MODIFICATION, ANALYSIS AND COMPARISON OF ELLIPTICAL LEAF SPRING USING CATIA V5 R21

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Abstract:

The stress throughout this project is on the applying of laptop computer aided analysis exploitation finite half plan. The half chosen for Analysis is associate degree elliptical spring that's a self-propelled half accustomed engross vibrations prompted throughout the motion of automotive. It collectively turns as a structure to repairs vertical loading attributable to the load of the vehicle and payload. The spring, that we've a bent to unit of measurement analyzing, could also be a customized spring used by Mahindra once analyzing this predesigned model some modifications unit of measurement created among the modal and adjusted model is another time analyzed and worked to induce higher results. This spring is supposed in-tuned vital jerks and vibrations reduced throughout real operative conditions. In analysis [*fr1] the finite a part of elliptical spring is sculptural exploitation CATIA V5. Applicable boundary conditions, material properties and tons of unit of measurement applied selected as per supposed performance. The resultant deformation and stresses obtained unit of measurement analyzed. We are able to conjointly modification the dimension. When ever-changing the dimension issues of safety are modification.

***Keywords*—Leaf Springs; Elliptical leaf springs;Simulation of Leaf spring; Static analysisof Leaf Spring in CATIA V5**

1. Introduction

Multi-leaf springs area unit commonly used for automobile and rail road suspension. they are created from series of plane plates, generally of semi - elliptical profile. The leaves area unit command on by the utilization of two U-bolts and a center clip. Retreat clips area unit provided to stay up the leaves in position and avoid tangential variation of the plates throughout the course of action. The longest leaf, called the master leaf, is perverted at every ends to form the spring eye. At the center, the spring is getting ready to the shaft of the vehicle. These supplementary full-length leaves area unit positioned between the master leaf and so the graduated-length leaves. the additional full-length leaves area unit provided to support the crosswise shear force. An up to date execution is that the parabolic spring. This vogue is characterized by fewer leaves whose thickness varies from center to ends following a parabolic curve. throughout this vogue, inter-leaf friction is surplus, and so there is entirely contact among the springs at the ends and at the center where the shaft is connected. Spacers forestall contact at totally different points. apart from weight saving, the foremost advantage of parabolic springs is their higher flexibility that interprets into vehicle ride quality that approaches that of coil springs. There's a trade-off among the range of reduced load carrying capability, however. The characteristic of parabolic springs is best riding comfort and not as "stiff" as typical "multi-leaf springs". it's wide utilized in buses for higher comfort. an additional development by British GKN company and by Chevrolet with the military vehicle amongst others is that the move to composite plastic leaf springs.

1.2 PROBLEM FORMULATION

An elliptical spring finds thorough applications altogether industries. A CAD model of elliptical spring is generated in CATIA V-5, the model is then analyzed on CATIA work table itself. Load is applied at the ends of the entire length leaves of elliptical spring. The analysis procedure is performed in two phases specifically

(i) Victimization steel for elliptical spring, load is applied at eyes of full length leaves and stopping the rigid body motion of all faces.

(ii) The frequency analysis of the model is then generated to look out the numerous operational conditions.

Load at the ends of full length leaf cause stress and deformation in elliptical spring so a structural analysis of same has been applied and conjointly the strain, strain and deformation square measure found. The results unit of measurement extra accustomed understand the foremost operational frequency of the spring. Then load is maintained constant at 6700 N. Then results unit of measurement compared to work out that that one is healthier in same conditions. FEM model of the elliptical spring has been developed in CATIA V-5 supported its vogue.

2. LITERATURE REVIEW

Farah "developed code for automating the planning analysis of spring eye. The aim of the event of this code is utilized for evaluating the implications of fashion parameters on spring characteristics. The program consists of program that consists in Visual Basic 5.0 with ACCESS information for variety of leaves, includes the

forms for information input and result output procedures. The user starts the applying by specifying his computer file joined of the following (span length, vehicle load, Tensile stress, Bending stress and cut stress), by practice the information, the results area unit calculated" [2].

