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Design, Analysis & Optimization of propeller shaft with composite materials by using software's

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Abstract - *The propeller shaft which is also known as driving shaft is one of the main part of vehicle for power transmission. The shaft is connected between the main shaft and differential at rear axles. Whenever there is a rotary motion in main shaft the power is transmitted through propeller shaft to differential, thus the rear wheel gets rotated. Conventionally the shaft is made up of SM45 STEEL. Vehicles use long propeller shaft for large wheel base. At a certain speed the shaft will produce critical whirling and the shaft vibrates violently. Thus to reduce the critical whirling, the shaft length should be reduced. Then the length can be reduced by dividing the shaft length and placing the intermediate using universal joint. When the number of universal joint increases its power transmission reduces. So, it can be controlled by using composite material. Composite materials have high strength and high stiffness. ''CHEVROLET TAVERA'' vehicle propeller shaft is analysed by using composite material. In this work, Al_2O_3 and AlSiC composite materials are used and analysing software's are SOLIDWORK & ANSYS*

Key Words - SM45 STEEL, Al_2O_3, Alsic, ANSYS, SOLIDWORK.

1. INTRODUCTION

A driveshaft, driving shaft, tail shaft, propeller shaft or cardon shaft is a longitudinal shaft used to deliver power from engine to other end of vehicle and passed through wheels. In front engine rear-drive vehicle the shaft will reduce power depending upon the length of vehicle. When the long shafts are used natural bending will occur, to avoid that it will be divided using universal joints. When the number of universal joints increases its power transmitting capability decreases. The overall objective of this work is to control the power loss using composite material. Composite materials have high strength and stiffness and they can also withstand high temperature. When the analysis is done by ANSYS &SOLIDWORK software's, properties like Strain energy, Equivalent elastic strain, Total deformation, Von-misses stress are analysed. The composite materials such as Al_2O_3 and Alsic and conventionally using SM45 STEEL shaft are analysed. It will reduce the usage of universal joint. Conventionally two pieces of steel shaft having three universal joints are used .But in case of composite material the universal joint intermediate is not used. Because, in composite material deformation and bending is low as compared to conventional shaft. The high strength composite materials are used to reduce weight and increase power transmission.The analysed values are compared by ANSYS & SOLIDWORK software's and detects the accuracy.

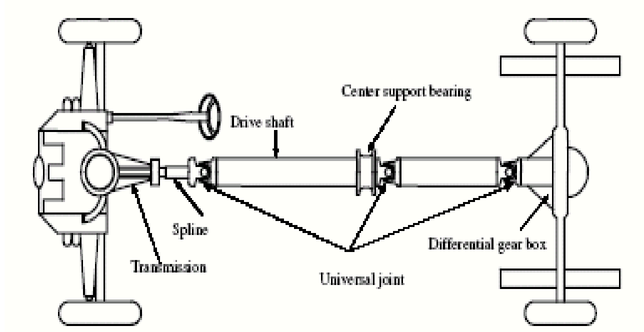

Fig-1: Propeller Shaft Arrangement in Vehicle

2. LITERATURE REVIEW

From the journal by author Jayanaidu termed as "Analysis of driveshaft for automobile applications" this study deals with the optimization of driveshaft using ANSYS. Implementation of titanium driveshaft replacing the conventional driveshaft material has increased the advantages of the design due to its high specific stiffness, strength and low weight. Conventional steel has lot of disadvantages such as low specific stiffness and strength. Journal goes through the analysis of equivalent stress, total deformation and max shear stress of titanium and steel driveshaft. The result shows that the model is applicable for saving development time and improving the decision making to optimize a design.

"Design and optimization of driveshaft with composite materials" from the authors R.P Kumar Rompicharla and Dr. K. Rambabu has the main objective of designing and analysing a composite driveshaft for power transmission. Using composite structures over conventional metallic structures has many advantages because of higher specific stiffness and strength of the material. The composite material used is Kevlar epoxy which reduces the weight and stress intensity. Study analyses the shear stress and von misses stress of Kevlar epoxy and conventional driveshaft materials. Result of the study shows that the use of composite material reduces the weight up to 28% and stress intensity value at crack tip.

Arun Ravi in his journal named "Design, analysis and comparison of a composite driveshaft for an automobile" show general weight reduction of the vehicles is a highly desirable goal. In these advanced composite materials such as graphite, carbon, Kevlar and glass is used over normal driveshaft materials. By using these, specific strength and specific modulus can be increased. Total deformation and equivalent elastic stress of the carbon fibre and structural steel is tested and result is specified. From the result we can understand that specific strength and specific modulus is increased by the usage of carbon fibre replacing structural steel, it also reduces the weight of driveshaft. One piece composite driveshaft for rear wheel drive automobile has been designed with high strength carbon composite which was capable of minimizing the weight of the shaft by 24% as compared to same dimension of steel shaft and comparable increase in the strength of the driveshaft.

