REVERSE ENGINEERING OF HELICAL COIL COMPRESSION SPRING IN CREO & ANSYS

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ABTRACT

In the present scenario due to cutting edge competition among industries, worldwide focus is more and more on enhancing the design feasibility, manufacturing process and selection of material of the product. This thesis is a sincere effort of applying the concept of reverse engineering which is being used by the designers in order to redesign the product to achieve several targets. Along with implementation of RE in this thesis attempt is also made to analyse different engineering materials. As per as reverse engineering is concerned a front suspension system of a automobile is taken and complete drawing/measurement is taken approximately and modeled in CREO design software .Further to analyse the model created it is meshed in ANSYS and analysis of coil spring is done by assignment of materials like structural , stainless and chromium vanadium steel .Overall intention of the thesis is to understand the concepts of reverse engineering , designing and analysis with knowledge of engineering materials by using suspension model .

Keywords: ***ANSYS & CREO, Helical Coil Spring, Modeling, Reverse Engineering, Simulation*.**

I. INTRODUCTION

1.1 Reverse Engineering

In situations like there may be a physical part/product without any technical details, such as drawings, bills-of-material, or without engineering data. Therefore it emerges the need of a technology to duplicate an existing part, subassembly of product, without drawings, documentation, or a computer model which is known as reverse engineering.RE is also known as the process of obtaining a geometric 3D CAD model from 3-D cloud points acquired by scanning and digitizing existing parts/products. The process of digitally capturing the physical entities/surfaces of components also referred as reverse engineering (RE). Reverse engineering digitalization into a CAD Model directly from product is to be done by several modes like Mechanical scanning ,Laser Techniques, Photographical Scanning .RE of mechanical parts includes acquiring 3D position data in the point cloud using laser scanners or computed tomography (CT)[8].In his findings Ngozi Sherry Ali May 2005[9] elaborated that Genex system does not need calibration and it is user friendly , while advantages of IVP Range scanner is it filtered ambient light more efficiently through lens along with detailed study of CMM , laser and structured lightening system was carried out by him . Reverse engineering is now one of the technologies that provide business benefits in shortening the product development cycle.

1.2 Role of CAD in Design and RE-Design

Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing.The engineering process is a long and complex one, and CAD modeling has had a profound effect on the process's development. First, a general idea must be made to solve a specific problem. Next, CAD modeling is used to work out the specifics of the model's design. At one time, this step would have involved several drafters making dozens of sketches and diagrams until a perfected model could be devised. Now, a single CAD file can be made, edited, and continually tweaked until the object is ready for production like in SOLIDWORKS, PROE/E, CREO, etc.

1.3 Finite Element Analysis

Finite element analysis (FEA) is a computerized method for simulating a product and analyse its reaction to real-world forces like vibration, heat, fluid flow, and other physical effects. Finite element analysis shows the result that how a model can behave when it undergone real working condition. It is called analysis later on in product development process FEA is used to predict effect on different parameters on the model.FEA works by breaking down a real object into a large number (thousands to hundreds of thousands) of finite elements mesh .Mathematical equations help predict the behavior of each element. A computer then adds up all the individual behavior to predict the behavior of the actual object.

1.4 Coil Springs

Coil springs have benefit in storing more energy along with compact in size .It is stressed during torsion in torsion bar with some bending .Life of the coil spring increased by shot peening their surface to induce compressive stresses and to reduce scratches in initial fatigue stresses. The first automotive coil spring was designed and manufactured for the Model-T Ford in 1910, where the suspension combined both the leaf spring and the coil spring. The earliest coil spring material had approximately a 500 M Pa design stress level (3). Coil spring materials have developed to the point where today it is common to have a coil spring with a design stress of around 1200 M Pa .In this thesis it is taken the case of a car which has Mc Pherson independent strut and coil springs.

