Investigation Of Different Composite Based Helical Gears In Automobile To Improve The Mechanical Properties

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Abstract- *This project mainly deals with the design and analysis of helical gear with involutes profile. The involutes gear profile is the most commonly used system for gearing today. Rotation of the gears causes the location of this contact point to move across the respective tooth surfaces. The teeth on helical gears are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement. Generally the helical gears are made up of stainless steel, cast iron which are producing high deformation, stress, strain values which results low safety factor and also having low strength, wear resistance and high friction. To overcome this problem the helical gear replace with carbon epoxy, aluminum silicon carbide, E-glass and S2-glass composite materials for minimizing the deformation, stress, strain values and improving the safety factor, strength and wear resistance and less friction due to this life time of the gear will be increased*

I. INTRODUCTION

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping.

Helical gears are cylindrical gears whose teeth are not parallel to the axis of rotation . The teeth are angled and appear as a segment of a helix which makes it transmit power between parallel or right angle axes. The main difference between a helical gear and other gears is that the teeth form a helix and has the potential to run more quietly. Another advantage of using these gears are that they will have more capability to transmit load between two parallel shafts as compared to the similar module and equivalent width of spur gears and also having less wear and tear as the load will be distributed between several teeth..

II. OBJECTIVES

i. To design a helical gear with high safety factor

ii. ii. To calculate the stress, strain, deformation values and suggest the best helical gear material by using ansys results compare with theoretical results

iii. By conducting structural analysis, modal analysis and theoretical analysis finding the best composite material instead of stainless steel and cast iron

III, DESIGN CALCULATION FOR HELICAL GEAR

The design calculation of the helical gear pair has the following steps.

Design Parameter	Value	Unit
Vehicle gross weight	700	kg
Power (P)	20	kW
R.P.M (N_p)	6500	rpm
Helix angle (ψ)	23	degree
Pressure angle (ϕ)	20	degree
Modulus of Elasticity (E)	207	GPa
Ultimate Strength	2220	MPa
Yield Strength	1790	MPa
Brinell Hardness (BHN)	627	-
Number of teeth of pinion	11	mm
Number of teeth of gear	34	mm

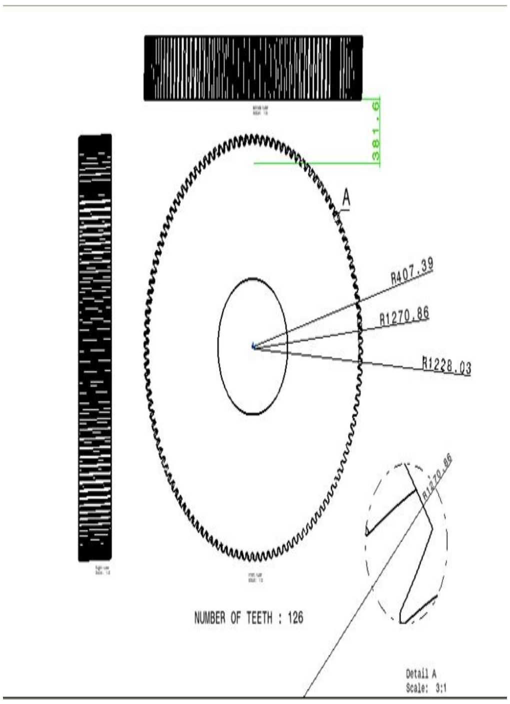
Parameters:

Number of teeth=34
Normal module-=2.8
Pitch Diameter=85
Normal pressure angle=20
Helix angle=26
Width=25

