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Design& Analysis of an Automotive CompositeDrive Shaft

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ABSTRACT
Drive Shaft is a rotating shaft that transmits power from the engine to the differential gear of a rear wheel drive vehicles Driveshaft must operate through constantly changing angles between the transmission and axle. Automotive drive Shaft is a very important component of vehicle. The present project focuses on the design of such an automotive driveshaft by composite materials. Now a day's two pieces steel shaft are used as drive shaft. However, the main advantages of the present design are only one piece of composite driveshaft is possible that fulfil all the requirements of drive shaft. The basic requirements considered here are torsion strength, torsion buckling and bending natural frequency.
In this project a drive shaft is designed and tested with the knowledge provided I base paper and is modified to improve is structural strength and fatigue life. All the work is done using Catia and Ansys. New models will be developed by varying the cross sections of the shaft .different materials are also included for better understanding.
KEYWORDS: *Driveshaft, New designs with varying cross section, composite materials, ANSYS.*

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I. INTRODUCTION

A drive shaft, driveshaft, driving shaft, tailshaft, propeller shaft (prop shaft), or Cardan shaft (after GirolamoCardano) is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them.

As torque carriers, drive shafts are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, while avoiding too much additional weight as that would in turn increase their inertia.

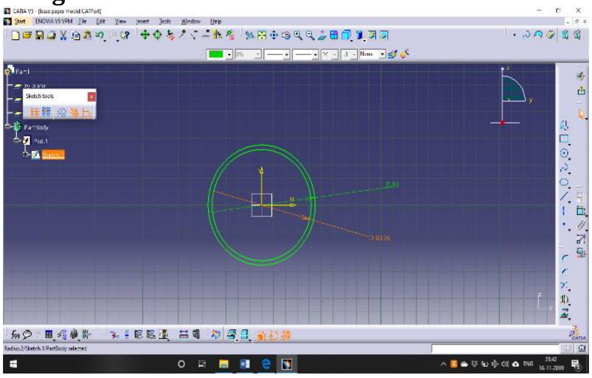
To allow for variations in the alignment and distance between the driving and driven components, drive shafts frequently incorporate one or more universal joints, jaw couplings, or rag joints, and sometimes a splined joint or prismatic joint.

The term drive shaft first appeared during the mid-19th century. In Stover's 1861 patent reissue for a planning and matching machine, the term is used to refer to the belt-driven shaft by which the machine is driven. The term is not used in his original patent. Another early use of the term occurs in the 1861 patent reissue for the Watkins and Bryson horse-drawn mowing machine. Here, the term refers to the shaft transmitting power from the machine's wheels to the gear train that works the cutting mechanism.

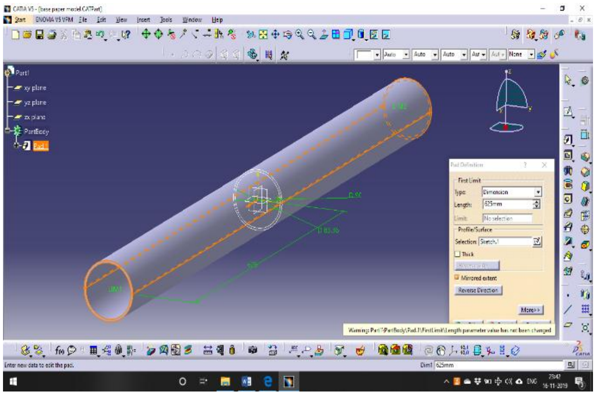
In the 1890s, the term began to be used in a manner closer to the modern sense. In 1891, for example, Battles referred to the shaft between the transmission and driving trucks of his Climax locomotive as the drive shaft, and Stillman referred to the shaft linking the crankshaft to the rear axle of his shaft-driven bicycle as a drive shaft. In 1899, Bukey used the term to describe the shaft transmitting power from the wheel to the driven machinery by a universal joint in his Horse-Power. In the same year, Clark described his Marine Velocipede using the term to refer to the gear-driven shaft transmitting power through a universal joint to the propeller shaft. Crompton used the term to refer to the shaft between the transmission of his steam-powered Motor Vehicle of 1903 and the driven axle.

The pioneering automobile industry company, Autocar, was the first to use a drive shaft in a gasoline-powered car. Built in 1901, today this vehicle is in the collection of the Smithsonian Institution.