II. LITERATURE REVIEW

Y. Prawoto et al. (3) basically reveals about the finite element analysis of coil springs basically analysed the coil in FEA and give result on the basis of several physical disorders in the selection of material like inclusion , imperfection , corrosion and decarburization s both Von Misses stress and max. Principal stress in all conditions.Ehsaaniyer(4).etal also focused on the importance of strong suspension system for better comfort and overall performance of ATV he modified analyzed and fabricated the wishbone suspension components on the Autodesk Inventor .He designed the sub parts according the dynamic loading conditions taking different values of Factor of safety .M T Todinov 99 (5) focused on improved design considerations of helical coil spring on keeping priority on fatigue stress .By taking large coil radius to wire radius ratio it is noticed on maximum principal stress on cyclic loading crack are seen on outer radius of spring. C.Berger, B.Kaiser 06 (6) author tested the si-cr alloyed spring wire on very high cycle fatigue test upto 10^8 cycles in order to study the mechanism of failure along with see new possible way to improve the strength of spring. Mehdi Bakshesh et al 2012 (7) in his study he elaborates about helical coil spring used in light vehicle and took several test on different composite material like E-glass /epoxy , Carbon /Epoxy ,Kevlar /Epoxy on finite elements and give new results . M. Sokovic, J. Kopac [10] in his paper tells about the concept of reverse engineering by elaborating the distinguished features of the technique. He elaborated the different salient features of the RE like the digitization, segmentation and data fitting. He shows how the formation of cloud points can be done by various techniques like CMM both touching probe and laser, also CMM in milling Machine, also the use of optical sensing by CCD cameras effectively .His studies focused on the implantation of RE in production process like in casting, production of tools, dies and moulds along with parts of automobile.K Pavan Kumar et al., 2013 (11) he proposed the static analysis of a coil spring negating the effect of inertia and damping .He analysed the two different material 60Si2MnA and chrome vanadium steel in which shear stresses so obtained are almost equal but there are considerable difference in deflection and less in 60Si2MnA .David Page et al.(12) University of Texas. given the concept of computer aided reverse engineering for that he considered the brake calliper and redesigned it by applying different techniques like Coordinate Measuring Machine, active stereo methods like continuous wave modulation , time of flight estimation and structured-light triangulation, Structured-light Range Imaging , scanner pipeline .Out of the various RE techniques he compares the advantages and disadvantages of each other .Also he focussed more on laser scanner and in which he found sheet-of-light scanner is the most suitable scanning technique for mesh generation . According to author processing pipeline is also used to convert object into 3D image which further processed into mesh generation.Niranjan Singh (13) in his review article published the design studies of mechanical springs by reviewing the different author’s research and in which he finally concluded some remarkable points for designing the springs. He elaborated the overall design process of spring based on the result obtained after analysis i.e. stress distribution analysis, maximum displacement and different mode of failure by applying different loading conditions .He also explained the different designing software like CATIA , PRO/E ,ANSYS , SOLIDWORKS which are deliberately using by the designers and research analysts for safely designing the springs .In his studies he told that fatigue stress , Shear stress , and displacement are much important in designing whereas shear stress and deflection equation is used for calculating the number of active turns and mean diameter in helical compression springs. Brita Pyttel et al (14) in the research publishes by the author consist of analysis of helical coil spring used in diesel engine fuel injection system further the investigation is done by applying very high fatigue cyclic behaviour .Finite element modelling of spring material is done in ABAQUS 6.10 with the element so opted for meshing are TET-C3D10 and TET-C3D4 .In his observation he analysed that stresses are oscillatory at the middle part which are responsible for rotational movement for spring in slots . Manish Dakhore et al june 13 (15) study of failures of primary helical springs of middle axle of locomotive both analytically and in simulation software .The analytical result so obtained are more than ultimate shear stresses of the material ***50CrV4*** and the stress is maximum in the middle axle inner spring. So he by increasing the bore diameter and some other parameters of the spring compensate the increased stress by reducing it to below the ultimate level. In the later part the spring is analysed in ANSYS10.0 by applying load of 9300 N for Nodal solution and Von mises stress. Prince Jerome Christopher J et al (16) they proposed an analysis of spring by varying coil diameter in PRO/E and ANSYS .In the research wire diameter of spring has been changed from present 6.7 mm to 7.5 mm. The loading constraints are one end of spring is fixed and end set free and the load so applied are in three different categories simply the weight of bike, bike with one person and bike with two person and the results so obtained are value of stress and deformation both get lowered with the increase of wire diameter .The element type is tetra mesh type .Tamas Varady et al (17) they proposed the reverse engineering of complex shapes. Firstly they discussed different data acquisition techniques like in optical methods triangulation, ranging, interferometry , structured lighting and image analysis all in order to locate a surface point relative to a reference plane in order to measure the geometry of model .Tactile methods and Coordinate Measuring Method represent another approach to shape capture. Acoustic method using the reflection of sound and magnetic field are also using for the surface measurement .They probably also focussed on problems on data acquisition like Calibration , Accuracy ,Accessibility, Occlusion, Fixturing ,Multiple views ,Noise and incomplete data ,Statistical distributions of parts , Surface finish .They also discussed the experimental studies in the direction of problems coming in the proper identification of surfaces of the model due to various edges , gaps , blends etc .They also discussed about segmentation techniques of model into subsets also for the free form surfaces like global approximating surfaces, curve network based surfaces, arbitrary topology surfaces and functionally decomposed surfaces .Later on with the increasing complexities of the surface and for proper segmentation in the paper discussion has also been done on Global approximating surface ,Curve network based surface techniques , Arbitrary topology surface and Functionally decomposed surface .Also there exist a problem during scanning the lower portion of the model does not get scanned so the concept of multiple view scanning emerges .Ling Sha *(ICCSIT 2011)* author has briefly explained the dynamic concept of reverse engineering with its playing a very crucial role in modern designing and manufacturing industry to stand against the innovative foreign products in order to survive in the rigorous competitive world. She has discussed the concept of physical revering of mechanical components using 3D digital measuring instrument and CAD also image and software reversing technology. In his studies she has taken the example of reversing the designing of Motorcycle in which she has done Scheme analysis, Structural Analysis, Material analysis , Dimension analysis , Process and precision analysis , Working performance analysis and Appearance modeling analysis.