Theoretical Results

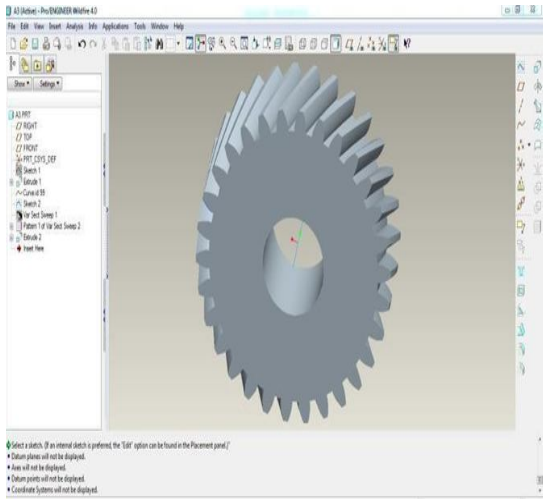
Materials	Deformation (mm)	Stress (MPa)	Strain	Safety factor
Stainless steel	0.0001035	2.224	$9.314*10^{-6}$	0.97
Cast iron	0.0004752	2.647	$4.357*10^{-6}$	0.82
Aluminum silicon carbide	0.000648	1.945	$4.149*10^{-6}$	1.1178
Carbon epoxy	0.000194	1.325	$1.256*10^{-6}$	1.64113
e-glass	0.000453	1.645	$1.497*10^{-6}$	1.322
S2-glass	0.000391	1.845	$6.4*10^{-6}$	1.1786

CAD Computer Aided Design (CAD) is a technique in which man and machine are blended in to problem solving team, intimately coupling the best characteristics of each. The result of this combination works better than either man or machine would work alone , and by using a multi discipline approach, it offers the advantages of integrated team work.



Helical gear formula:

Transverse module=Normal module/cos(Helix angle)
Normal circular pitch=p*Normal module
Transverse circular pitch=p*Transverse module
Transverse pressure angle=((tan(normal pressure angle)/(cos(helix angle)))
Outer diameter= pit
Base diameter=Pitch diameter*(cos(transverse pressure angle)



Helical Gear-PTC CREO Parametric

	Symbol	Pinio n	Gear	Unit
No. of teeth	n	11	34	-
Pitch circle diameter	D	27.5	85	mm
Outside diameter	D_0	32	89	mm
Root diameter	D_R	21	78	mm
Face width	b	21	21	mm
module	m	2.5	2.5	mm
Speed	N	6500	5000	rpm

Design result data for helical gear

ANSYS:Ansys is a general purpose finite element modeling package for numerically solving a wide variety of mechanical, electrical problems.

In general, a finite element solution can be broken into the following these categories.

Preprocessing module: Defining the problem The major steps in preprocessing are given below

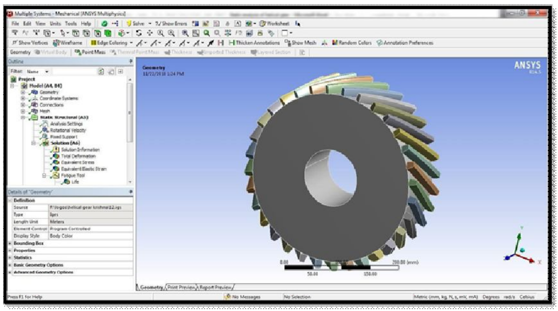
- defining key points /lines/areas/volumes
- define element type and material /geometric /properties
- mesh lines/areas/volumes/are required

The amount of detail required will depend on the dimensionality of the analysis (i.e. 1D, 2D, axis, symmetric)

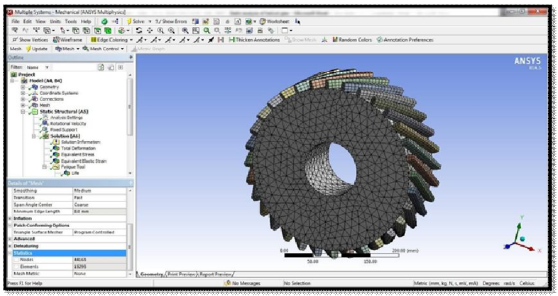
Solution processor module: assigning the loads ,constraints and solving. Here I specify the loads (point or pressure), constraints (translation, rotational) and finally solve the resulting set of equations.