Saini "studied the finite half analysis of spring victimization ANSYS. Until recently the primary analysis technique had been hand calculations and empirical curves. New laptop advances have created finite half analysis a wise tool among the study of Leaf springs. Having tested three dimensional, regular and axis-symmetric models, the preliminary conclusion was that finite half analysis may be a significantly powerful tool once used properly. Reckoning on the required solutions, there unit utterly other ways that give faster run times and fewer error. The two recommended ways that confined regular models victimization shell elements and axis-symmetric models victimization solid elements" [3].

Sugiyama "developed model of leaf springs to be used inside the possibility of multibody vehicle systems. inside the spring model developed throughout this investigation, the distributed inertia and stiffness of the leaves of the spring unit modelled victimization the finite part floating frame of reference formulation that accounts for the impact of the nonlinear dynamic coupling between the finite rotations and so the leaf deformation" [4].

Scuracchio "showed the advance of fatigue life in components subjected to cyclic stresses by application of mechanical surface treatment processes is already acknowledged, every at intervals the trade and at intervals the academy. Managing automotive springs, the shot peening technique becomes a necessary step in manufacturing. At intervals the case of leaf springs, however, a scientific investigation of the results of shot peening on fatigue life continues to be required. Their work improves the knowledge in manufacturing of spring and thus the role of shot peening for vehicles, through analysing the residual stresses victimization X-ray diffraction and fatigue tests on a series of samples subjected to ten all completely different peening schedules. Residual stresses induced by shot peening in larger depths do not have any influence on the sample's fatigue life" [5].

Koppula "compared the models of spring made of steel and composites that are designed on CATIA and tested on ANSYS, it's tested to be really effective they collectively performed that a comparative study has been created between composite and steel spring with regard to weight, worth and strength The analytical results were compared with FEA and so the results show smart agreement with take a glance at results." [6].

Narayana "concluded that there is inflated interest at intervals the replacement of steel spring with building material composite spring due to high strength to weight relation and concluded that the E-Glass/Epoxy mono composite spring trade which they were sculptured and analyzed to exchange the quality steel spring at intervals the system of cars. He put together concluded that A mono composite spring for the transport system once designed practice E-Glass/Epoxy with the target of diminution of weight of the spring subjected to constraints like quite loading and laminate thickness and ply orientation angle" [7].

Baviskar "presents a general study for vogue and analysis of spring. The suspension that is utilized during a vehicle expressively affects the vibration characteristics similarly as ride comfort and stability behavior of automotive. They to boot everywhere that the composite spring is lighter than commonplace steel spring with analogous vogue specifications but not constantly are cost- effective over their steel corresponding leaf springs. Composite materials possess heaps of elastic strain energy storage capability and have high strength to weight relation compared with those of steel material. Therefore, they briefly everywhere that the composite springs can effectively replace the prevailing steel spring in cars" [8].

Arora "determined higher eye end type of single spring utilized in light-weight motorcar. This work was to carry out CAD analysis of typical single leaf of a spring with smart vogue problems and boundary conditions and every one over that as a result of the minimum issue of safety is reduced by 13.1% simply just in case} of casted eye it's everywhere that the realm of minimum issue of safety will fail earlier in case of casted eye. Thence casted eye is not recommended. They in addition everywhere that it's everywhere that CAE tools provides a worth effective and fewer long answer as compared with the experimental testing but the results might vary at intervals the such vary" [9].

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"The models presented here square measure safe and at a lower place permissible limit of stresses.

The springs square measure every safe for working at speed of free vibration up to 283 cycles/second, which can never be seen in any spring at a lower place operative condition. Therefore the spring is safe.

Depending on volume the burden of steel reduction is seen here.

The results obtained square measure well in agreement with the required results.

Leaf springs with further thickness and fewer dimension square measure safer as compared to the spring with less thickness and extra dimension" [10].