"Analysis of driveshaft" by Bhirud Pankaj Prakash, Bimlesh Kumar Sinha deals with the usage of lightweight materials such as fibre reinforced polymer composite material over conventional metallic structures. This work is carried out to analyse the composite driveshaft for power transmission. Use of composite material like Kevlar/epoxy or E glass polythene resin with high specific strength and stiffness minimizes the weight of the shaft. In this shear stress and torsion of the composite driveshaft with conventional driveshaft is tested and obtained that the composite materials are more preferred than the metallic driveshaft. Implementation of composite material has resulted to in considerable amount of weight in the saving range of 24-29% as compared to conventional steel shaft. The presented study was aimed to reduce the fuel consumption of the automobile by the light weight Kevlar/epoxy. This work also deals with the design and optimization of converting two piece driveshaft into a single piece light weighted composite driveshaft.

"Design and Analysis of an automobile propeller shaft" by A R Sivaram uses the propeller shaft coated with nickel chromium the propeller shaft coated with nickel chromium is designed analysed and compared with the existing propeller shaft similarly a propeller shaft made up of stainless steel is designed analysed and compared with existing propeller shaft. Shear stress and directional deformation of stainless steel and nickel chromium propeller shaft is analysed and the result shows that the propeller shaft made up of nickel chromium has least deformation the propeller shaft made up of nickel chromium showed enhanced properties when compared with the existing propeller shaft.

"Design and analysis of propeller shaft of an automobile using composite materials" by Natarajan R and Salaisivabalan mainly subjected to weight reduction and vehicle fuel efficiency. Composite materials are used replacing conventional steel materials used in auto parts which will reduce the weight and improve the mechanical properties of those components composite materials are generally light weighted and has more strength and stiffness. Replacing conventional steel material with composite materials such as carbon/epoxy and glass/epoxy material to minimize the current problems faced by using conventional steel. In thus test maximum deflection maximum shear stress and von-misses stress steel propeller shaft, carbon/epoxy composite propeller shaft and glass/epoxy propeller shaft is carried out. Result shows that in overall comparison glass/epoxy composite shaft is better only in weight reduction and that too only 1.56% lesser weight than carbon/epoxy composite shaft. Otherwise carbon/epoxy composite is better in shear stress and von-misses stress with a small deformation and bending natural frequency of carbon/epoxy composite shaft is 100.9% greater than glass/epoxy composite shaft

3. DEMERITS OF CONVENTIONAL STEEL SHAFT

- Fuel consumption can be increased due to increase in weight.
- Power loss can be formed.
- Less corrosion and fatigue resistance.
- They having less strength and stiffness.
- Conventionally shaft is made up of two pieces due to bending, and then three universal joints are used. When universal joint increases power transmitting capability decreases.
- Efficiency decreases.

3.1. APPLICATION OF COMPOSITE MATERIAL

- Aircraft
- Boats and marine
- Sporting equipment
- Automotive components
- Body armor
- Building materials
- Water pipes
- Bridges
- Tool handles

- Ladder rails
- Military

3.2. MATERIAL PROPERTIES

CHARACTERISTICS	STEEL	Al_2O_3	Al-SiC	UNIT
Young's Modulus	207	380	117.2	Gpa
Density	7600	4000	3000	Kg/m^3
Poisson Ratio	0.3	0.21	0.33	-
Shear modulus	80	88.165	-	Gpa
Thermal Conductivity	25	35	200	w/mk
Specific Heat	400	880	680	J/Kgk
Coefficient of Thermal Expansion	$8.6x10^{-6}$	5.6 x 10^{-6}	12.4x 10^{-6}	/k
Tensile strength	648.1	280	1206	Mpa

4. DESIGN CALCULATION

In the analysis "CHEVROLET TAVERA" vehicle is used. The dimensions are

Sl.No	Parameter of shaft	Symbol	Value	Unit
1	Outer Diameter	O.D	75	mm
2	Inner Diameter	I.D	71.8	mm
3	Length	L	1288	mm
4	Torque	T	178	Nm
5	Power	P	78	Bhp
6	Fixed Bolt		M8	