Post processing module: further processing and viewing of results In this stage I can see:

List of nodal displacement Elements forces and moments Deflection plots Stress contour diagrams



Imported model

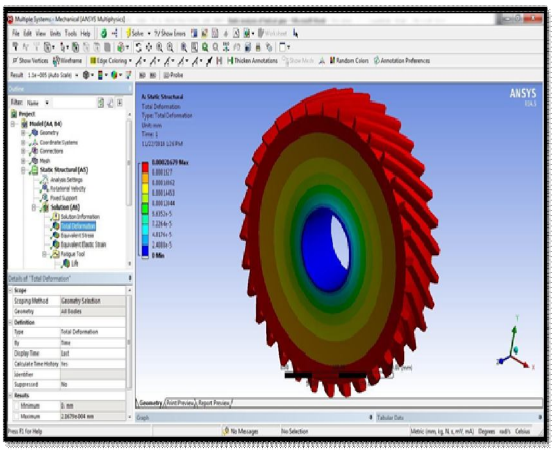


Meshed model

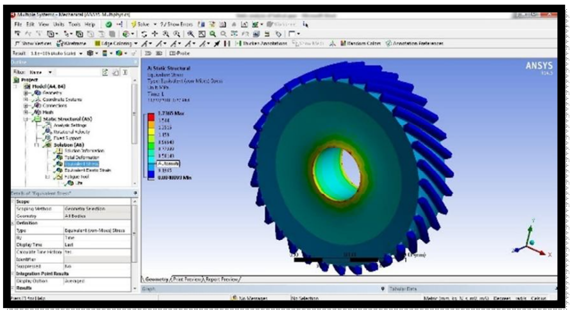
Static analysis of stainless steel helical gear

Chart : Density Outline Row 3: stainless steel

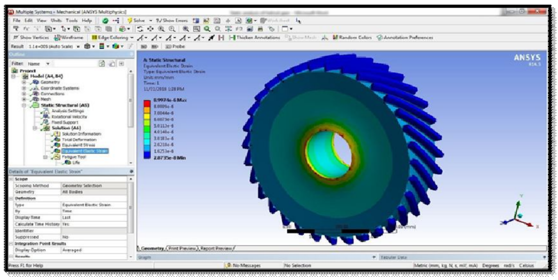
	A	B	C
1	Property	Value	Unit
3	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's M...	
8	Young's Modulus	1.93E+05	MPa
9	Poisson's Ratio	0.311	



