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Experimental and Weight Optimization of Existing Steering Column

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Abstract - *Finite Element Analysis and parametric investigation of directing segment for new age vehicles to decrease or invalidate the controlling unit. The examination is completed regarding vibration. Stresses created in an article structure prerequisite at the joints, disfigurement in body because of vibrations, nonstop curving and stacking these are identified with steering rod. Symphonious examination will be giving us common recurrence of body that contrasted and consonant recurrence. Point of venture is to perform plan enhancement of steering rod to invalidate its capacities capacity issues related with stresses, deformation, vibrations additionally limit cost by sparing material to think about unique model. Design of existing steering column in CATIA software while static and topology optimization analysis in ANSYS software to determine stress, topology optimized model. FFT analyzer and Impact sledge will be utilized to perform trial modular investigation. Approval will be finished by looking at both exploratory and FEA results. Reasonable ends will be drawn and future degree will be recommended.*

***Key Words*: Topology optimization, ANSYS, Static analysis**

1. INTRODUCTION

The car directing section is a gadget planned essentially for associating the controlling wheel to the guiding instrument. The controlling segment is basically a bolstered shaft that associates the driver's guiding wheel to the apparatus unit. The steering rodin the cutting-edge car is an unpredictable component. It is intended to crumple in an impact to secure the driver. In certain establishments it might be tilted and extended to put it at an advantageous plot for the driver. It additionally contains controlling apparatus and transmission locks. This frenzy stop will in general lift the travelers and driver from their seats and convey them into front of the compartment, except if they are made sure about with seat and shoulder belts. In a head-on crash, two impacts really happen. The first is the vehicle's crash with the item and the second is the inhabitants' impact with the instrument board and windshield in the front of the traveler compartment. In a head-on impact, the driver is tossed against the guiding wheel around one-hundredth of a second after the front of the vehicle starts to pound. The old-style directing segment is frequently driven into the driver as the front of the vehicle is fell. Effect engrossing controlling segments have been intended to fall their lower area instead of pushed back. The upper finish of these sections is additionally intended to assimilate the auxiliary effect of the driver hitting the wheel by crumbling. Collapsible controlling sections are a need in car vehicles. This is on the grounds that without the component, the controlling section would regularly pierce the driver once the vehicle encountered an adequate effect. When actualized, the directing section can assimilate the majority of the vitality got at the front of the vehicle in case of an accident. At its most fundamental level, the structure of the directing section has stayed unaltered since its origin; the segment despite everything comprises of a long shaft interfacing the controlling wheel to the vehicle's gearbox. The 'collapsible' structure presented an 'inward' and 'external' sleeve to the pole, with various steel course squeezed in the middle of every sleeve. A solid 'security gum' is utilized to bond the direction to the sleeves. When a particular degree of weight is surpassed, the uncommon sap breaks, permitting the sleeves to pack adaptively.

2. LITERATURE REVIEW

Imran J. Shaikhet al. [1]In this paper it executing vitality retaining controlling segment in the vehicle which assists with engrossing the effect experienced by the driver during the hour of crash requiring little to no effort. Vitality Absorbing Steering Column (Collapsible steering rod) is a sort of Steering Column which limits the injury of the driver during an auto collision by breakdown or breaking specific piece of framework. Collapsible steering rods are a need in car vehicles. This is on the grounds that without the system, the controlling section would regularly pierce the driver once the vehicle encountered an adequate effect. When actualized, the directing segment can ingest the vast majority of the vitality got at the front of the vehicle in case of an accident. This keeps the vitality of the effect from being moved totally into the driver. Collapsible vitality engrossing directing section can be viably utilized taking all things together landscape vehicle to give wellbeing to the driver. This framework is less expensive than the other security things like air pack and collapsible directing segment and the significant thing is its retractable needs no substitution. It retains almost about 15KN of the load given to the driver and in this manner giving wellbeing to the driver. Just if the load surpasses the most extreme ingestion limit of spring the load would be straightforwardly following up on the driver.