III. METHODOLOGY

3.1 Redesigning In CREO & ANSYS

3.1.1 Design of Experiment

In order to understand the concept of Reverse Engineering and its implementation technique to achieve the targets of RE all this experiment and research is carried out. Under the concept of RE the whole thesis is divided into five steps:

1] Disassembly of Suspension System from the Car.

Measurement of individual parts by vernier callipers and screw gauge.

Draw neat sketch of individual parts approximately.

2] Modeling of parts done in CREO by using sketch and dimensions.

3] Analysis of Modeled parts carried out in ANSYS workbench.

3.1.2 Reverse Engineering Modules

It is the process of measuring of an object and then reconstructing its 3D model in design software. RE is done in academics for learning the key issues of a product and its material studies. Reverse engineering is the process of extracting knowledge or design information from anything man-made .For the complete design and analysis of a suspension system a front axle suspension system of a car is taken as specimen .Dimensions of each and every part of suspension is measured approximately in workshop by initially complete disassembly of suspension is carried out further each and every parts are measured accurately and precisely by vernier callipers and screw gauge .Along with dimensions rough drawing of all components are made on the basis of that an approximate assembly of suspension model is prepared in CREO software.

3.2 Reverse Engineering Includes Following Steps

3.2.1 Disassemble, Measurement and Sketching of Parts

In this first of all suspension system uninstalled from the car is disassembled in the workshop .After that complete measurement of all parts like spring free length, approximate pitch because it is force fitted, spring d & D , strut dia. , barrel inner and outer dia. ,fixed support dimension , spring holder etc .After measuring a rough drawing of all components in different views is prepared in paper and then finally it is modelled in CREO .

Image of Disassembled Suspension of a Car [MC Pherson]

3.2.2 Product Modeling:

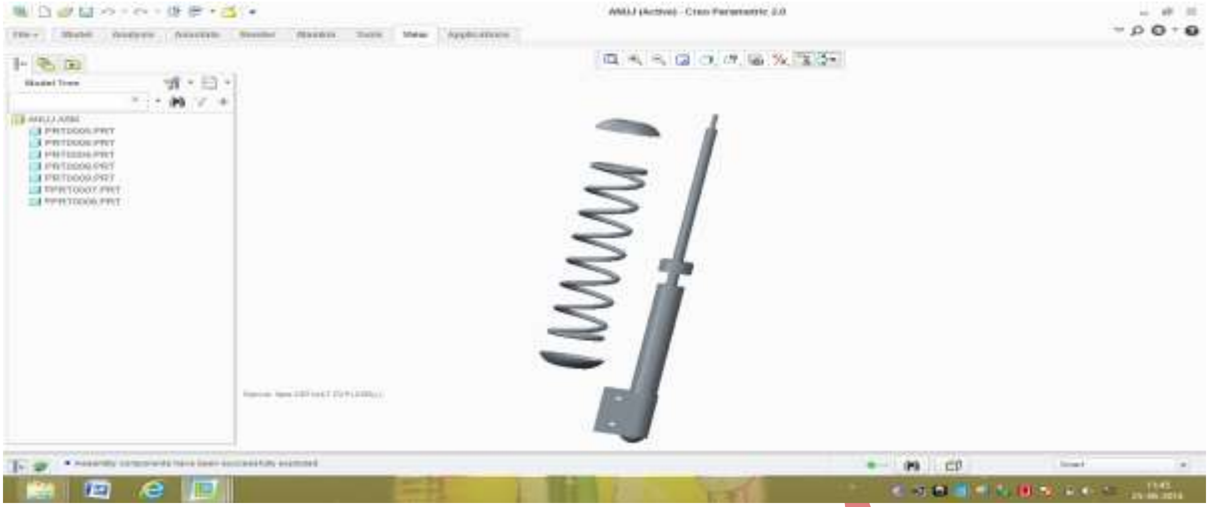
Parametric simulation of suspension system is done in CREO Parametric .Following is the assembly view of the suspension system designed in the CREO parametric software.

WEIGHT: - Since weight varies with density .Therefore changes with every material.