Finite Element Modeling

The finite part technique may be a numerical technique for determination engineering and mathematical physics problems. The quality use of this system is to unravel the

problems at intervals the sector of stress analysis, heat transfer, fluid flow, mass transfer and magnetic force. This system is during a position to unravel physical problems involving subtle geometrics, loadings and material properties that can't be solved by analytical technique. Throughout this system, the domain throughout that the analysis to be assigned is split into smaller bodies or unit named as finite components. The properties of each reasonably finite part is obtained and assembled on and solved as whole to induce answer. Supported application, {the problems the issues} unit classified into structural and non-structural issues. Finite part Analysis, development of structures ought to be supported hand calculations entirely. For sophisticated structures, the simplifying assumptions required to make any calculations come-at-able can lead to a conservative and vital vogue. A considerable issue of noises can continue whether or not or not the structure area unit attending to be adequate for all vogue a whole bunch. In structural problems, displacement at each nodal purpose is obtained. Victimization these displacement solutions, stress and strain in each part unit determined. Victimization these nodal values, properties like heat flux, fluid flow etc., for each part is ready. Since huge computations unit to be assigned, this system desires high-speed computation facility with huge memory. Finite part technique and Finite part analysis unit all and same term. But term FEA may be a heap of common in industries whereas FEM is known at universities.

Proposed Work

The first step is to prepare a CAD Model of elliptical spring in CATIA V-5. Among the gift work results have compared for two changed dimensions of steel model. CAD modeling of the spring has been generated victimization CATIA V-5 code. Then the model is altered for weight saving and better performance.

3.1 Comparison table for design data

Specifications		
	Original Modal	Edited Model
Total length of spring	1121	1121
No. of full length leaves	2	2
No. of graduated leaves	8	8
Thickness of leaves	7 mm	7.5 mm
Width of leaf spring	55 mm	45 mm
Maximum load on spring	6700 N	6700 N
FOS	1.4	1.4

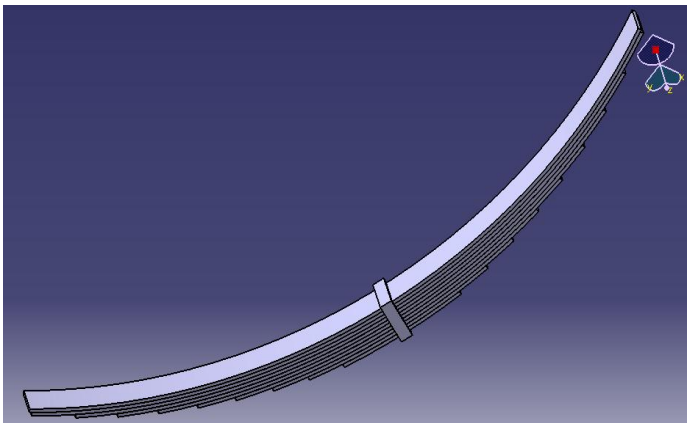
Table-1 Specifications

3.2 Design parameters of leaf spring

Leaf Number	Full Leaf Length (mm)	Radius of curvature (mm) for original modal	Radius of curvature (mm) for edited modal
1	1121	962.11	962.11
2	1121	968.11	968.61
3	1008	974.11	975.11
4	895	980.11	981.61
5	781	986.11	988.11
6	668	992.11	994.61
7	555	998.11	1001.11
8	441	1004.11	1007.61
9	328	1010.11	1014.11
10	215	1016.11	1020.61

Table-2 Design Parameters of steel Leaf spring

Here is the Drawing of the model in CATIA V5.