M.Soundar Rajanet al. [2]In this article it present examination regarding vibration. Stresses created in an article structure necessity at the joints, distortion in body because of vibrations, consistent bending and loading these are identified with steering rod. To perform structure streamlining of controlling section to invalidate its capacities capacity issues related with stresses, distortion, vibrations additionally limit cost by sparing material to look at unique model. There is a much degree in structure of controlling pole to limit its imperfection because of turning, Vibrations enhancement of plan [existing/optimized] will give better steadiness and less vibration surrenders in directing pole just as segment for improving the pole the pole closures ought to be made thicker where the coupling is to be utilized toward the end were the widespread joint utilized toward the end. The material properties at both the finishes ought to be made, unique and rather than round cut at the closures if some other shapes ought to be pursued for better outcomes.

S. R. Goreet al. [3]In this investigation topology improvement of car directing knuckle is done by utilizing FEA. In topology optimization differing the network between auxiliary individuals from discrete structures or between areas of continuum structures this adds to the improvement of basic plan and mass decrease of vehicle segments. Weight of the vehicle can be decreased to accomplish reserve funds in crude material expenses and thus preparing cost just as improve eco-friendliness and lessen carbon outflows to help support the earth. The greatest relocation is seen as at the area where upper undercarriage interfaces with the guiding knuckle and it has greatness equivalents to 0.177mm and most extreme worry of 150.9 MPa was seen as at shaft corner. The greatest removal and concern for the slowing down condition is seen as 0.182 mm and 155.6 MPa. The aftereffect of the computational examination and the experimentation study are changed by 2.90%. The outcomes acquired are good. Feeling of anxiety of the enhanced model is corresponded with the feeling of anxiety of the benchmark model. That implies new proposed geometry is palatable. The mass of the current knuckle is decreased from 5.320Kg to 4.600 Kg. By utilizing topology, the mass decrease accomplished is 13.20% in the activity.

M. Sohail Parvezet al. [4], In this paper it presents with actualizing vitality absorbing steering rodin the vehicle which assists with retaining the effect experienced by the driver during the hour of crash requiring little to no effort. The most great situation of the guiding wheel as for the driver is accomplished through a blend of both rakish and tallness alteration. Guiding segment would regularly cause wounding of the face and chest, or now and again, squashing of the driver's skull. The collapsible directing section can retain a large portion of the vitality got at the front of the vehicle in case of the accident. This keeps the vitality of the effect from being moved totally into the driver. This is an inflexible segment which under accident circumstance moves the vitality straightforwardly to the driver. A more secure controlling segment configuration called collapsible directing segment is configuration by supplanting dangerous single-piece guiding segment for example inflexible directing segment. The securely improved development of the collapsible guiding segment, regardless of which configuration is utilized, assimilates, as opposed to moves, frontal effect vitality by crumbling or breaking upon sway. From this driver engaged with frontal effect impacts can maintain a strategic distance from the perils of non-collapsible guiding parts.

Tae Hee et.al[5] In this paper detail FE model investigation is done for steering rod. It is set up a directing segment breakdown by examination strategy. The definite model and investigation technique created in this examination have the accompanying qualities Deformable materials utilized in characterizing most parts to consider the impacts that can be caused from section bowing and so forth. Bizarre conduct that can happen from inflexible part is limited by portraying each component fit as a fiddle and not utilizing unbending FE joint, aside from on certain heading. Rubbing part and breakdown load segment, for example, twisting plate and breakdown ring, contact thickness is characterized as real thickness, and by expelling beginning entrance, the contact was unequivocally depicted. Foundation displaying strategies shows same conduct with full vehicle examination was created by contributing the accident results. The impacts of the pretended, airbag and other restriction outline could be assessed by the aftereffects of occupant investigation. By streamlined model of the case pin, build up a material that reflects failure properties of case pin.