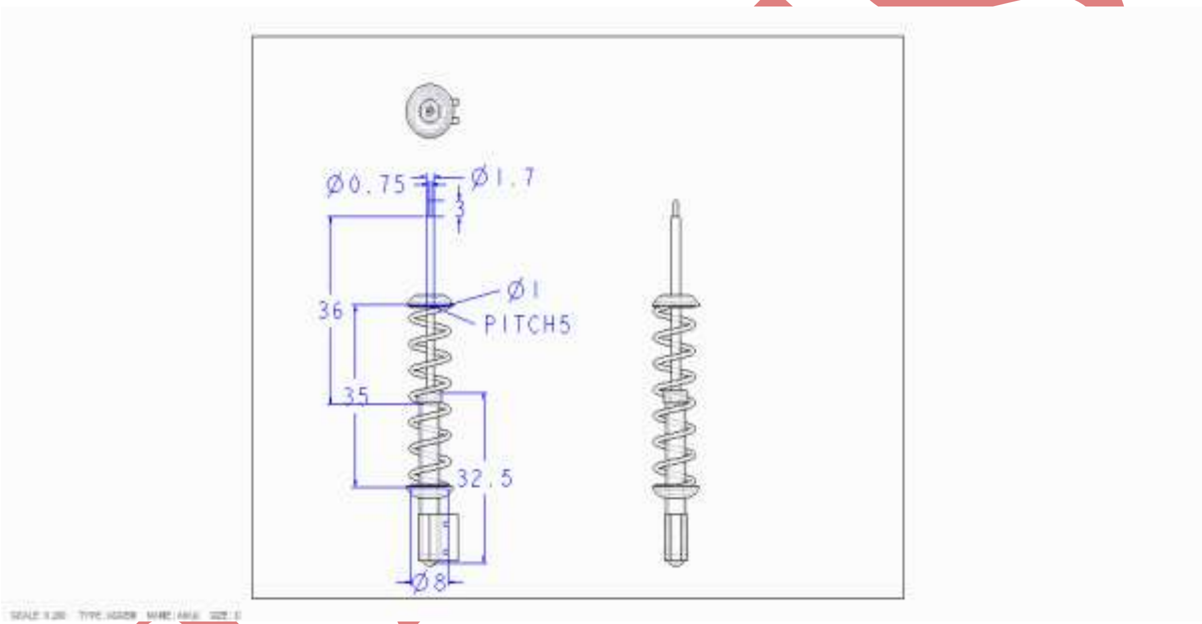
For Structural Steel: - 5.7504 Kg

For Cr- Vn Steel: - 5.7995 Kg

For Stainless Steel: - 5.7995 Kg



Exploded View



Detailed Drawing

3.2.3 Product Analysis:

Finite Element Analysis of Suspension Spring:

The suspension spring is analyzed using ANSYS workbench .Analysis of spring is done by using materials structural steel, stainless steel , chromium-vanadium alloy

3.2.4 Material Properties

Sr. No	Material	Poisson Ratio	Young Modulus (Pa)	Density(kg m^-3)	Ultimate Tensile Strength (Pa)
1.	Structural Steel	0.3	2.e+011	7850	4.6e+008
2.	Cr-Vn	0.3	2.0684e+011	7917	1.2878e+009 Pa
3.	Stainless steel	0.3	1.93e+011	7917	1.2983e+009

