Design and Weight Optimization of Axle with using Different Composite Material

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Abstract— An axle is a central shaft for a turning wheel or apparatus On wheeled vehicles, the axle might be altered to the wheels, pivoting with them, or settled to the vehicle, with the wheels pivoting around the axle. In the previous case, orientation or bushings are given at the mounting focuses where the axle is upheld. In the last case, a course or bushing sits inside a central gap in the wheel to permit the wheel or apparatus to turn around the axle. Now and then, particularly on bikes, the last sort axle is alluded to as a spindle. Tractor trolley (or) trailers are exceptionally prominent and less expensive method of products and transport in country and additionally urban zones. A large portion of the tractor trolley axle utilized today is rectangular cross area sort which thus prompts increment in the heaviness of tractor trolley and axle. To begin with we need to discover the hassles, distortion and FOS of the current axle logically. At that point find such shape which is having preferred properties over existing. At that point do the systematic estimation or the recommended shape and discover its weight. Examination is done on the premise of systematic figuring for existing state of axle and weight with its proposed material. In this work an endeavor has made with rectangular cross area by change in the materials of SAE 1040 and SAE 1020 is done in view of this outcomes, it is presumed that round cross segment with SAE 1040 material is best in weight decrease and in addition in stretch diminishment, Further improve the model roundabout cross segment display broke down with kevlar and boron epoxy composites for static auxiliary and modular examination. At that point pick such a material which is having great result when contrasted with the current one. Last period of my paper is to analyze the consequence of programming produced on the premise of the correlation propose the most ideal shape and material for the present applications. Which bring about diminishing the disfigurement and stretch of the axle and further the cost of the axle

Key words: SAE, FOS

I. Introduction

A. Axle:

The trolley axle is a central shaft for turning wheels. The wheels are settled to the axle, with direction or bushings gave at the mounting focuses where the axle is bolstered. The axle keeps up the position of the wheels with respect to each other and to the vehicle body. The trolley axle is a central shaft for pivoting wheels. The wheels are settled to the axle, with course or bushings gave at the mounting focuses where the axle is upheld. The axle keeps up the position of the wheels in respect to each other and to the vehicle body. Trolley axle under thought is a supporting shaft on which a wheel spins. The axle is settled to the wheels, altered to its environment and an orientation sits inside the center with which a wheel rotates around the axle. A trolley axle is likewise called as bar axle which is ordinarily suspended by leaf springs

Fig. 1:

B. Cab:

This allowed a sleeper compartment in a short tractor, and maximum wheelbase relative overall length, important for bridge formula weight restrictions

C. Composites:

A composite material is an arrangement of materials making out of at least two materials fortified on a perceptible scale. For the most part, a composite material is made out of fortification (fibers, particles, flakes, and additionally fillers) implanted in a lattice (polymers, metals, or ceramics). The network holds the support to frame the sought shape while the fortification enhances the general mechanical properties of the framework. At the point when composed legitimately, the new blend of materials exhibitsmuch preferable quality over the individual material.

D. Classification of composites:

The two classes of composites are (1) Particulate composites and (2) fibrous composites.

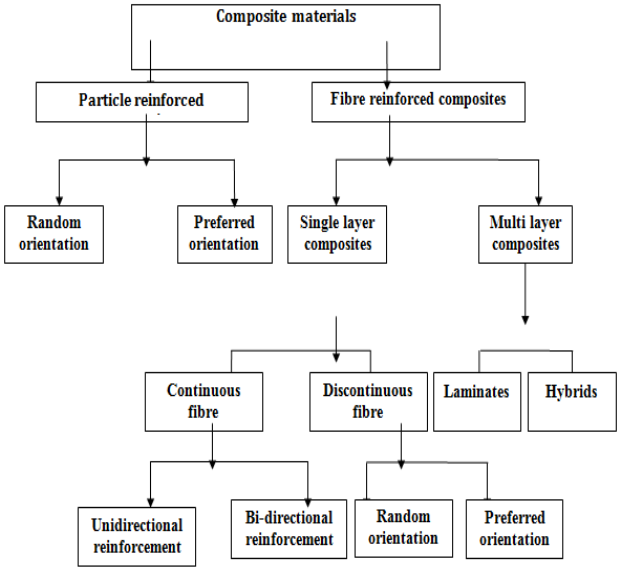

Fig. 3:

E. Materials used as matrix in composite:

The basic form a composite material is one, which is composed of at least two elements working together to produce properties of material that are different to the properties of those elements on their own

II. FORMULATION

A. Finite Element Analysis:

The finite element analysis (finite element method) is a numerical technique for finding approximate solutions of partial differential equations as well as of integral equations.