3. PROBLEM STATEMENT

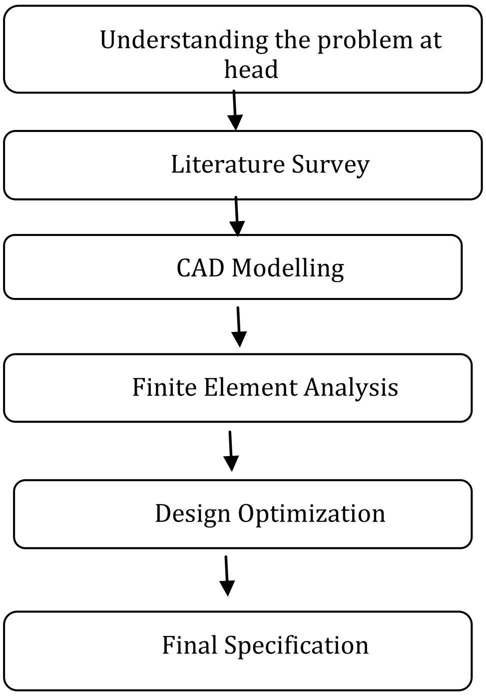
In present situation because of high operational expense and toughness life existing steering column quality and weight has been a concern issue. The reason for increment in weight are expected to overdesign, client request, throwing acceptability and the working conditions. This will prompt emanation standards of the motors and vehicles, increment in eco-friendliness and furthermore builds starter solidness or Fatigue life.

4. OBJECTIVES

1. Modeling of existing Steering Column of automobile car in CATIA V5 software.
2. Analyzing for stresses and deformation of Steering Column of automobile car using ANSYS software.
3. Topological optimization for Steering Column of automobile car.
4. Experimental manufacturing of optimized part.
5. Validation of experimental testing and correlating results with FEA analysis.

5. METHODOLOGY

The approach to our design problem is elaborated through the flow-chart given below.



6. DESIGN AND ANALYSIS

CATIA MODEL

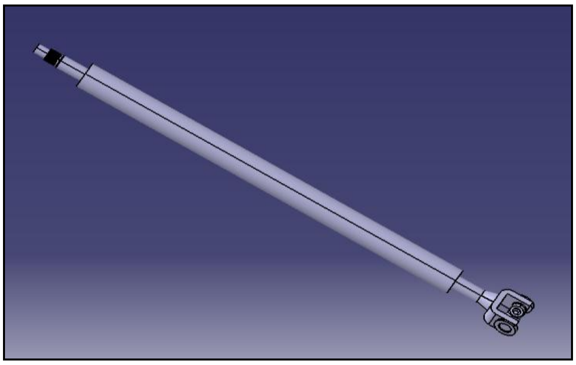


Fig -1: CATIA model of steering column

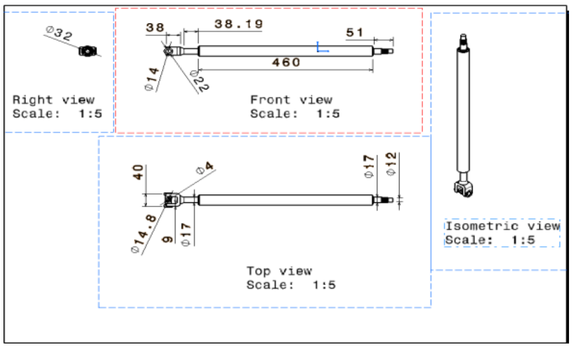


Fig -2 : Drafting of steering column

Material Properties

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Poisson's R...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

Table -1: Material properties of S.S

6.2 Analysis

Geometry

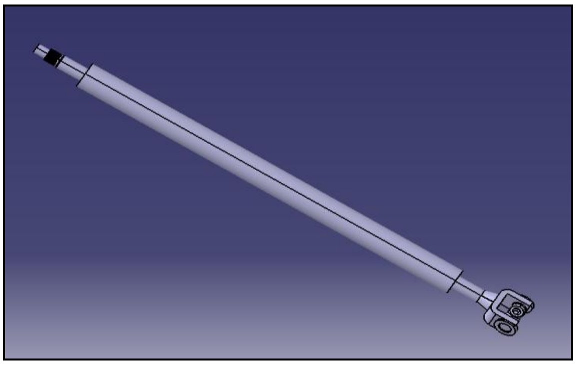
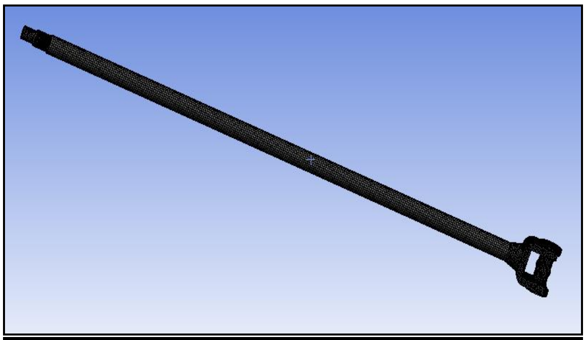


Fig -3: CATIA model imported in ANSYS

Mesh

In ANSYS meshing is performed as similar to discretization process in FEA procedure in which it breaks whole components in small elements and nodes. So, in analysis boundary condition equation are solved at this elements and nodes.