3.3 Stress Conditions Evolved By Applying Different Loads on Different Materials

3.3.1 Material: Structural Steel

For Load 2000 N

Von Mises stress

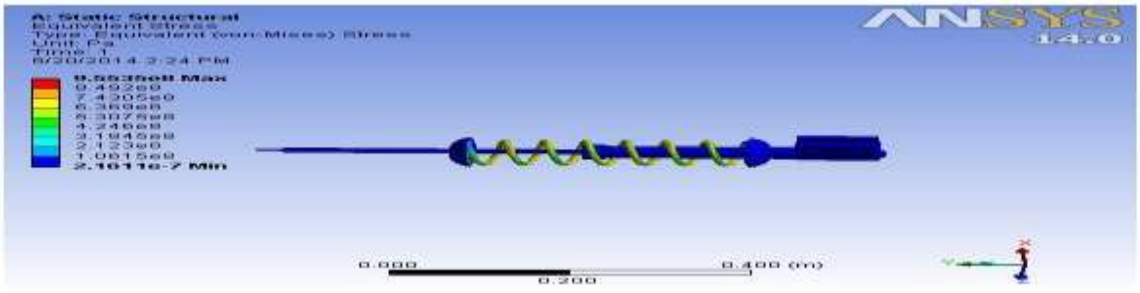


Figure: Von Mises Stress Plot

For Load 2500 N

Von Mises Stress

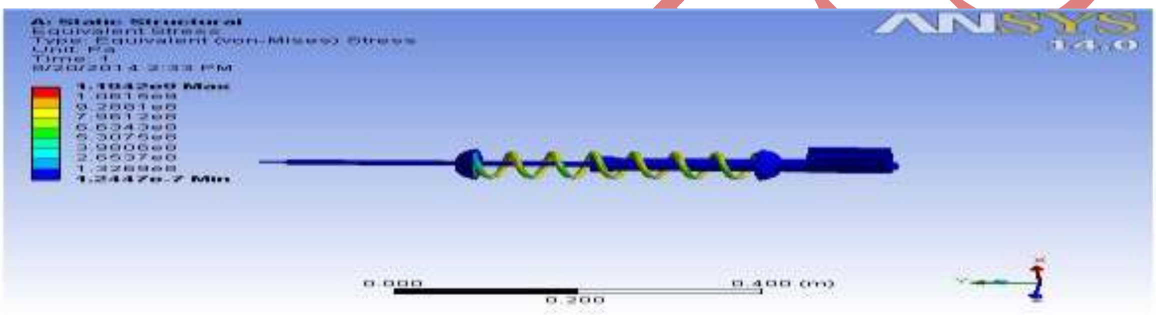


Figure: Von Mises Stress Plot

For Load 3000 N

Von Mises Stress

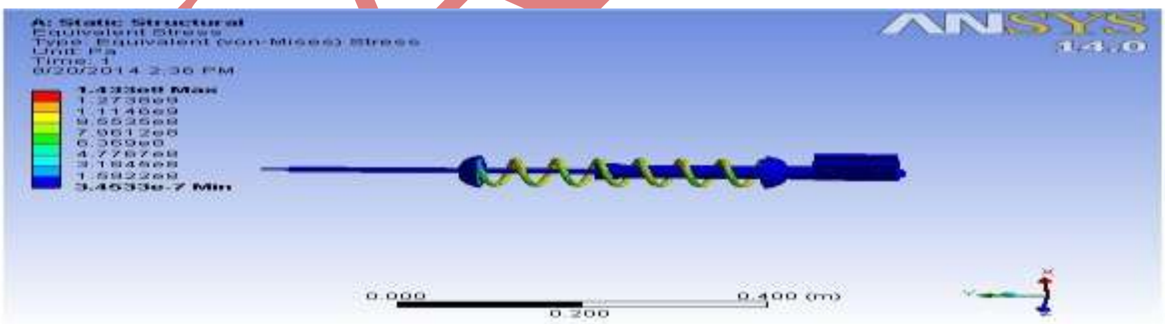


Figure: Von Mises Stress Plot

3.3.2 Material: Stainless Steel

For Load 2000 N

Von Mises Stress

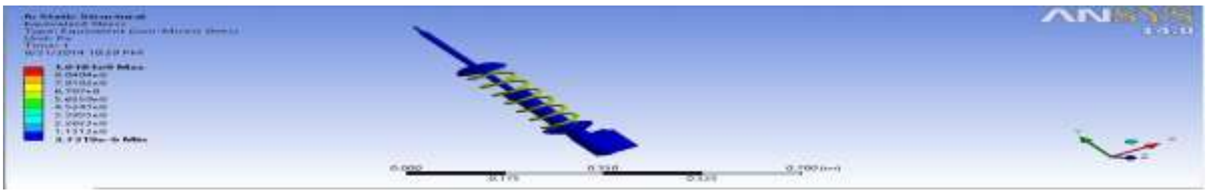


Figure: Von Mises Stress Plot

For Load 2500 N

Von Mises Stress