Power transmitted by shaft, P = $(2\pi NT/60)$

Maximum Torsional Stress, $\frac{T}{J}=\frac{\tau}{R}=\frac{C\theta}{l}$

This is called Torsion equation

For Solid shaft T = $\frac{\pi}{16}d^3\tau$

For hollow shaft, T = $\frac{\pi}{16}\tau(D^4-d^4)$/D

Polar moment of inertia, J = $\frac{\pi}{32}(D^4-d^4)$

Deflection, Ymax =$\frac{ML^2}{2EI}$

Maximum deflection = $(T*\frac{d.0}{2})$ I

Maximum Shear stress = (T*R.O) J

5. ANALYSIS OF PROPELLER SHAFT

The propeller shaft solid work analyses are

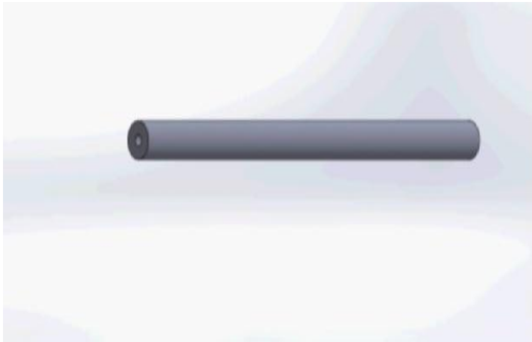

Fig -5.1: Solid work model of propeller shaft

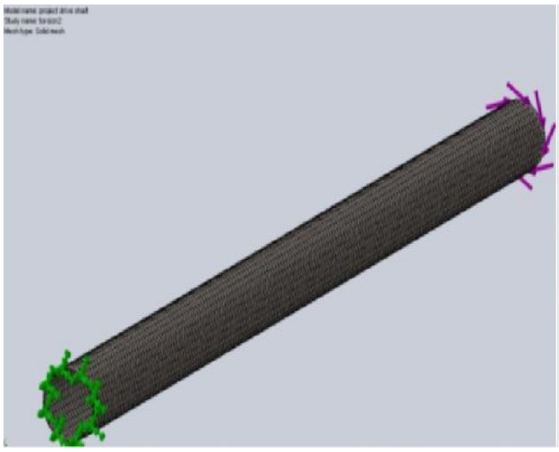

Fig-5.2: Meshing of propeller shaft

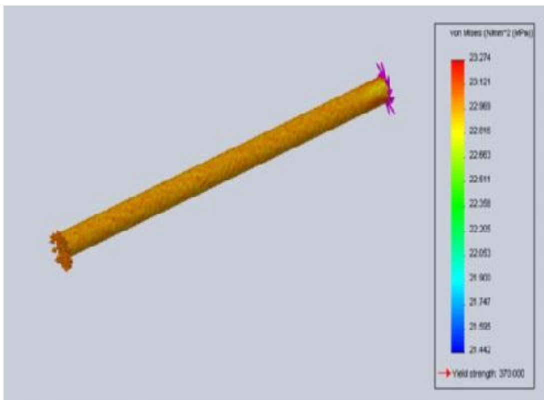