Statistics	
Nodes	211506
Elements	76061

Fig -4: Details of meshing of steering column

After meshing of steering column are 211506 and elements 76061.

Boundary condition

Boundary condition are applied as per calculation

Mass of vehicle – 1200 kg

Mass of vehicle with driver – 1280 kg

Mass on front wheel – 0.45 x 1280 = 576 kg

Mass on rear wheel – 704 kg

Coefficient of friction is considered as 0.7

The basic concept is that torque required to turn the wheel should be more than resisting torque by friction

Force of friction on one wheel = μ x g x corner mass acting on wheel = 0.7 x 9.81 x 288= 1977.6 N

We know that steer happens about king pin axis of car

Input torque from ground (on one wheel) = force of friction x perpendicular distance from contact path to king pin axis

Torque due to friction = 1977 / 52 = 38 Nm

This torque will be equal to lateral push from tie rod

Torque due to lateral push = force on tie rod x 0.094

Force on tie rod = 402 N

As we know tie rod pushing the tire from one side and pulling it from other side

So, Total force on rack – 402 x 2 = 804 N nearly 1000N is considered for safe design

Radius of pinion – 40 mm = 0.04 m

Torque on pinion – 1000 x 0.040 = 40 Nm

Torque on steering wheel – torque on pinion

So, generally above 40 Nm maximum torque is considered for safe design

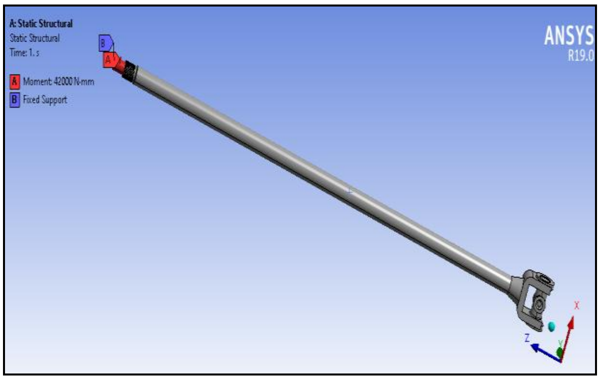


Fig -5: Boundary condition of steering column

Deformation Results

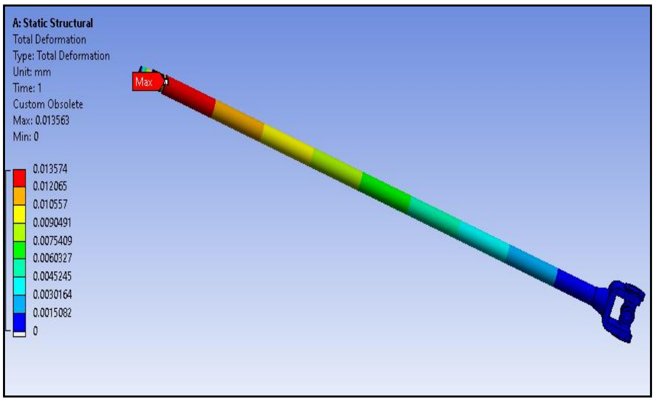


Fig -6: Deformation results of existing of steering column

Equivalent stress

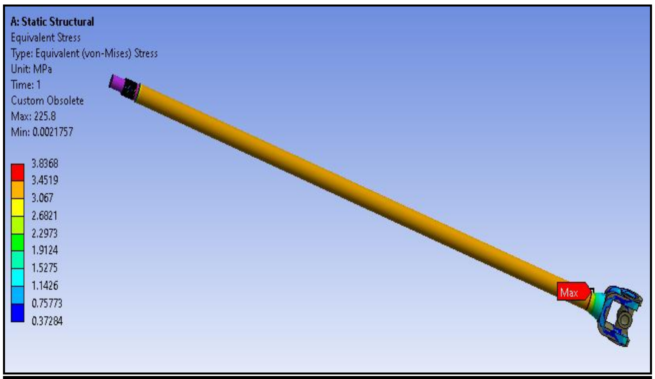


Fig -7: Equivalent stress results of existing of steering column

Shear stress

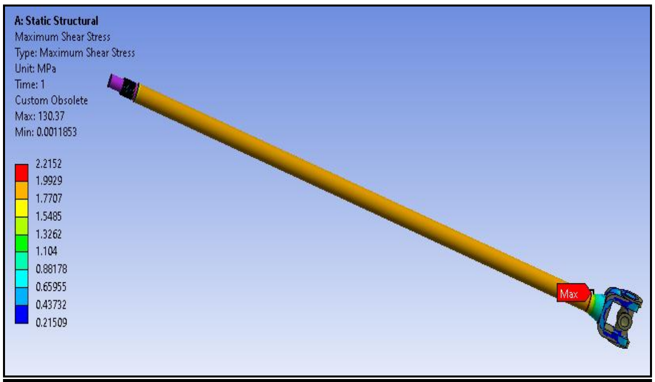


Fig -8: Shear stress results of existing of steering column

TOPOLOGY OPTIMIZATION

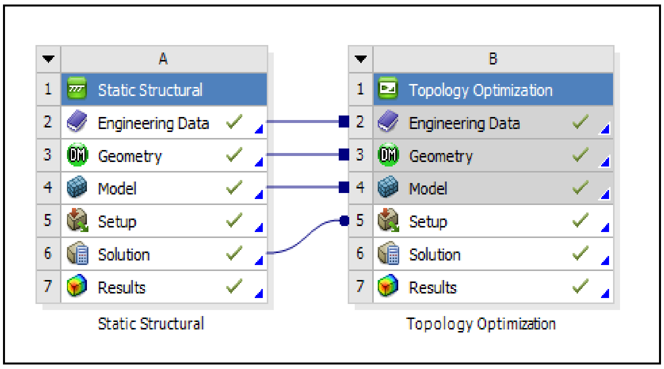


Fig -9: Flow of process in ANSYS

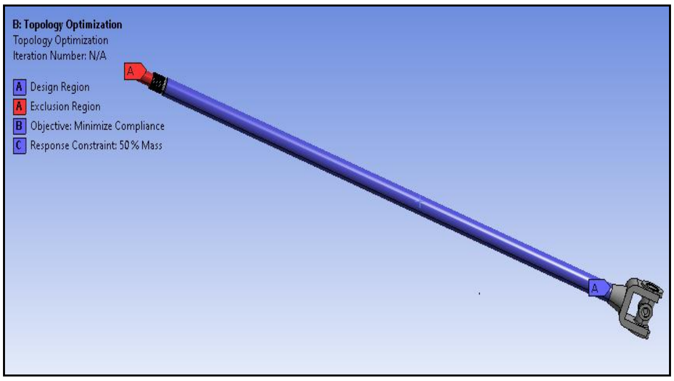


Fig -10: Topology optimization boundary condition

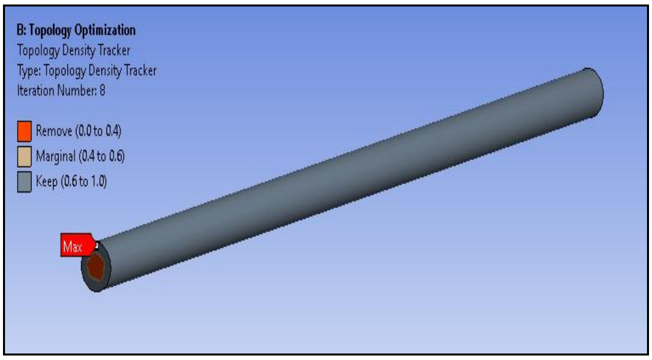


Fig -11: Optimized region in topology optimization

Hollow pipe is used as per topology optimization

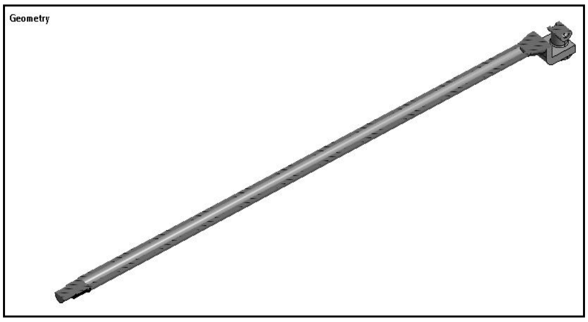
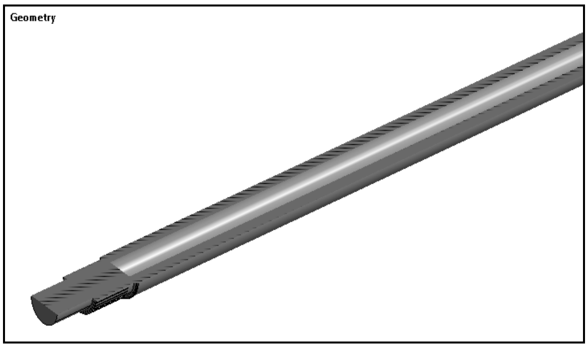


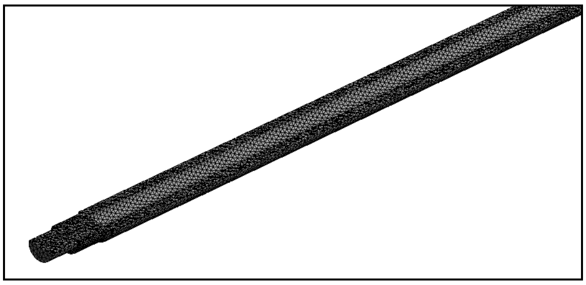
Fig -12 : optimized model of steering column



Mass	0.90322 kg

Fig -13 : optimized model of steering column

MESH



Statistics	
Nodes	213647
Elements	135364

Details of "Body Sizing" - Sizing	
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Type	Element Size
Element Size	2.0 mm