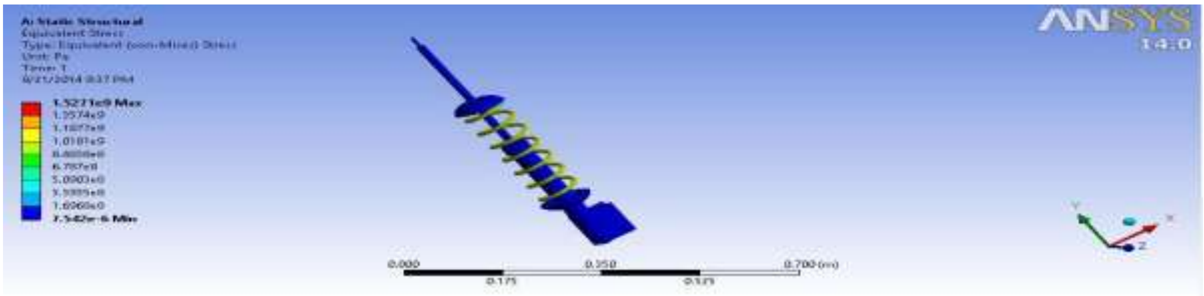


Figure: Von Mises Stress Plot

For Load 3000 N

Von Mises Stress

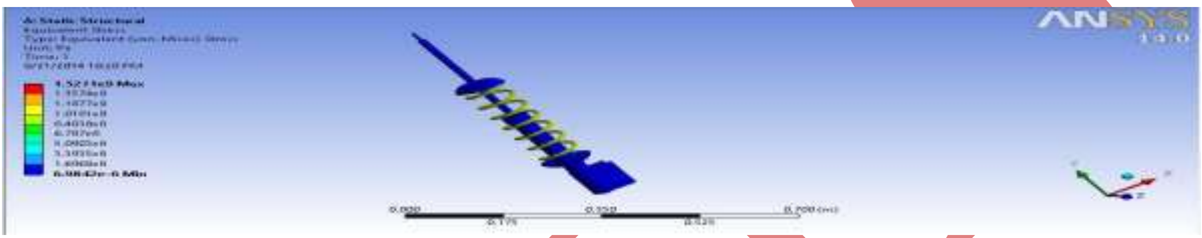


Figure: Von Mises Stress Plot

3.3.3 Material: Chromium Vanadium

For Load 2000 N

Von mises stress

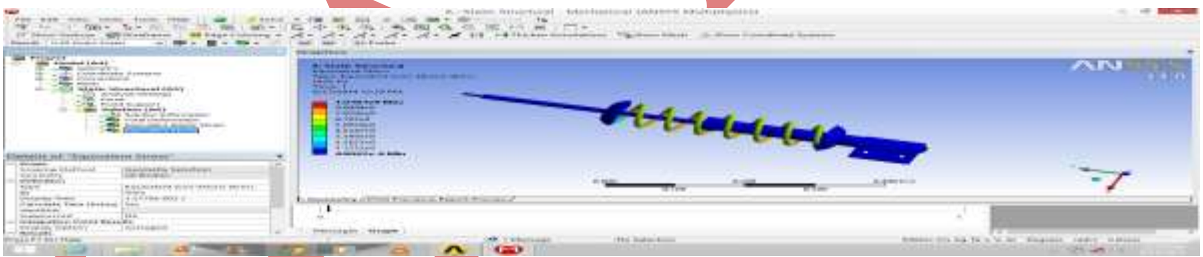


Figure: Von Mises Stress Plot

For Load 2500 N

Von Mises Stress

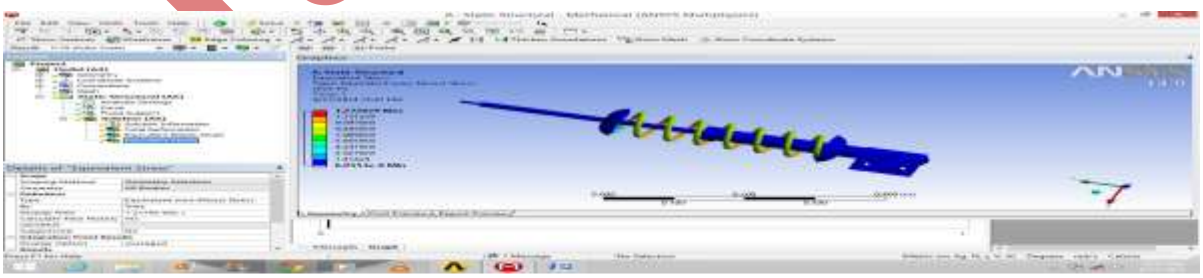


Figure: Von Mises Stress Plot

For Load 3000 N

Von Mises Stress

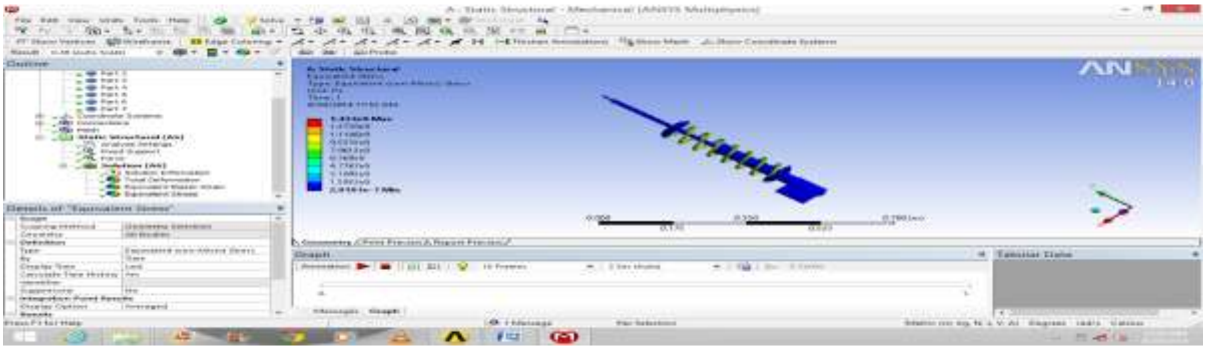


Figure: Von Mises Stress Plot

IV. RESULT OF ANALYSIS

The Static Analysis of spring coil has been done ignoring the inertia and damping effects.