Design



Cross section



Base Model

Material Properties

Properties of Outline Row 3: carbon/epoxy

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	1.6	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Young's Modul...			
6	Young's Modulus	2.1E+11	Pa		
7	Poisson's Ratio	0.3			
8	Bulk Modulus	1.75E+11	Pa		
9	Shear Modulus	8.0769E+10	Pa		

Carbon/epoxy

Properties of Outline Row 4: glass epoxy

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	2	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Young's Modul...			
6	Young's Modulus	1.34E+11	Pa		
7	Poisson's Ratio	0.3			
8	Bulk Modulus	1.1167E+11	Pa		
9	Shear Modulus	5.1538E+10	Pa		

Glass/epoxy

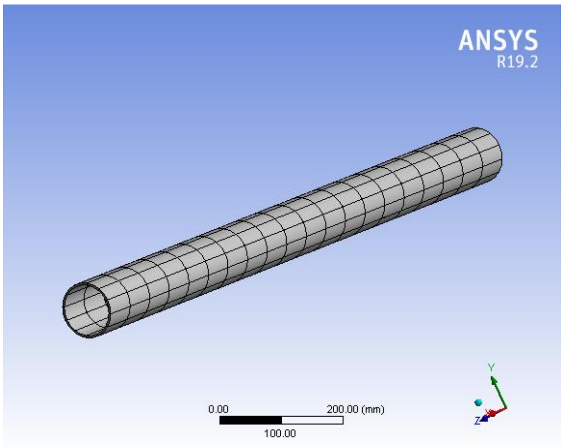
Properties of Outline Row 5: Structural Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	7850	kg m^-3		
4	Isotropic Secant Coefficient of Thermal Expansion				
5	Coefficient of Thermal Expansion	1.2E-05	C^-1		
6	Isotropic Elasticity				
7	Derive from	Young's Modu...			
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		

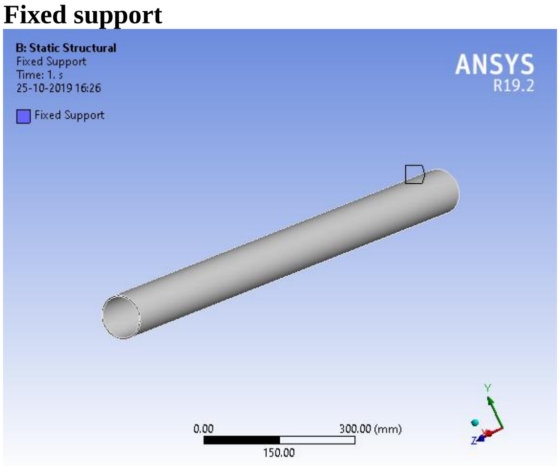
Structural steel

Boundary conditions

Mesh



Fixed support

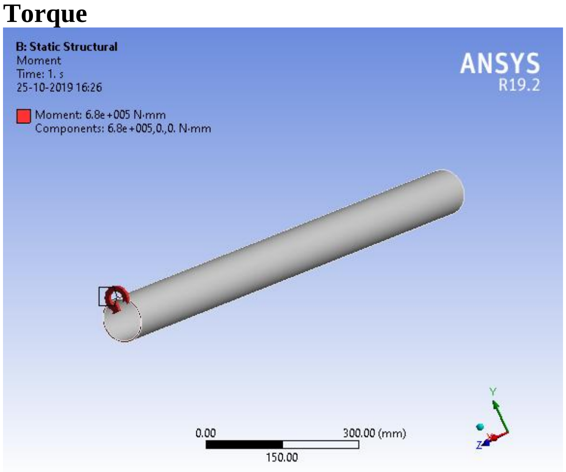


Details of "Mesh"

Display	
Display Style	Use Geometry Setting
Defaults	
Physics Preference	Mechanical
Element Order	Program Controlled
Element Size	Default
Sizing	
Use Adaptive Sizi...	Yes
Resolution	Default (2)
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Span Angle Center	Coarse
Initial Size Seed	Assembly
Bounding Box Di...	1256.5 mm
Average Surface ...	1.1358e+005 mm²
Minimum Edge L...	130.94 mm
Quality	
Check Mesh Qua...	Yes, Errors
Error Limits	Standard Mechanical
Target Quality	Default (0.050000)
Smoothing	Medium
Mesh Metric	None
Inflation	
Advanced	
Number of CPUs ...	Program Controlled
Straight Sided El...	No
Number of Retries	Default (4)
Rigid Body Behav...	Dimensionally Reduced
Triangle Surface ...	Program Controlled
Topology Checki...	Yes
Pinch Tolerance	Please Define
Generate Pinch o...	No
Statistics	
Nodes	1740
Elements	240