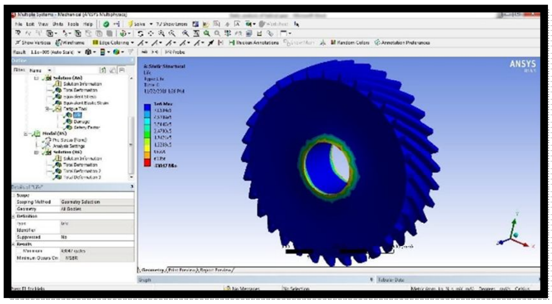
Deformation



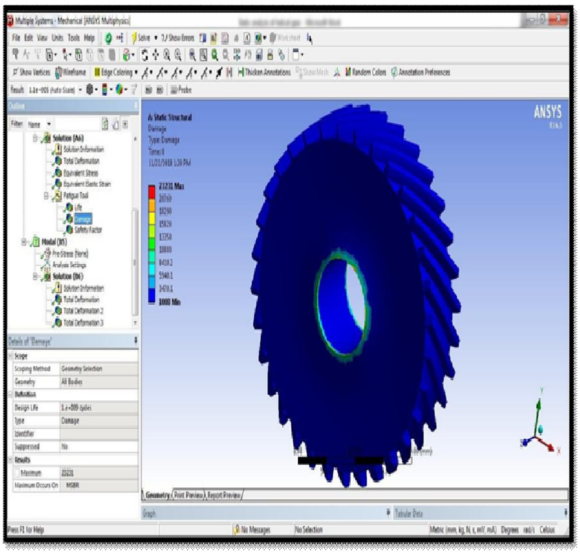
Stress



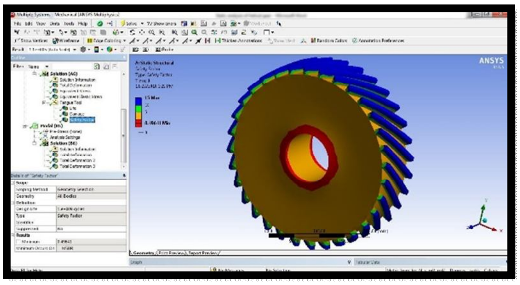
Strain



Fatigue analysis of helical gear Life



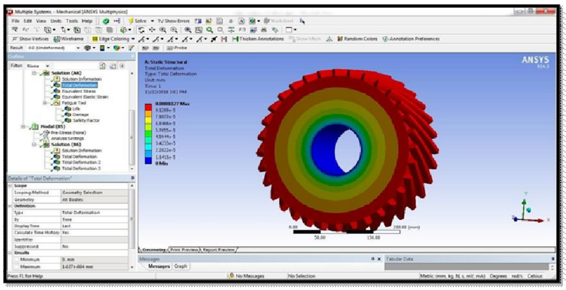
Damage



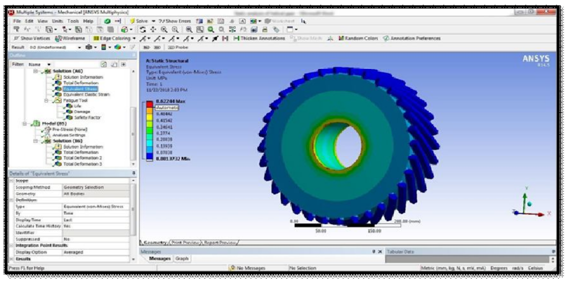
Safety factor

Static analysis of aluminum silicon carbide helical gear

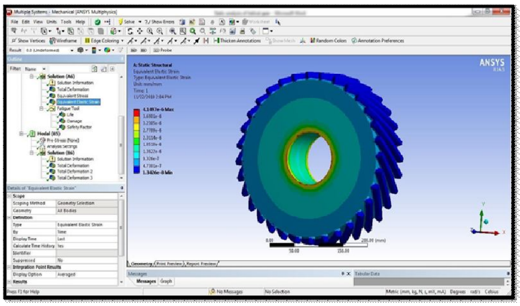
Chart : Density Outline Row 3: aluminum silicon carbide					
		A	B	C	
1		Property	Value	Unit	
2		Density	2810	kg m^-3	
3	⊞	Isotropic Secant Coefficient of Thermal Expansion			
6	⊟	Isotropic Elasticity			
7		Derive from	Youngs M...		
8		Young's Modulus	1.5E+05	MPa	
9		Poisson's Ratio	0.3		