For Structural Steel

Ultimate Tensile Strength = 4.6e+008 pa or 460 M Pa

Von Mises Stress

Load applied Vs maximum stress

Sr No.	Load in N	Max. Stress (Pa)
1.	2000	0.955*e^9 or 955 M pa
2.	2500	1.194*e^9 or 1194 M pa
3.	3000	1.43*e^9 or 1430 M Pa

For Total Deformation (m)

Load applied Vs Maximum Deflection

Sr.No	Load (N)	Max. Deflection
1.	2000	0.0647
2.	2500	0.0808
3.	3000	0.097

In the analysis we can see the deformation is maximum in the first coil of the spring. Since the loading is applied from the upper holder and top coil face the forces primarily.

For Stainless Steel:-

Ultimate Tensile Strength =1.2983e+009 pa or 1298 M Pa

Von Mises Stress

Load applied Vs maximum stress

Sr No.	Load in N	Max. Stress (Pa)
1.	2000	1.018 * e^9 or 1018 M Pa
2.	2500	1.52 * e^9 or 1527 M Pa
3.	3000	1.52 * e^9 or 1527 M Pa

For Total deformation (m)

Load applied Vs Maximum Deflection

Sr.No	Load (N)	Max. Deflection
1.	2000	.079
2.	2500	.119
3.	3000	.119

For Cr – Vn Steel:-

Ultimate Tensile Strength = 1.190e^+009 pa 1190 M Pa

Von Mises Stress

Load applied Vs maximum stress

Sr No.	Load in N	Max. Stress (Pa)
1.	2000	1.018 * e^9 or 1018 M Pa
2.	2500	1.27 * e^9 or 1270 M Pa
3.	3000	1.43 * e^9 or 1430 M Pa

For Total deformation (m)

Load applied Vs Maximum Deflection

Sr.No	Load (N)	Max. Deflection
1.	2000	.0742
2.	2500	.092
3.	3000	.093

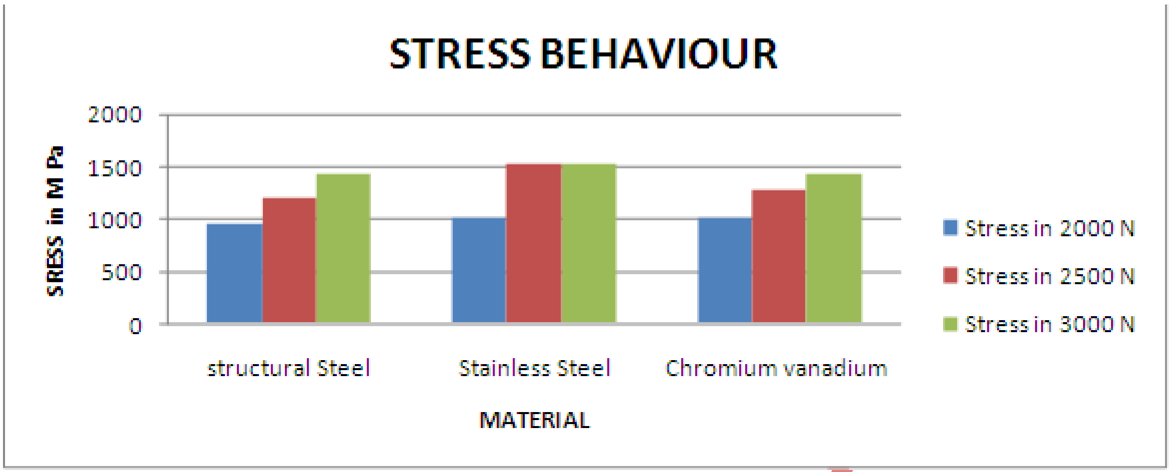
V.CONCLUSION

5.1 Stress Behaviour

Behaviour of different Material in loading is found out .Since in the design of spring damping and inertia effect is not considered and the loading is also static structural and which is not practically correct because spring undergoes various fatigue loading .It is very clear from the above results that stress generated in structural steel are very less as compared to other material but although ultimate strength of structural steel is 460 M Pa thus design is not safe in any of the above loading .We can see the results that stress growth is almost linear increment.