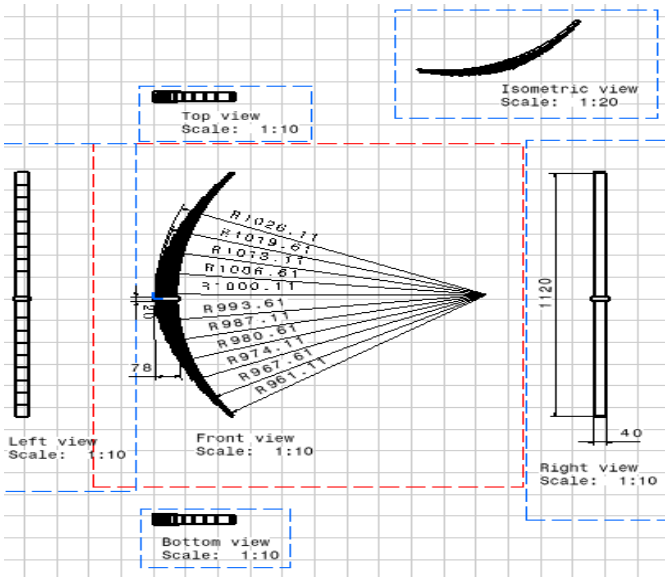


Figure-1 drawing of leaf spring of model

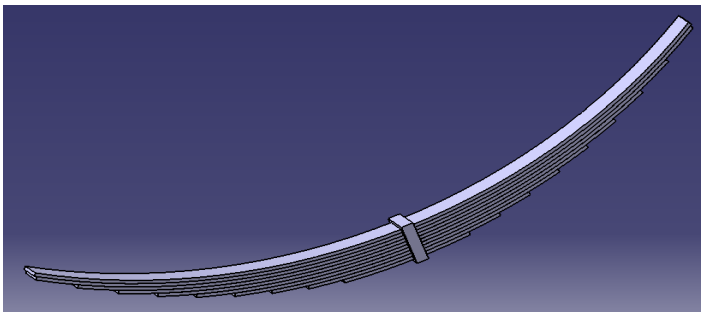


Figure-2 model of leaf spring

Model is saved in the CATAssembly format. Finally the model imported in Generative structure analysis Workbench for further analysis. Static Analysis is done on the model.

4. Material properties of material of leaf spring

Property	Structural steel
Young's Modulus,(E)	$2*10^5$ MPa
Poisson's Ratio	0.266
Tensile Yield strength	250 MPa
Compressive yield strength	250 MPa
Density	7850 kg/m^3
Behavior	Isotropic

Table-3 Material properties of structural steel for Leaf Spring

5. Mesh generation

There are 2 techniques used for meshing.

Meshing by algorithmic program: This section describes the meshing by

Patch freelance - Patch freelance meshing depends of masses, stipulation, named choices results on any scoped object. Therefore we are going to ought to re-mesh.

Mesh refinement isn't supported with patch freelance meshing.

Meshing by component form: This section describes the meshing by

a) Tetrahedral meshing

b) Hexahedral meshing

a) Quad meshing

b) Triangle meshing

c) CFX mesh

d) Sweep meshing

An automatic method has been used to generate the mesh in the present work.