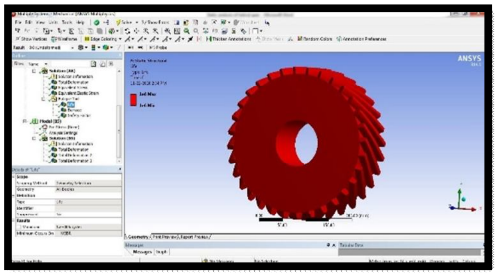
Deformation



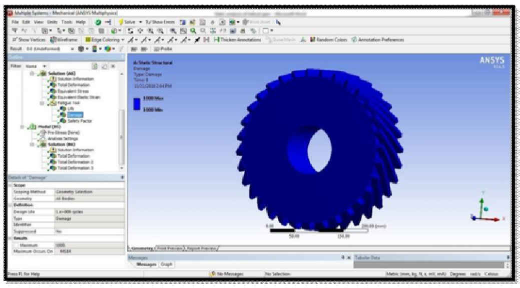
Stress



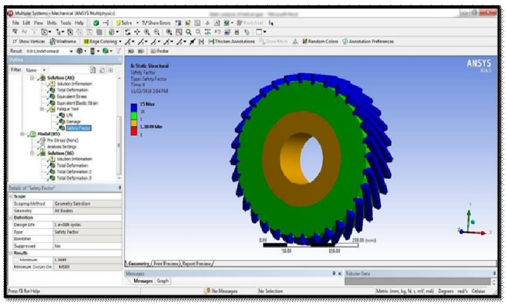
Strain



Fatigue analysis of helical gear Life



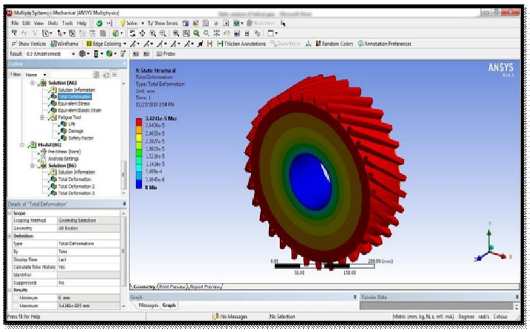
Damage



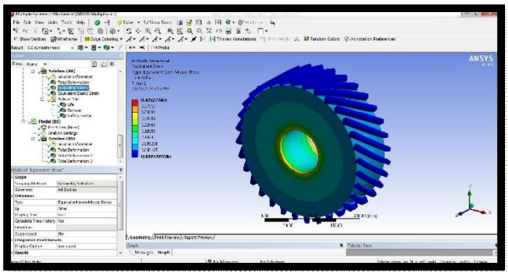
Safety factor

Static analysis of E-glass helical gear

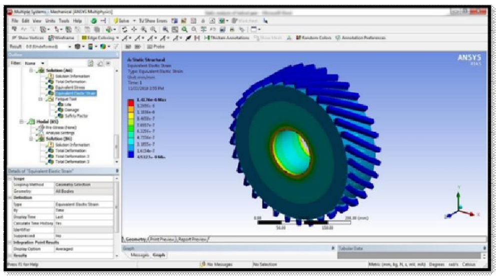
Chart : Density Outline Row 3: eglass					
		A	B	C	
1		Property	Value	Unit	
2		Density	1900	kg m^-3	
3	⊞	Isotropic Secant Coefficient of Thermal Expansion			
6	⊟	Isotropic Elasticity			
7		Derive from	Young's M...		
8		Young's Modulus	3E+05	MPa	
9		Poisson's Ratio	0.31		