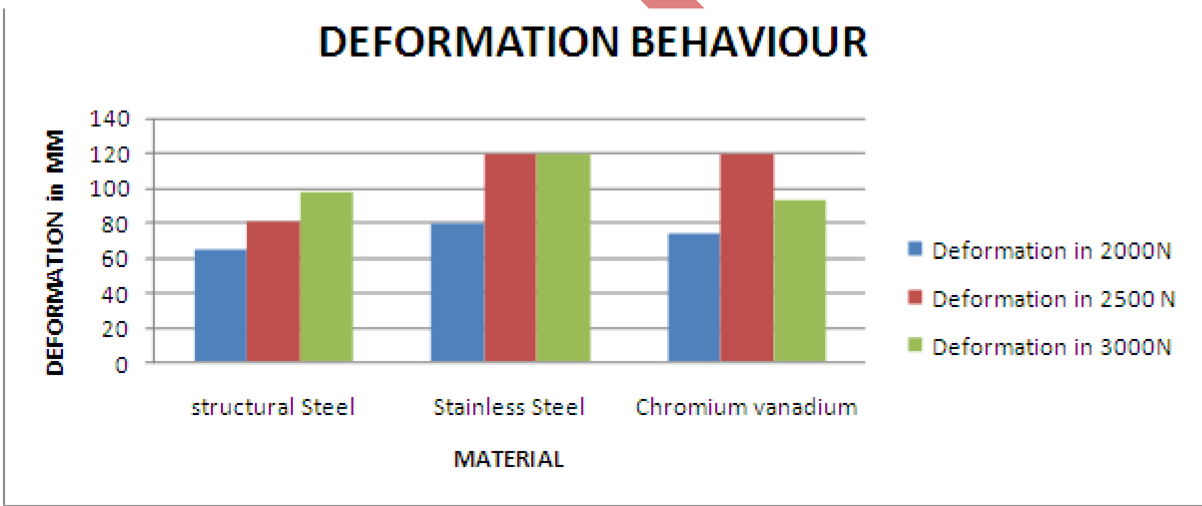
Stress generated in stainless steel in 2000N are safe as its ultimate strength is 1298 M pa but on further loading it raises to higher values which is not safe .In stainless Steel we can see the stress is constant in higher loading .

For 2000N load design of spring is safe in chromium vanadium because ultimate strength is 1190 M pa.So it means in my findings it is clear that structural steel is not suitable material for springs whereas stainless steel & cr- vn steel are more suitable materials due to their high ultimate strength .



5.2 Deformation Behaviour

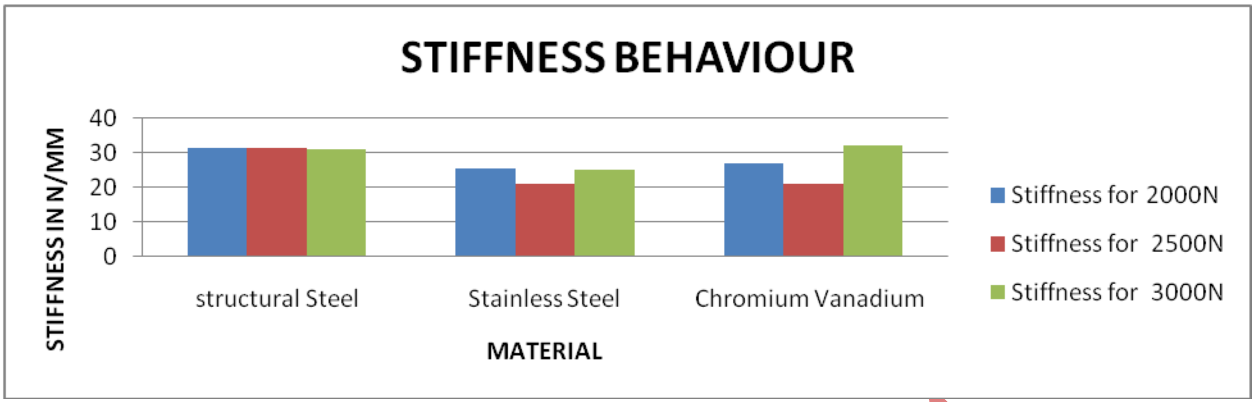
We can see the maximum deformation of structural steel is 79 mm which is not most probably suitable for spring material because spring required deformation due to its working conditions.We can see the maximum deformation is 119 mm in stainless steel and it is further constant.In chromium vanadium steel maximum deformation shows in 2500 N load which is almost equal to stainless steel loading. By seeing the results of deformation we can easily estimate that in 2000 N load which is safe for design in stainless steel and CR-VN the deformation for CR-VN is maximum .So researchers can take the result for better implementation in spring industries.



Graph Shows Variation of Stress with Load in Materials

5.3 Stiffness Behaviour

It is clear from the above results that average stiffness of the spring in Stainless steel is less in different loading conditions. For the spring material less stiffness is required.



Graph shows Variation of Stiffness with load in Materials

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