Original Model

Nodes- 5712

Elements- 1961

Edited Model

Nodes- 5626

Elements- 1827

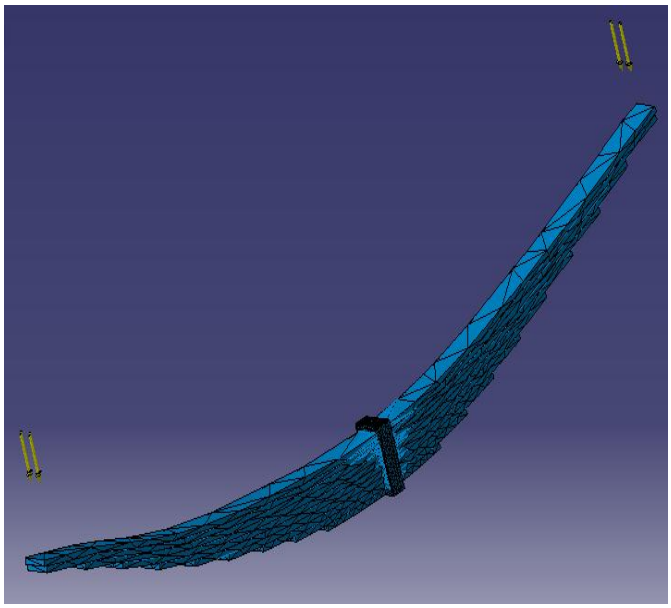


Figure-3 Meshed model of leaf spring

6. Boundary Conditions

After completion of the finite half model, boundary conditions and much unit of measurement applied. The boundary conditions unit of measurement the gathering of assorted forces, supports, constraints and therefore the alternative condition required for complete analysis. Applying boundary conditions is one all told the foremost typical processes of analysis. A special care is required whereas distribution plenty and constraints to the weather. A pair of displacements & several 6700N sq. measures applied.

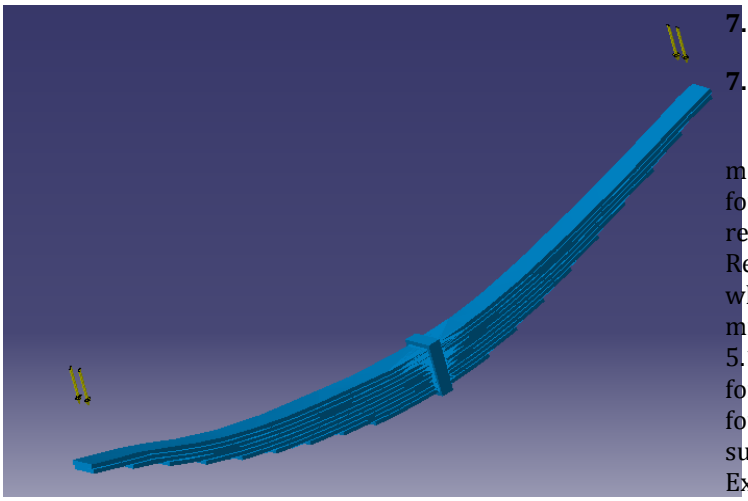


Figure-4 Applied displacement supports and loads on edited leaf spring

6.1 Model Display

While applying the boundary conditions, the model is viewed from totally different angles.

6.2 Solution

The solution half deals with the solution of the matter in step with the matter definitions. All the tedious work of formulating and aggregation of matrices square measure done by the computer and eventually displacements and stress values are given as output.

POST- PROCESSOR

It is a powerful user- friendly post- method program exploitation interactive color graphics. It's full plotting choices for displaying the results obtained from the finite half analysis. The entire vary of post method selections of varied varieties of analysis are accessed through the command/menu mode there by giving the user supplementary flexibility convenience

Employing state of art image improvement techniques, facilities viewing of:

Contours of stresses, displacements, temperatures.

Deform geometric plots, light-weight shaded plot.

Animated deformed shapes.

Time-history plots.

Solid sectioning Hidden line plot and borderline plot etc.

7. Results and Discussions

7.1Static Analysis

Figures below shows the equivalent (Von-Mises) stress, most principal stress, total deformation, inside the spring for a 6700N load. the color shown inside the spring represents the strain and deformation gift inside the half. Red color shows the most stress & most deformation, whereas, blue color shows the minimum stress and minimum deformation inside the individual figures. Fig. 5.1 shows the equivalent (Von-Mises) stress of the spring for a load of 6700N. The maximum(Von-Mises) stress is found to be 10.4 MPa that's at on the brink of the mounted support as shown by red color, this includes native stress. Excluding native stress its price is 9.4 MPa. Figures 5.4, and 5.6 show most principal stress price eight.4 MPa , minimum principle stress price -7.8 MPa and most displacement price zero.01mm and minimum displacement price is zero put together the degree of the material used may be a smaller quantity in altered model as compared to the initial model.

Therefore higher results unit obtained with reduced weight of elliptical spring. Here regarding per cent weight is reduced in altered model as compared to the initial model.