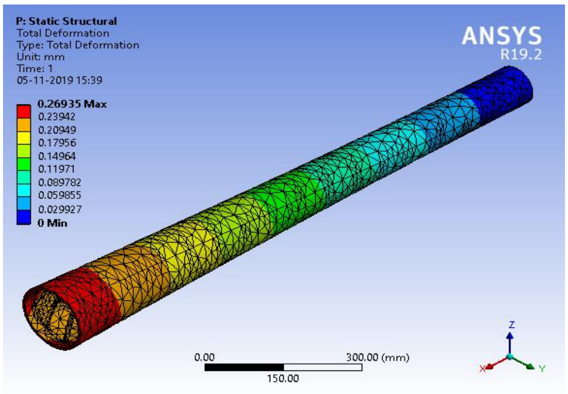
Meshdetails

Torque

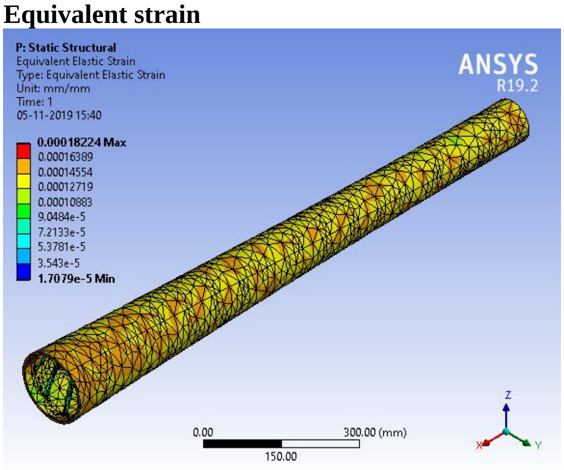


Ansys pictorial graphs of model 4 with material carbon/epoxy

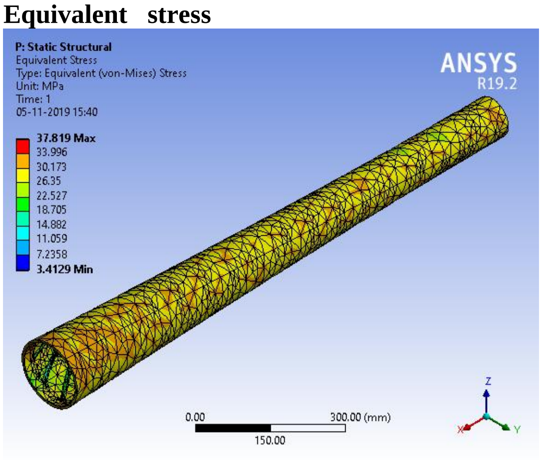
Total deformation



Equivalent strain



Equivalent stress



II. Report

Tables

Table presenting the values of various models with material structural steel

Structural Steel	total deformation (mm)		Equivalent Elastic Strain (mm/mm)		Equivalent stress (Mpa)	
	min	max	min	max	min	Max
model 1	0	0.29254	1.47E-04	0.00016	28.393	31.95
model 2	0	0.32369	3.25E-05	0.000302	2.2937	59.236
model 3	0	0.27773	1.38E-05	0.000202	1.8958	40.348
model 4	0	0.46378	4.57E-05	0.000533	3.7133	106.03
model 5	0	0.28281	1.79E-05	0.000191	3.4129	37.819

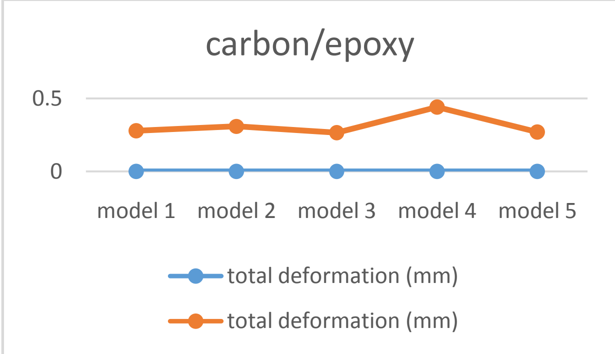
Table presenting the values of various models with material glass/epoxy

glass epoxy	total deformation (mm)		Equivalent Elastic Strain (mm/mm)		Equivalent stress (Mpa)	
	min	max	min	max	min	max
model 1	0	0.43663	0.00021887	0.000238	28.393	31.95
model 2	0	0.48311	4.86E-05	0.000451	2.2937	59.236
model 3	0	0.41452	2.06E-05	0.000301	1.8958	40.348
model 4	0	0.69221	6.83E-05	0.000795	3.7133	106.03
model 5	0	0.42211	2.68E-05	0.000286	3.4129	37.819