Fig-5.3: von-misses stress for SM45 steel shaft

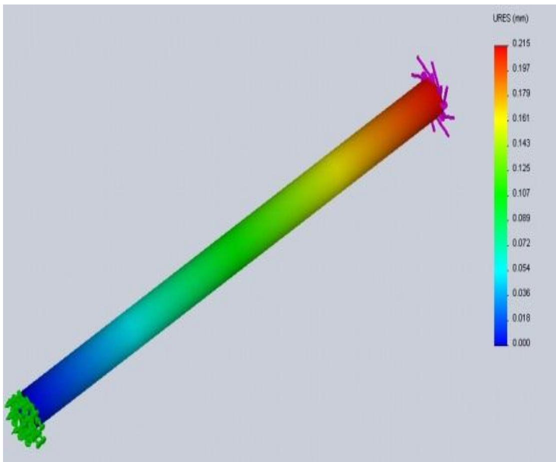

Fig-5.4: Displacement for SM45 steel shaft

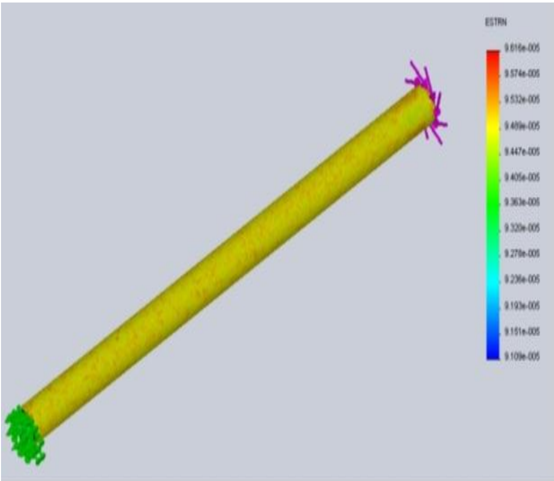

Fig-5.5: Equivalent strain for steel shaft

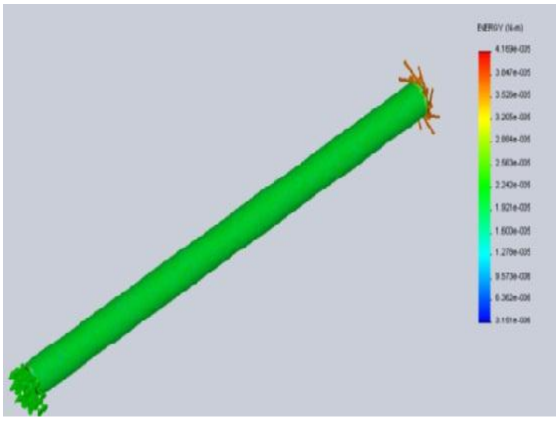

Fig-5.6: Total strain energy for steel shaft

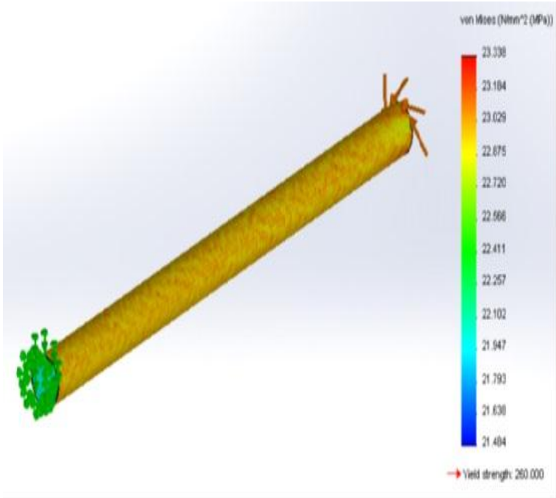

Fig-5.7: Von-misses stress for Al_2O_3

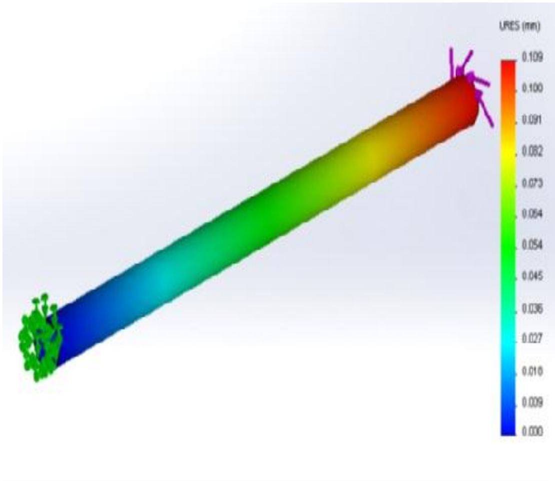

Fig-5.8: Displacement for Al_2O_3

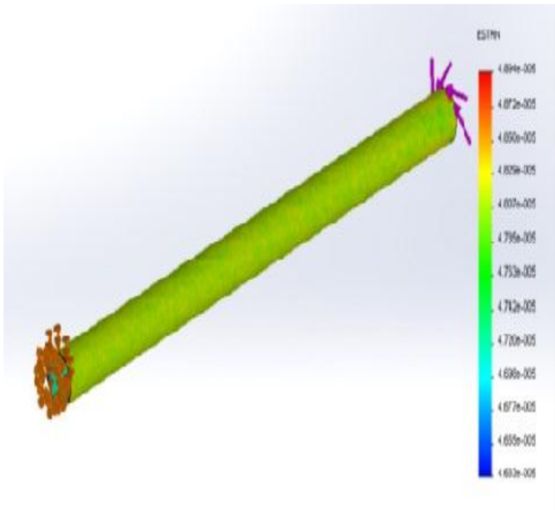

Fig-5.9: Equivalent strain for Al_2O_3

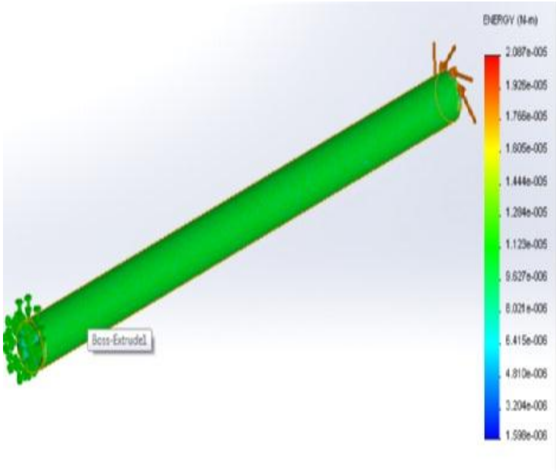

Fig-5.10: Total strain energy for Al_2O_3

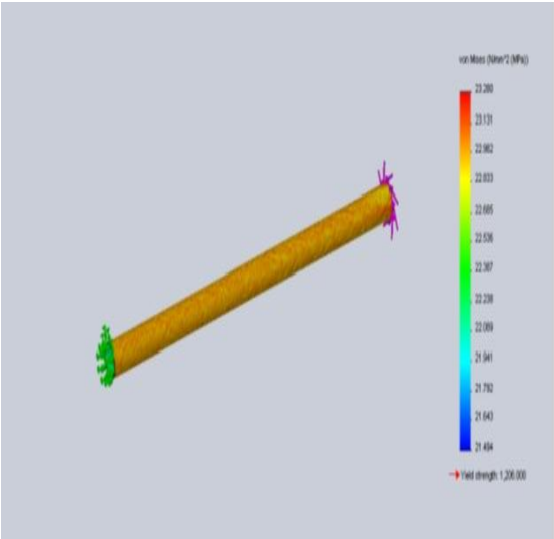