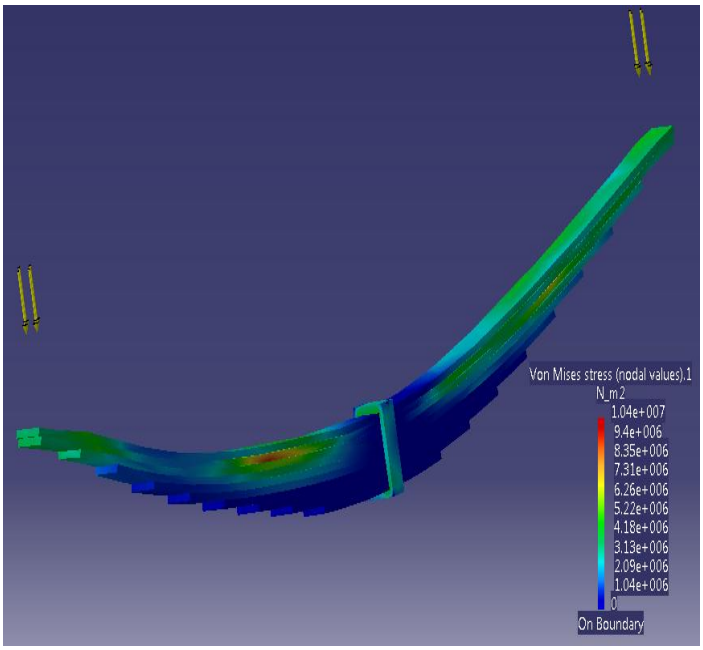


Figure-5 Equivalent (Von-Mises) stress for each element in the leaf spring

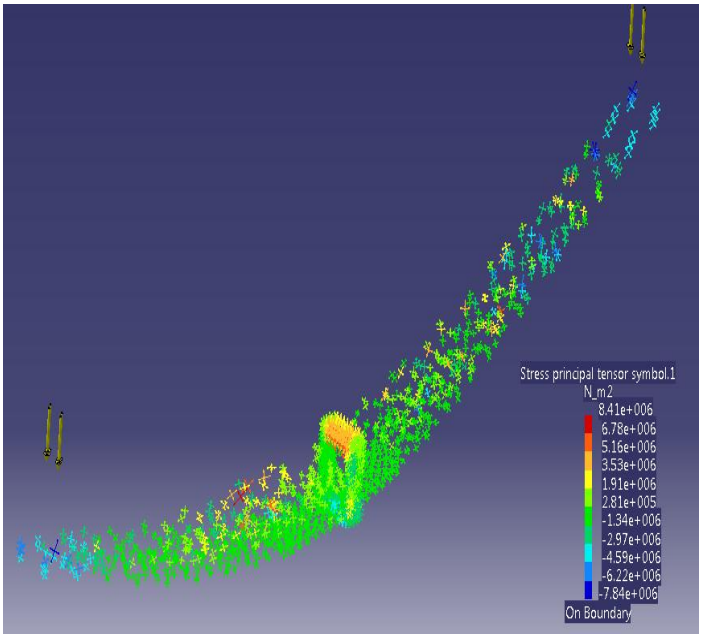


Figure-5 Maximum Principal stresses for each element in the leaf spring

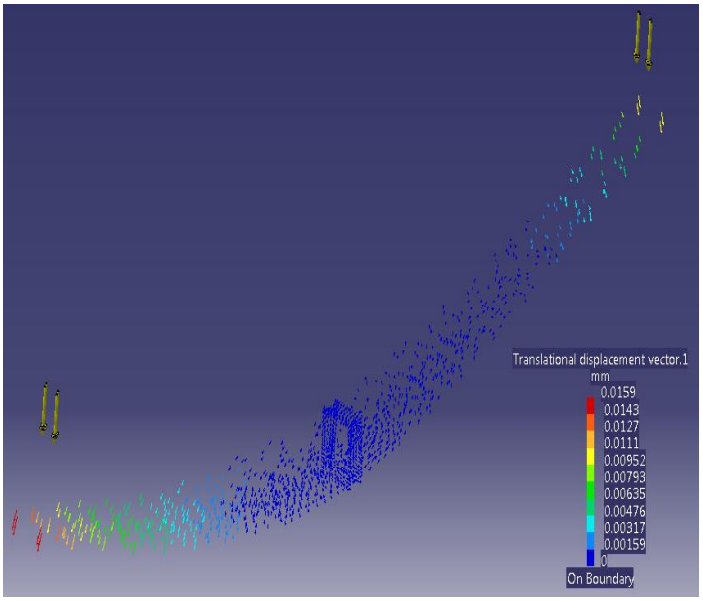
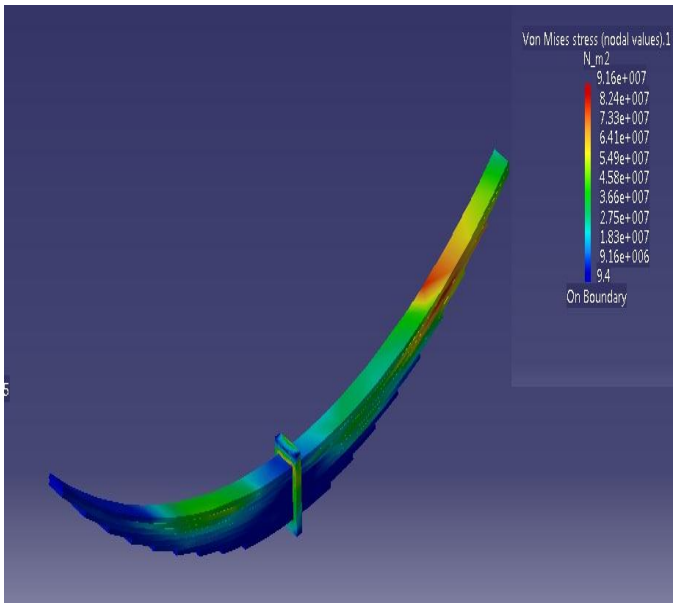


Figure-5 Maximum Displacement for each element in leaf spring

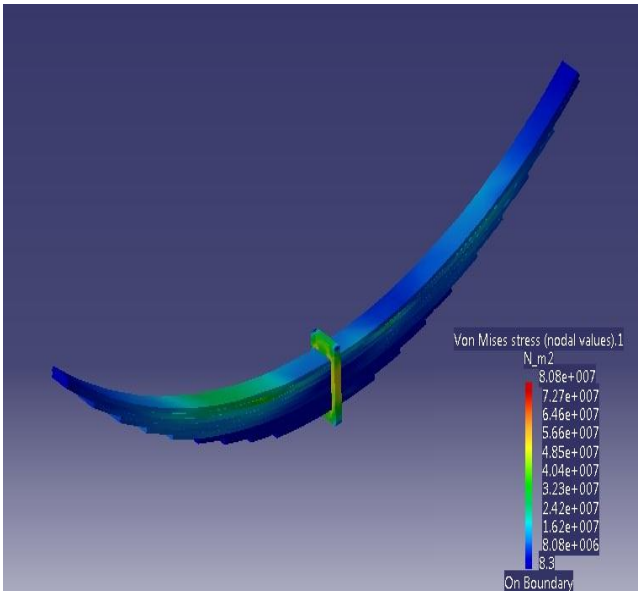
DYNAMIC ANALYSIS

Figures below show the equivalent (Von-Mises) stress, most principal stress, total deformation, within the spring for a 6685N load. The colour shown within the spring represents the strain and deformation gift within the component. Red color shows {the most|the utmost|the most} stress & maximum deformation, whereas, blue color shows the minimum stress and minimum deformation within the individual figures. Fig. 5.8 shows the equivalent (Von-Mises) stress of the spring for a load of 6700N. The maximum (Von-Mises) stress in original model is found to be ninety one.6 MPa that is at close to the mounted support as shown by red color, this includes native stress. Excluding native stress its price is eighty two.4 MPa and also the most maximum (Von-Mises) stress in altered model is found to be eighty.8 MPa that is at close to the mounted support as shown by red color, this includes native stress. Excluding native stress its price is seventy two.7 MPa. So higher results square measure obtained with reduced weight of elliptical spring. Here concerning



eighteen.8 per cent weight is reduced in altered model as compared to the first model.