1) Procedure of FEA:

- STEP 1 - The continuum is a physical body, structure or strong being investigated. Discretization might be essentially depicted as process by which the given body is subdivided into identical arrangement of finite elements..
- STEP 2 - The determination of uprooting or temperature models or shape capacities speaking to around the genuine dispersion of the relocation or temperature. The three elements which impact the choice of shape capacities are
  - The sort and level of uprooting model
  - Displacement sizes
  - The necessities to be fulfilled which guaranteeing right arrangement.
- STEP 3 - The induction of the solidness framework which comprises of the coefficients of the harmony conditions got from the geometric and material properties of the element. The firmness relates the uprooting at nodal focuses to connected powers at nodal focuses.
- STEP 4 - Assembly of the mathematical conditions for the general ruined continuum incorporates the get together of general solidness network for the whole body from individual element firmness grids and the general worldwide load vector from the elemental load vectors.
- STEP 5 - The logarithmic conditions amassed in step 4 are comprehended for obscure relocations by forcing the limit conditions. In direct balance issues, this is a generally clear use of network variable based math methods.
- STEP 6 - In this progression, the element strains and burdens are registered from the nodal relocations that are as of now ascertained from step 5.

B. ANSYS:

ANSYS is a universally useful finite element-displaying bundle for numerically settling a wide assortment of mechanical issues. These issues include: static/dynamic auxiliary analysis (both straight and non-direct), warm exchange and liquid issues, and acoustic and electro-attractive issues.

1) Structure of ANSYS:

In general, a finite element solution may be broken into the following three stages. This is a general guideline that can be used for setting up any finite element analysis.

- Pre-processing: This stage deals with defining the problem. The major steps in pre-processing are given below:
- Define key points/lines/areas/volumes
- Define element type and material/geometric properties
- Mesh lines/areas/volumes as required.

2) Steps Involve in ANSYS:

- Thoroughly comprehend the genuine issue
- Predict what you think the answer will be
- Decide if finite element analysis is a sensible technique for investigating this issue
- Determine the kind of analysis expected to acquire sensible answers
- Determine the kind of elements you will utilize
- Determine the geometry expected to produce the elements
- Create the geometry inside Ansys or import it from another source
- Create the ascribes expected to characterize the elements
- Set element sizes
- Mesh the geometry and make whatever other elements that is required
- Apply limit conditions
- Set the heap step controls
- Write the heap step records
- Solve the heap step records
- Review the outcomes
- Interpret the outcomes

III. DESIGN AND ANALYSIS

A. Simulation of tractor axle:

Taking after strides were performed for the reproduction of the section:

- CAD model was produced with the assistance of CATIA of the Tractor axle
- Mesh was produced for the analysis.
- Static analysis was performed for rectangular and round cross segment for SAE 1020 and SAE 1040 materials.
- Based on the static results select best cross area
- For the chose best cross area play out the analysis with Composite materials, for example, Kevlar epoxy and boron Epoxy.
- Modal Analysis likewise performed for the best cross segment for Steel material and composite materials.
- Based on the static and modular analysis select best material to produce the axle.

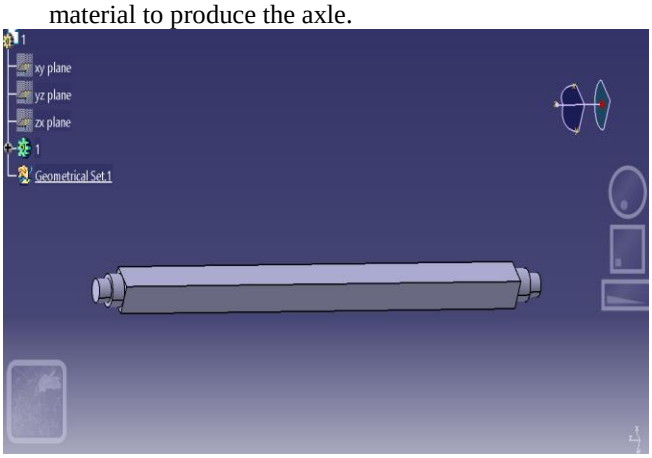

Fig. 3:

B. FE Analysis:

It is necessary to identify the tedious and time consuming steps and try to automate them to reduce the FE simulation time and to avoid the constant interaction of the user with the FE tool. Following the list of steps are presented.