Fig-5.11: Von-misses stress for AlSiC

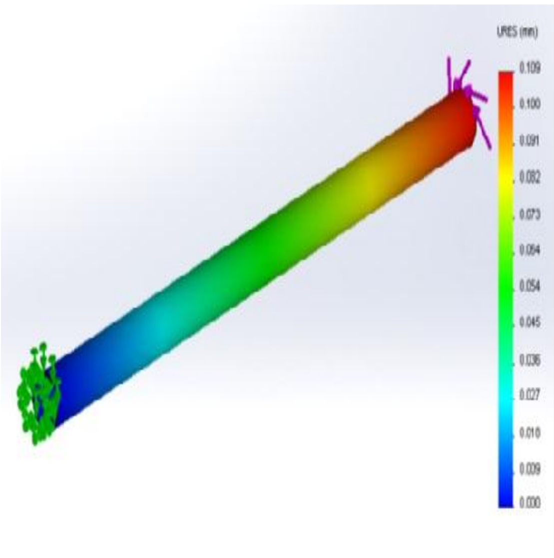

Fig-5.12: Displacement for AlSiC

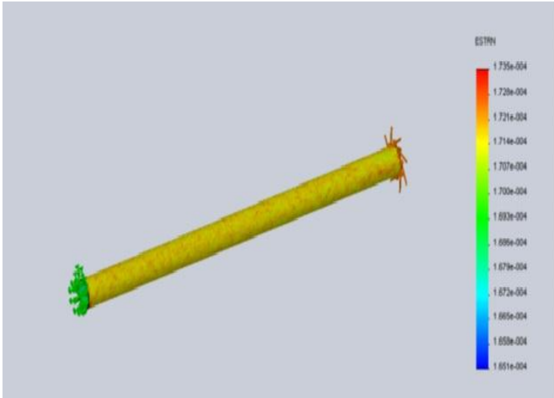

Fig-5.13: Equivalent Strain for AlSiC

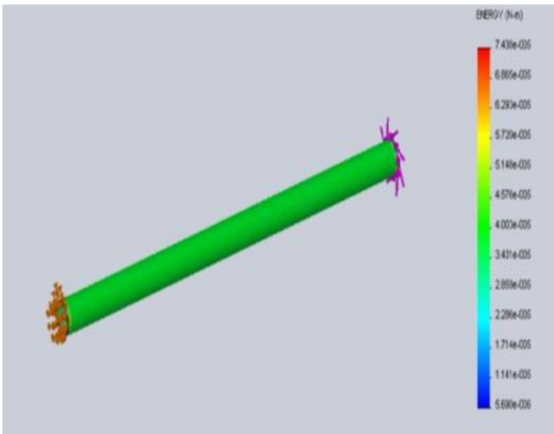

Fig-5.14: Total strain energy for AlSiC

The Propeller Shaft ANSYS analyses are

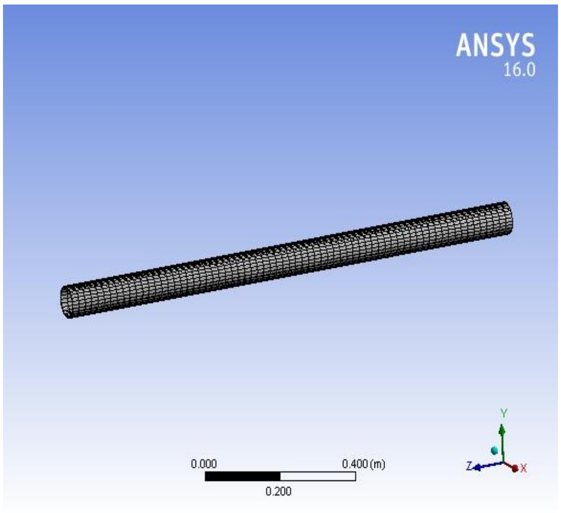

Fig-5.15: Meshing of Propeller shaft

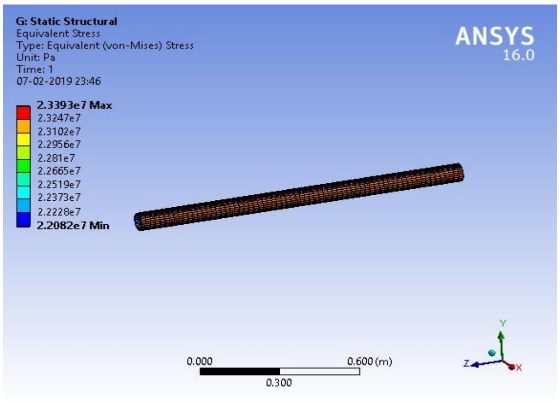

Fig-5.16: Von-misses stress for SM45 steel shaft

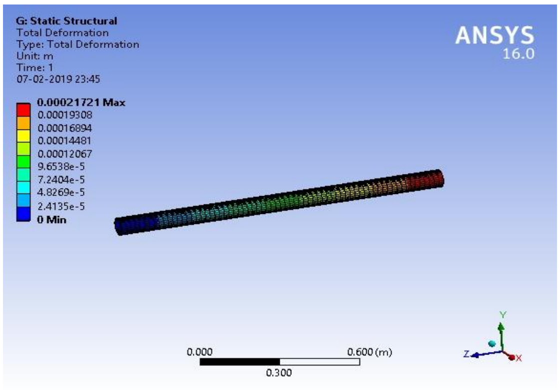

Fig-5.17: Displacement for SM45 steel shaft

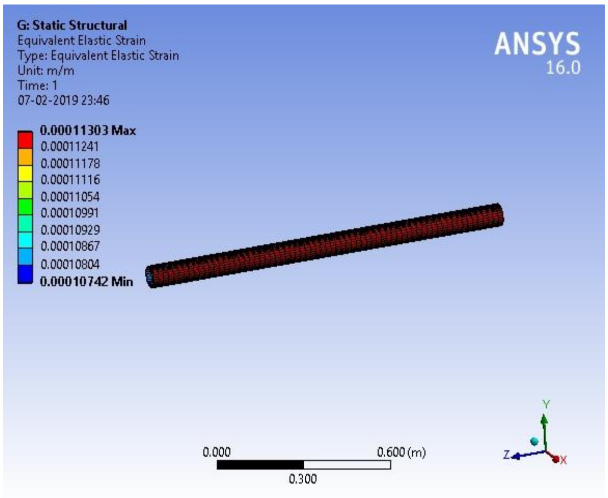

Fig-5.18: Equivalent strain for SM45 Steel Shaft

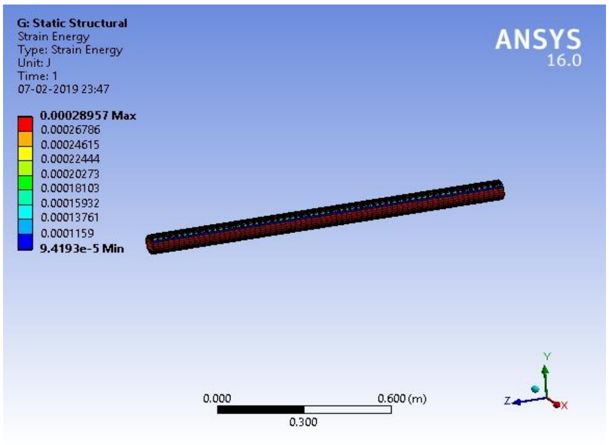

