for 1 hour, air cool.
CONDITION A1750- After fabrication, heat solution treated material to 1750 F (955 C), hold for 10 minutes, cool rapidly to room temperature.
CONDITION R100- Within 1 hour of treating to Condition A1750, cool to -100 F (-73 C) and hold for 8 hours.
CONDITION RH 950- From Condition R100 material, heat to 950 F (510 C), hold for 90 minutes, air cool.
CONDITION T- After fabrication, heat to 1400 F (760 C) and hold for 90 minutes. Within 60 minutes, cool to 55 F (13 C), and hold for 1/2 hour.
CONDITION TH1050- from Condition T, heat to 1050 F (565 C) and hold for 90 minutes, air cool.

VIII. PHYSICAL TESTING

After manufacturing of valve helical spring, we test it to calibrate CAE results and physical results and also some other test to know the physical properties of modified material.Firstly we take we take a helical spring and measure its free length by verniercaliper. The measured value is 58.5.After measuring the free length, we are going to calibrate load v/s displacement value, and this can be tested by valve spring pressure testing machine.We applied the load of valve 274N and get the displacement value is 13.0 mm , then load for valve opening is 350N and get displacement of 16.6mm which is approximate same as our CAE results.

IX. FATIGUE LIFE TESTING

In the automobile industries valve spring subjected to high repeated load and are required to reliable for long period of time. The valve helical spring are designed for higher stress so the spring needs to be designed for higher fatigue strength.



There are three cases for fatigue life test first one is normal steel material with 310 mpa yield stress, when we test it of fatigue we got minimum life of spring is 7.786E-01 that is not useable for the engine, after changing the material property we again test fatigue and we got minimum life of spring is 2.280E+04, then in the third case we changed the diameter of wire from 4.21 to 6mm, and the minimum life of spring we got 6.077E+04 showed in blue region or other than this blue region all component is in red region , the life of red region is more than E+06 which is consider as infinite life , so our helical spring is in safe in both case.

X. CONCLUSION

May be considered the cost of valve helical spring is very low as compared to whole engine sub parts, but the failure of valve helical spring can cause major damages in the engine. And also as per the literature the performance and reliability of an engine is depends on valve spring performance, so that is not a negligible thing in the internal combustion engine , although it is most crucial part of the engine and valve train mechanism. We need to design the valve helical spring by predicting all cause of failure.In our research the spring failed to meet the basic design requirement, after upgrading the modules of elasticity up to 4.21E+05, we meet the design requirement and make the spring stiffer. But in real that is not so easy to gain a desired stiffness that can be gain by heat treatment process , the specific heat treatment we used in our material is heat to 1400 F (760 C) and hold for 90 minutes. Within 60 minutes, cool to 55 F (13 C), and hold for 1/2 hour. This design is also safe in fluctuation loading, have high fatigue strength, and have a maximum permissible stress up to 1260mpa.

XI. REFERENCES

I. YuxinPenga,b, ShilongWangb, JieZhoub, Song Leib," Structural design, numerical simulation and control system of a machine tool for stranded wire helical springs, Journal of Manufacturing Systems, 2012".

II. Sid Ali Kaoua, KamelTaibia, NaceraBenghanem, KrimoAzouaoui, Mohammed Azzaza,"Numerical modelling of twin helical spring under tensile loading Applied Mathematical Modelling, 2011.

III. William H. Skewis Failure Modes of Mechanical Springs Supported System Technology Corporation.

IV. Sudhakar V "FAILURE ANALYSIS OF AUTOMOBILE VALVE SPRING" Elsevier journals pg.no 513-514.

V. "A combined analytical, numerical, and experimental study of shape-memory-alloy helical springs" Reza Mirzaeifara, Reginald DesRochesb, ArashYavarib

VI. GT Conference: Valve Train Validation for New Engine Program- GT Conference: Valve Train Validation for New Engine Program

VII. H. Yamagata and O. Izumi: Nippon Kinzoku Gakkaishi, 44 (1990) 982 (in Japanese).

VIII. The valve spring- Chuo Spring Co., Ltd., Corporate Catalogue, (2003) (in Japanese).

IX. Failure analysis of an automobile valve spring, received, college of science of technology, central Michigan University, Mount Pleasant, MI 48859, USA.

X. Helical coil buckling mechanism for a stiff nanowire on an elastomeric substrate, Center for Applied Mechanics, State Key Laboratory for Strength and Vibration of Mechanical Structure, School of Aero space, Xi'an Jiao tong University, Xi'an 710049, China b Department of Mechanic a land Aero space Engineering, North Carolina State University, NC27695,USA c Columbia, Nano mechanics Research Center, Department of Earth and Environmental Engineering, Columbia University, New York, NY 10027,USA.

XI. Multiracial fatigue and failure analysis of helical compression springs Engineering Failure Analysis 13 (2006) 1303–1313.

XII. Bhandari V B. Design of machine elements.

XIII. BharathrinathGorakhnathKadam, P. H. Jain., Swapnil S. Kulkarni."Design and Analysis of Exhaust Valve spring used in Two wheeler" International Journal of Scientific Research and Management Studies Volume 1 Issue 10, pg: 307-316 .

XIV. CingaramKushal Chary, Dr. Sridara Reddy "DESIGN AND ANALYSIS OF HELICAL COMPRESSION SPRING OF IC ENGINE" International Advanced Research Journal in Science, Engineering and Technology Vol. 3, Issue 10, pg no 153-157.

XV. Syed Mujahid Husain and Siraj Sheikh "DESIGN AND ANALYSIS OF ROCKER ARM" International journal of mechanical engineering and robotics research.

XVI. GoliUdaya Kumar FAILURE ANALYSIS OF INTERNAL COMBUSTION ENGINE VALVES BY USING ANSYS American International Journal of Research in Science, Technology, Engineering &Mathemara, Reginald DesRochesb, ArashYavarib

XVII. Youlong Chen a, Yilun Liu a,n, Yuan Yan a, Yong Zhu b, Xi Chen "Helical coil buckling mechanism for a stiff nanowire on an elastomeric substrate"

XVIII. Chang-Hsuan Chiu a,*, Chung-Li Hwan b, Han-Shuin Tsai a, Wei-Ping Lee a "An experimental investigation into the mechanical behaviors of helical composite springs"

XIX. L. Del Llano-Vizcaya a, C. Rubio-Gonza´lez a,*, G. Mesmacque b, T. Cervantes-Herna´ndez a "Multiaxial fatigue and failure analysis of helical compression springs"