Properties of Outline Row 3: SAE 1040

	A	B	C
1	Property	Value	Unit
2	Density	7845	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus an...	
8	Young's Modulus	2E+05	MPa
9	Poisson's Ratio	0.29	
10	Bulk Modulus	1.5873E+11	Pa
11	Shear Modulus	7.7519E+10	Pa
12	Alternating Stress Mean Stress	Tabular	
16	Strain-Life Parameters		
24	Tensile Yield Strength	2.5E+08	Pa
25	Compressive Yield Strength	2.5E+08	Pa
26	Tensile Ultimate Strength	4.6E+08	Pa
27	Compressive Ultimate Strength	0	Pa

Fig. 4: Material mechanical properties for SAE 1040

Properties of Outline Row 3: Kevlar Epoxy

	A	B	C
1	Property	Value	Unit
2	Density	1042	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus an...	
8	Young's Modulus	9.5E+10	Pa
9	Poisson's Ratio	0.34	
10	Bulk Modulus	9.8958E+10	Pa
11	Shear Modulus	3.5448E+10	Pa
12	Alternating Stress Mean Stress	Tabular	
16	Strain-Life Parameters		
24	Tensile Yield Strength	2.5E+08	Pa
25	Compressive Yield Strength	2.5E+08	Pa
26	Tensile Ultimate Strength	4.6E+08	Pa
27	Compressive Ultimate Strength	0	Pa

Fig. 5: Material mechanical properties for Kevlar Epoxy

C. Meshing:

One of the most relevant steps in the Finite Element Analysis is the meshing. The speed and the accuracy of the results have a direct connection in how this part is done. The higher the numbers of nodes are the higher the accuracy of the results, however the speed of the simulation decreases. Figure 5 shows how the mesh looks in ANSYS Mechanical.

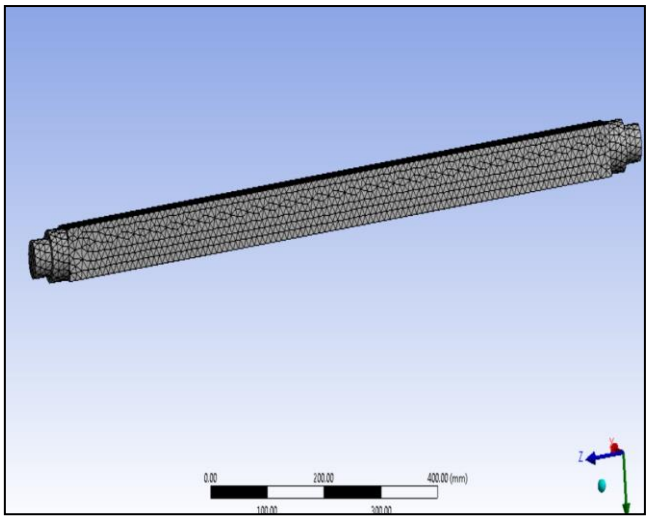

Fig. 6: Mesh of the structure

D. Loads:

Truck Weight Of 9tons Considered And Is Applied on the axle at two locations In The Structure.

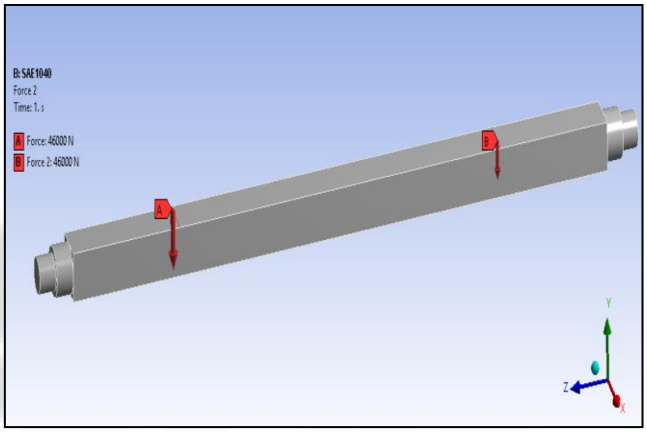

Fig. 7: Load applied

E. Boundary conditions:

Fixed Supports Are Applied At The Highlighted Surfaces In The Figure.