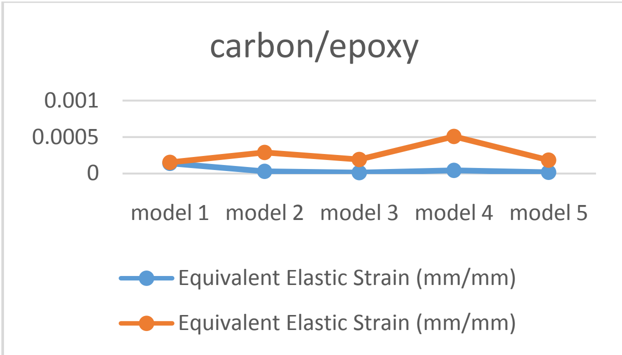
Table presenting the values of various models with material carbon/epoxy

carbon/epoxy	total deformation (mm)		Equivalent Elastic Strain (mm/mm)		Equivalent stress (Mpa)	
	min	Max	min	max	min	max
model 1	0	0.27861	0.00013966	0.000152	28.393	31.95
model 2	0	0.30827	3.10E-05	0.000288	2.2937	59.236
model 3	0	0.2645	1.32E-05	0.000192	1.8958	40.348
model 4	0	0.44169	4.36E-05	0.000507	3.7133	106.03
model 5	0	0.26935	1.71E-05	0.000182	3.4129	37.819

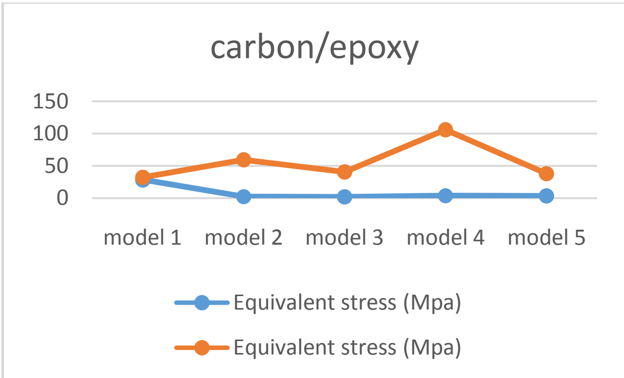
Graph representing the trends in various models with material carbon/epoxy



Total deformations



Equivalent strain



Equivalent stress

III. CONCLUSIONS

Here in this thesis four different models of drive shaft are developed in Catia by using the dimensions of the base model. These models are subjected to 680 N-m Peak torque for 1,000,000cycle reversed fatigue with one end fixed. Factors like total deformation, equivalent strain, and equivalent stress are measured and compared. Apart from base material structural steel, two new composite materials are applied on the models. Namely glass/epoxy composite and carbon/epoxy. The observations made are as follows.

- TheGlass/epoxycompositedriveshaftshavebeendesignedtoreplacethesteeldriveshaftofanautomobilebecauseof highstrengthcomparedtostructuralsteelandcarbon/epoxy
- Stressaresameirrespectiveofallthethreematerials,butbothstrainanddeformationsvaries

- Glass/epoxymodelsrecordedhighervaluesinallthreeconditions,whichareindeformation,equivalentstrainandstress,comparingwithremainingtwomaterials.Glass/epoxyisgivingbestresult.
- Carbon/epoxymodelsrecordedlowestvaluesinallthreeconditions,whichareindeformation,equivalentstrainandstress,comparingwithremainingtwomaterials.
- Toughthevaluesofcompositesarenearlyequaltostructuralsteel,compositesarepreferableastheyhavehigheryieldpointsandlowdensity
- Discussingaboutmodelsmodel2andmodel4ofallthreematerialshavelesservalueswhencomparedwithbasemodel.Andallmodelsincarbon/epoxycompositehavelesservaluescomparedtostructuralsteel.
- Accordingtotheliteraturesafetyfactorfordriveshaftsis2formetalsand3forcompositematerialsallourmodelswillpassthiscriteria.
- Byconsideringalltheseglass/epoxycompositeofmodel3whichishavingdriveshaftprovidinginternalandexternalthreadsisrecommended.

FUTURE SCOPE

In this work all the research is carried out using simulation and is mainly concentrated on stress and deformation in composite shafts when cross-sectional geometries are varied. But it is highly recommended to study stress intensity value at crack tip for the structures used in this study with reference to R. P. Kumar Rompicharla and Dr. K. Rambabu [6] use Kevlar /Epoxy composite material and The drive shaft of Toyota Qualis was chosen for determining the dimensions, which were used to study the stability of drive shaft by limiting the include values with in the permissible range in ANSYS 12.0.

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