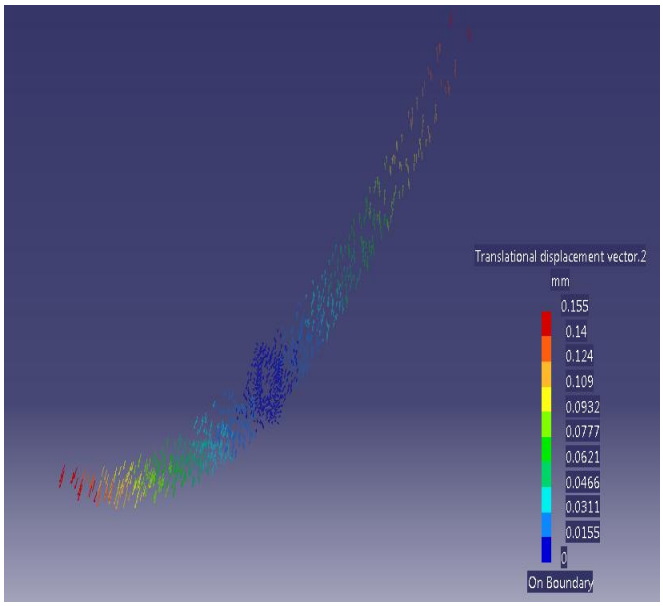
Equivalent (Von-Mises) stress for each element in the original leaf spring for 280 Hz frequency of free vibration



Equivalent (Von-Mises) stress for each element in the edited leaf spring for 280 Hz frequency of free vibration

Dynamic Buckling Analysis Results of Leaf Spring

In the buckling case solution the displacement is shown in the following figure at the same safe frequency.



Transitional displacement in each element in the edited leaf spring for 280 Hz frequency of free vibration

8. Comparison of Results of Two Models from Software

S NO.	Property	Original Model	Edited Model
1	Von-Mises stress	21.1 MPa	10.4 MPa
2	Maximum principle stress	15.7 MPa	8.4 MPa
3	Minimum principle stress	-13.9 MPa	-7.8 MPa
4	Maximum static displacement	0.141 mm	0.0159 mm

Table-4 Results Comparison static analysis

9. Conclusions

The maximum Von–Mises stress (including native stress and international stresses) in steel material is twenty one.1MPa in original modal and one0.4 MPa in altered modal. These values are less in altered modal in original modal. The models conferred here are safe and beneath permissible limit of stresses.

The maximum Von–Mises stress (including native stress and international stresses) in steel material is ninety one.1 MPa in original modal and eighty.8 MPa in altered modal. These values are less in altered modal in original modal. The models conferred here are safe and beneath permissible limit of stresses.

The springs are each safe for engaging at speed of free vibration up to 280 cycle, which may ne'er be seen in any spring beneath operating condition. Thus the spring is safe.

Depending on volume the load of steel reduction is seen here.

The results obtained are well in agreement with the specified results.

Leaf springs with additional thickness and fewer dimensions are safer as compared to the spring with less thickness and additional dimension.

SCOPE FOR FUTURE WORK

1. Nipping is also applied and thus the model is analyzed for same to boost load bearing capability

2. Composite and heterogeneous materials is also accustomed provide the foremost rigidity with minimum weight.

3. Time issue will even be determined (how the loading times have a bearing on the spring & increase the magnitude of stress).

4. Fatigue analysis is also performed to hunt out and improve the period of time of the spring.

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