Fig-5.19: Total strain energy for SM45 Steel Shaft

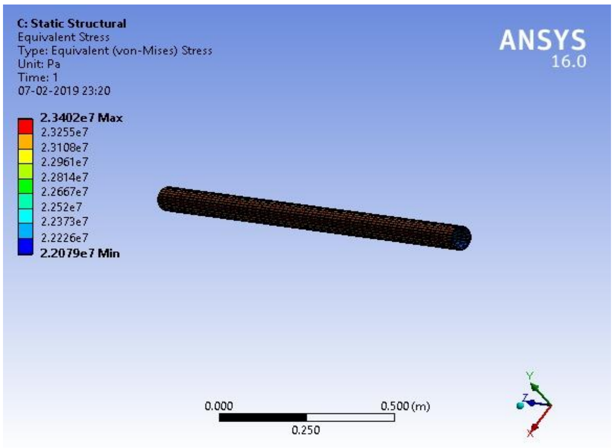

Fig-5.20: Von-misses stress for Al_2O_3

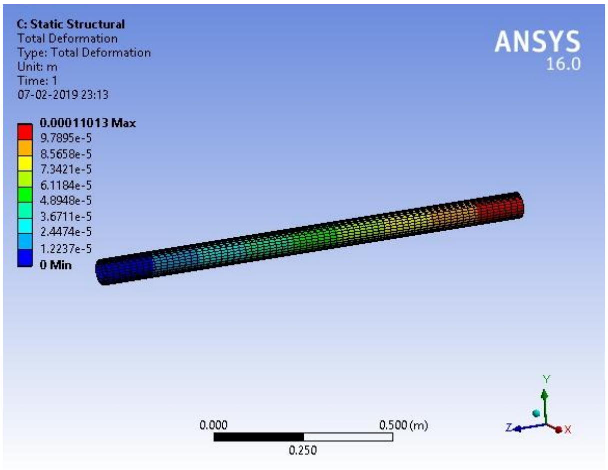

Fig-5.21: Displacement for Al_2O_3

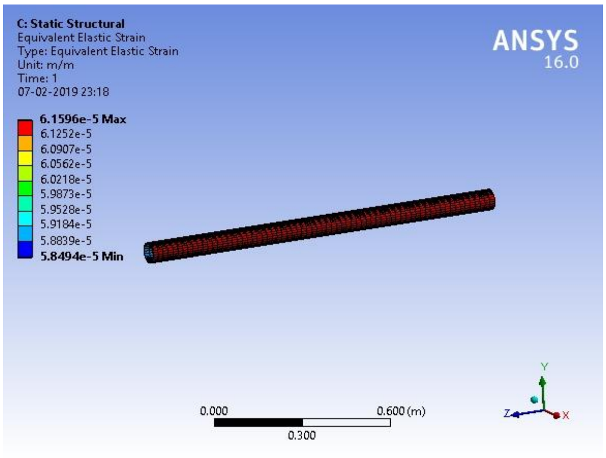

Fig-5.22: Equivalent strain for Al_2O_3

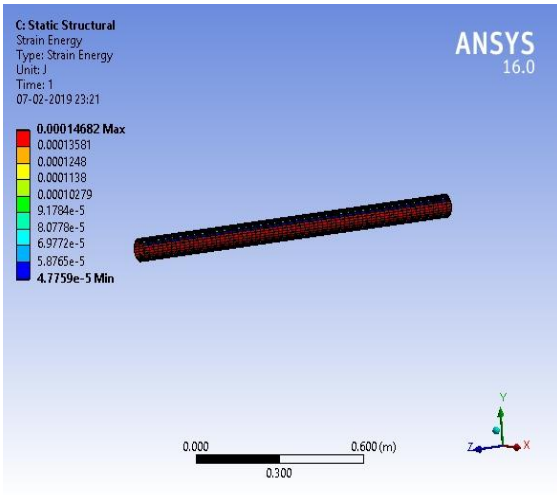

Fig-5.23: Total strain energy for Al_2O_3

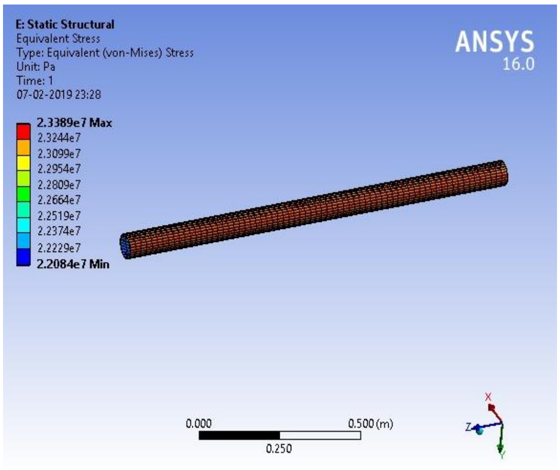

Fig-5.24: Von-misses stress for AlSiC

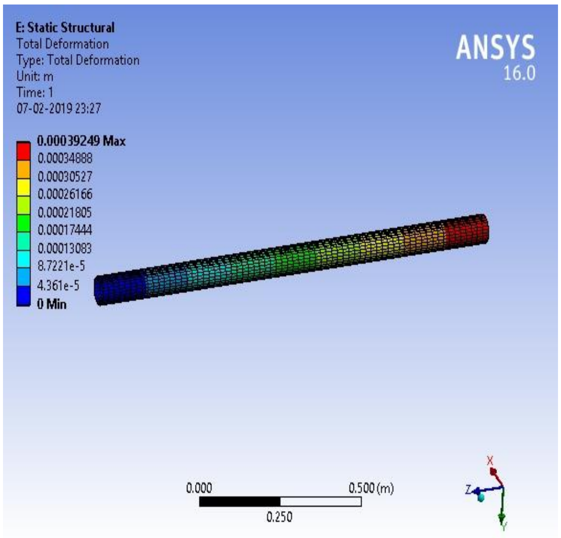

Fig-5.25: Displacement for AlSiC

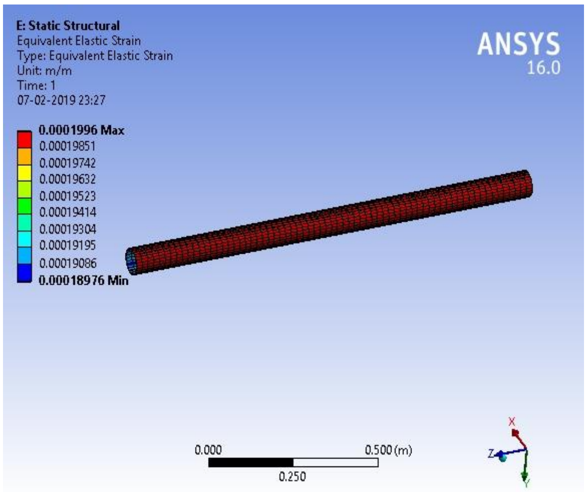

Fig-5.26: Equivalent strain for AlSiC

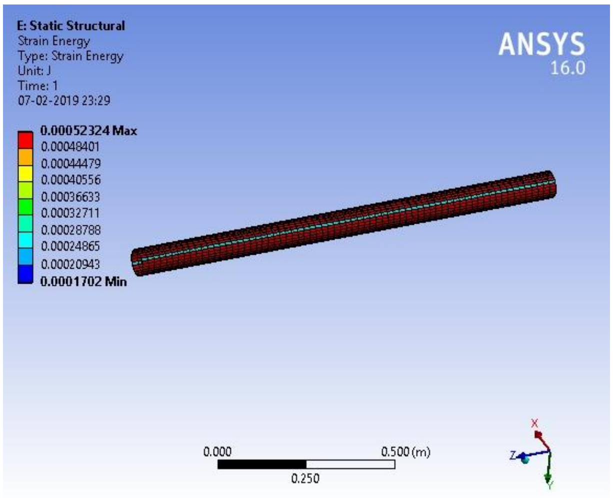