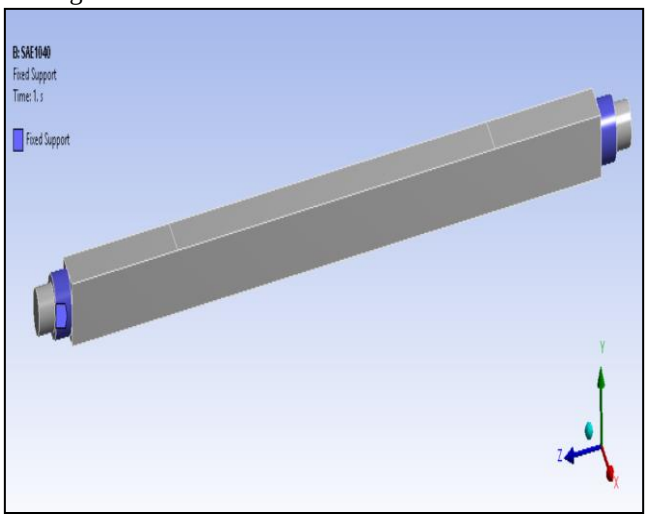

Fig. 8: Boundary condition applied in the structure

F. Post Processing:

The final step is to run the simulations, but before it has to be specified which results are required by the user. In order to determine if the model can resist the loads applied to it, it is

necessary to know, e. g. the Maximum Von Mises stress and the displacement. Knowing these results the user can compare with the data from the material used and applying the safety factor it can be determined if the structure is stiff enough. Another use is being able to extract the results automatically for the possibility

IV. RESULTS

A. Analysis Results:

This topic is intended for presenting the results obtained after learning the theories and applying the method described in the two previous chapters. It starts with the validation of the model.

B. Results _ SAE 1040 Rectangular Cross Section:

The total deformation observed in the structure is shown in below figure.

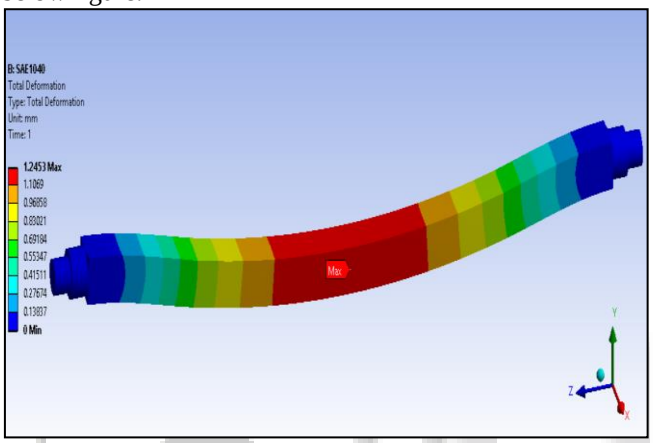

Fig. 9: Total deformation _ SAE1040

von-Mises stress observed in the structure is shown in below figure

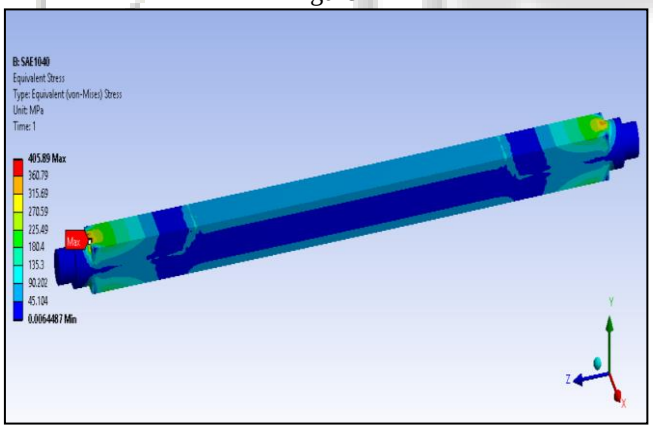

Fig. 10: von - Mises stress _ SAE1040

Properties	
Volume	3.2429e-003 m³
Mass	25.441 kg
Scale Factor Va...	1.
Statistics	
Basic Geometry Options	
Advanced Geometry Options	

Fig. 11: Weight of the Structure

C. Results _ SAE 1020 Rectangular Cross Section:

The total deformation observed in the structure is shown in below figure.