Fig -14 : meshing of optimized model

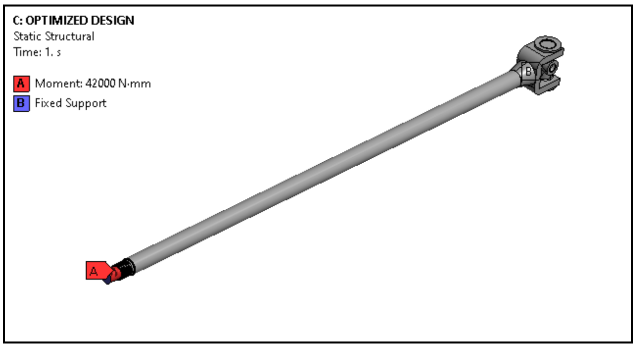


Fig -15 : boundary condition for optimized model

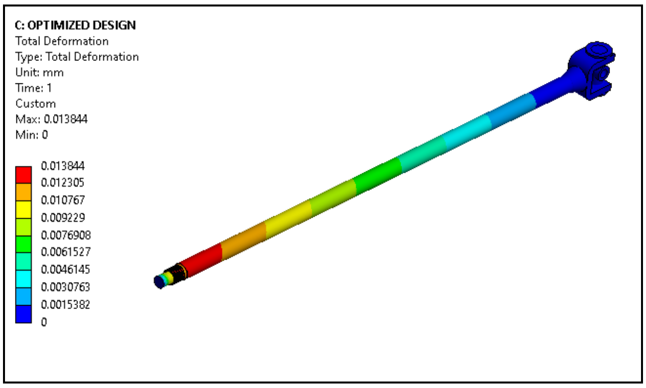


Fig -16 : Total deformation for optimized model

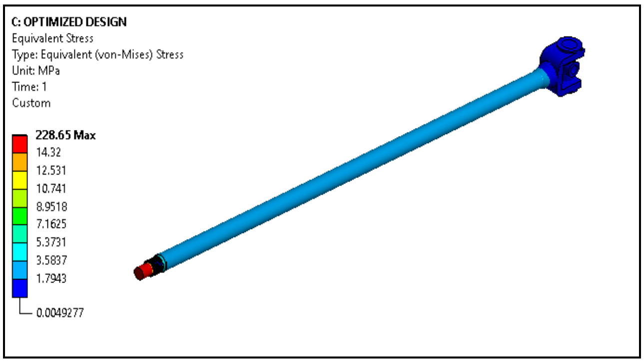


Fig -17 : Equivalent stress for optimized model

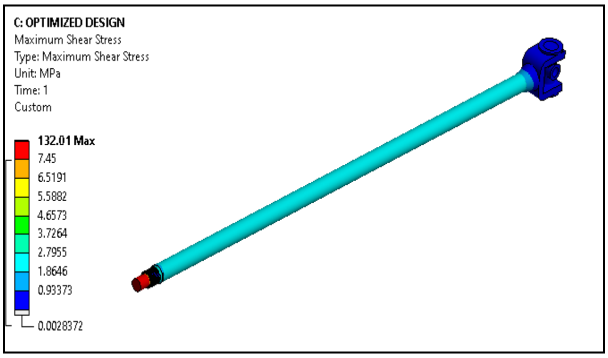


Fig -18: maximum shear stress for optimized model

7. EXPERIMENTAL SETUP

A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. An earlier name for a tensile testing machine is a tensometer. The "universal" part of the name reflects that it can perform many standard tensile and compression tests on materials, components, and structures (in other words, that it is versatile). The set-up and usage are detailed in a test method, often published by a standards organization. This specifies the sample preparation, fixturing, gauge length (the length which is under study or observation), analysis, etc. The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen.

SPECIFICATION OF UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase, 440Volts, 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

8. EXPERIMENTAL FEA

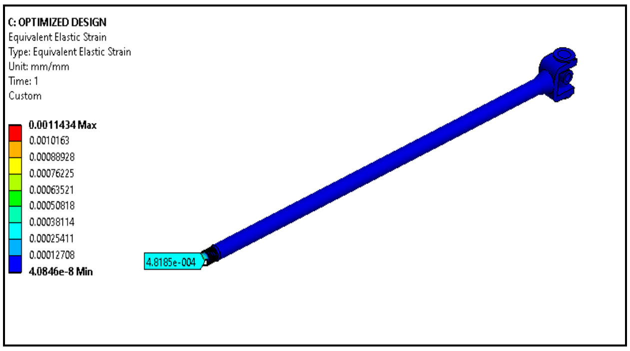


Fig -19 : experimental FEA

- Weight optimization of 24 % is observed
- Strain is observed around 256 microns using FEA.

9. EXPERIMENTAL PROCEDURE