Fig-5.27: Total strain energy for AlSiC

6. RESULT AND COMPARISON

The SM45 Steel Solid work & Ansys analysis values are

Characteristics	Solid Work	Ansys	Unit
Von-misses stress	23.274	23.393	Mpa
Displacement	0.215	0.217	Mm
Equivalent Strain	$9.616e^{-005}$	0.00011303	-
Total strain energy	$4.169e^{-005}$	0.00028957	J

The Al_2O_3 Solid work & Ansys analysis values are

Characteristics	Solid Work	Ansys	Unit
Von-misses stress	23.338	23.40	Mpa
Displacement	0.109	0.11	mm
Equivalent Strain	$4.894e^{-005}$	$6.1596e^{-5}$	-
Total strain energy	0.00014062	0.0001468	J

The AlSiC Solid work & Ansys analysis values are

Characteristics	Solid Work	Ansys	Unit
Von-misses stress	23.20	23.389	Mpa
Displacement	0.0003880	0.00039249	m
Equivalent Strain	$1.735e^{-004}$	0.0001996	-
Total Strain energy	$7.438e^{-005}$	0.00052324	J

7. CONCLUSIONS

1. The usage of composite material will decrease the amount of weight, when compared to conventional steel shaft.
2. When the weight decrease, fuel consumption also decreases.
3. By usage of composite material single piece shaft can be implemented. Then the power loss decreases.
4. In this analysis Al_2O_3 composite shaft is comparatively better. Because they have less deformation when compared to conventional steel shaft.
5. In the software analysis, the ANSYS is more accurate as compared to Solid work software.

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