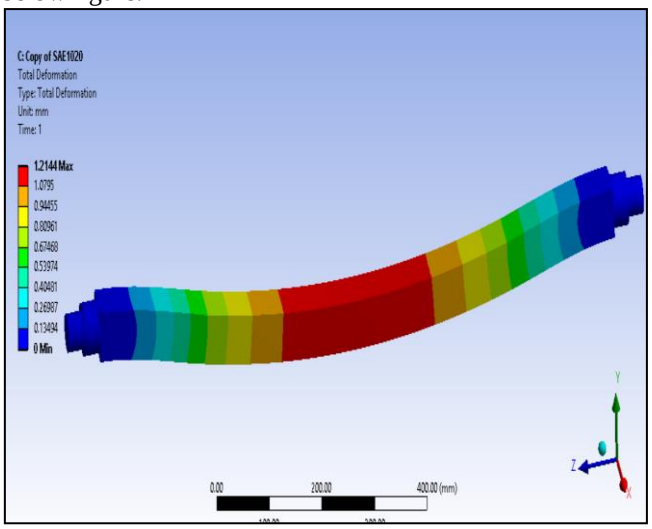

Fig. 12: Total deformation _ SAE1020

von-Mises stress observed in the structure is shown in below figure

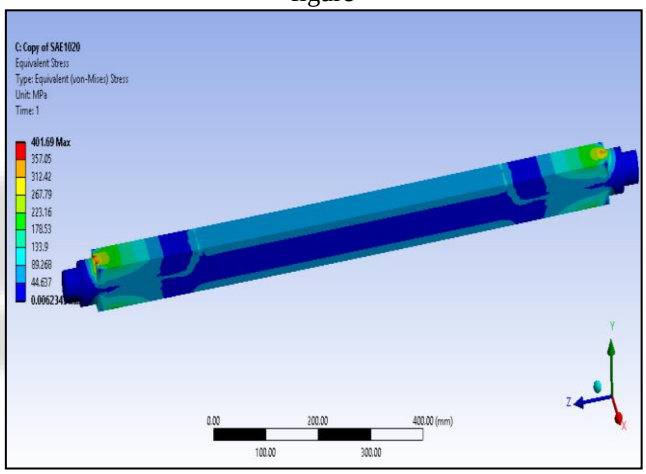

Fig. 13: von - Mises stress _ SAE1020

D. Results Summary:

The summary of the results for the rectangular and circular cross sections with SAE 1040 and SAE 1020 materials are shown in below figure

Material	SAE 1040	SAE 1020	SAE 1040	SAE 1020
Total Deformation (mm)	1.24	1.21	1.25	1.31
von Mises stress(MPa)	405	401	385	392
Allowable stress(MPa)	415	420	415	420
FOS	1.02	1.05	1.08	1.07
Weight(kg)	25.44	25.5	22.9	24.03
Change in Weight %	0.2	0.0	10.2	5.8
Change in Stress %	-1.0	0.0	4.0	2.2

Table 1:

From the results Circular cross section with SAE 1040 material is having more positive points and less deformation & stress compare to existing square cross section

From the previous analysis we concluded that SAE 1040 material with circular cross section is best in stress, Deformation and weight point of view. The same circular cross section model is analyzed further to optimize the model with composite materials. The results with composite materials are tabulated in the below table.

Material	SAE 1040	Kevlar Epoxy	Boron Epoxy
Total Deformation (mm)	1.25	2.6	0.8
von Mises stress(MPa)	385	373	397
Allowable stress(MPa)	415	1400	1590
FOS	1.08	3.75	4.01
Weight(kg)	22.9	3.04	6.57
Natural Frequency(Hz)	275.54	523.88	620.2
Change in Weight %	0.0	**86.7**	71.3
Change in Stress %	0.0	**3.1**	3.1
Change in Frequency %	0.0	90.1	125.1
% are calculated with SAE 1020 as reference			

Table 2:

V. CONCLUSION

1) The axle 3d models with rectangular cross area and roundabout cross segment were created by utilizing CATIA and are foreign made to Ansys workbench15 for analysis.
2) Performed static auxiliary analysis on the roundabout and rectangular cross areas with SAE 1020 and SAE 1040 materials.
3) To improve the axle outline chooses best cross area from the Analysis comes about. In the present analysis SAE 1040 with round cross segment given upgraded aftereffects of 10.2% decrease in weight and 4 % lessening in stretch.
4) Further improve the model round cross area display broke down with kevlar and boron epoxy composites for static auxiliary and modular analysis.
5) The comes about demonstrated that the weight decrease around 86%, stretch lessening around 3% and recurrence enhanced around 90% as contrast and SAE 1040 material. While other boron epoxy composite material has 71% in weight decrease, 3 % in stretch diminishment and recurrence enhanced around 125%.
6) From the outcomes it is presumed that cicular cross area with kevlar epoxy indicates push and disfigurements are normal and inside the reasonable limitsand in best weight decrease.

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