- Fixture is manufactured according to component designed.
- Single force is applied as per FEA analysis and reanalysis is performed to determine strain by numerical and experimental testing.
- Strain gauge is applied as per FEA results to maximum strained region and during experimental testing force is applied as per numerical analysis to check the strain obtained by numerical and experimental results.
- During strain gage experiment two wires connected to strain gage is connected to micro controller through the data acquisition system and DAQ is connected to laptop. Strain gage value are displayed on laptop using DEWESOFT software.

Fig -20 : Experimental setup of optimized model

Fig -21 : Experimental testing of optimized steering column

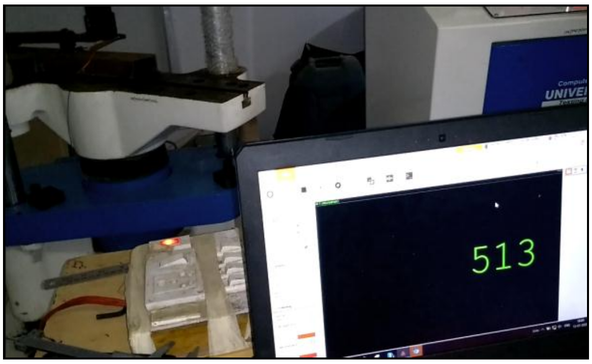


Fig -22 : Experimental result

CONCLUSIONS

- In present research static and topology optimization of existing steering shaft have been performed to determine stress and deformation.
- In topology optimization red region indicate material removal area so, in next semester removal of material in specific standard size is to be performed and reanalysis so that it can withstand existing boundary conditions.
- Weight reduction of around 24% is observed along with strain measurement of 481 microns and 513 microns by numerical and experimental testing respectively.

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