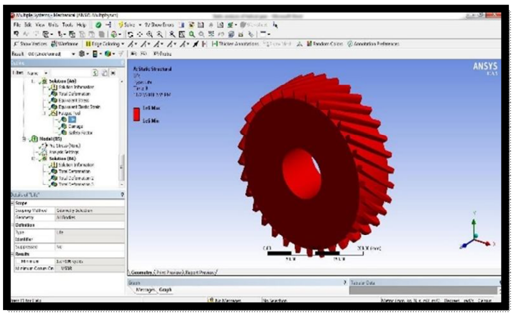
Deformation



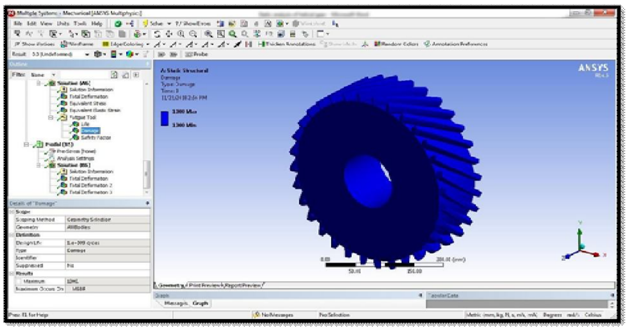
Stress



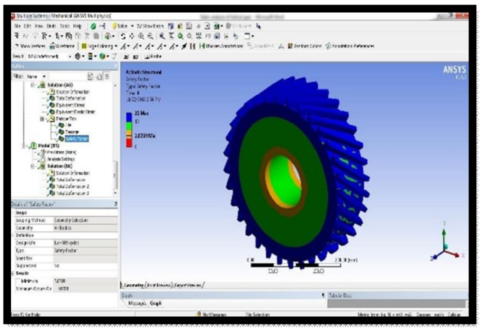
Strain



Fatigue analysis of helical gear Life



Damage

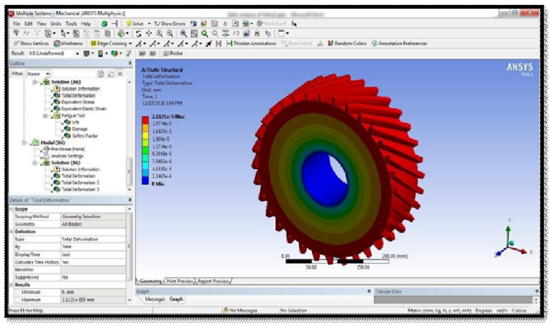


Safety factor

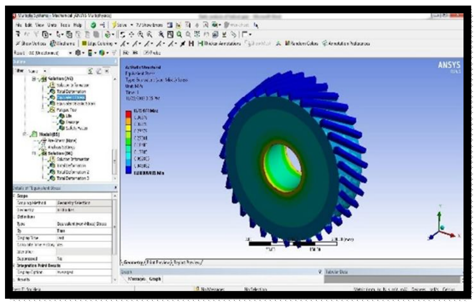
Static analysis of s2-glass helical gear

Chart : Density Outline Row 3: s2-glass

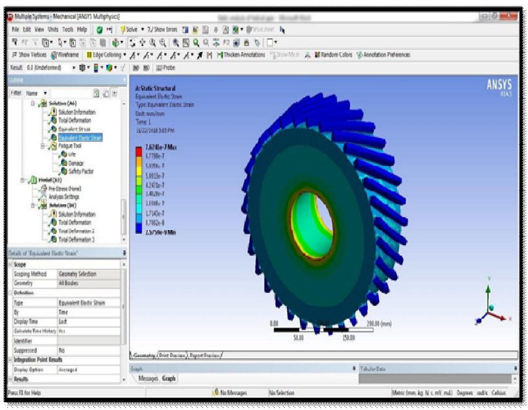
	A	B	C
1	Property	Value	Unit
2	Density	1969	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's M...	
8	Young's Modulus	5.44E+05	MPa
9	Poisson's Ratio	0.252	



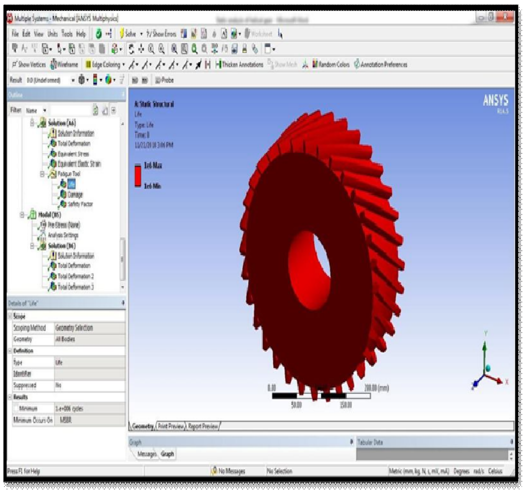
Deformation



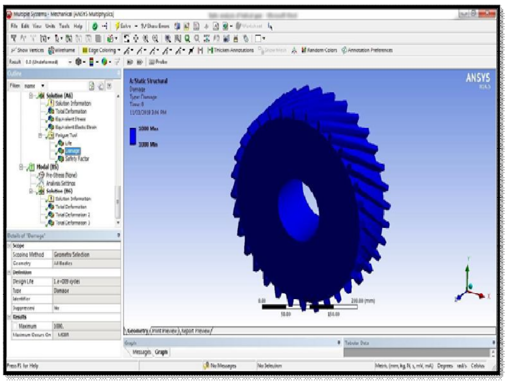
stress



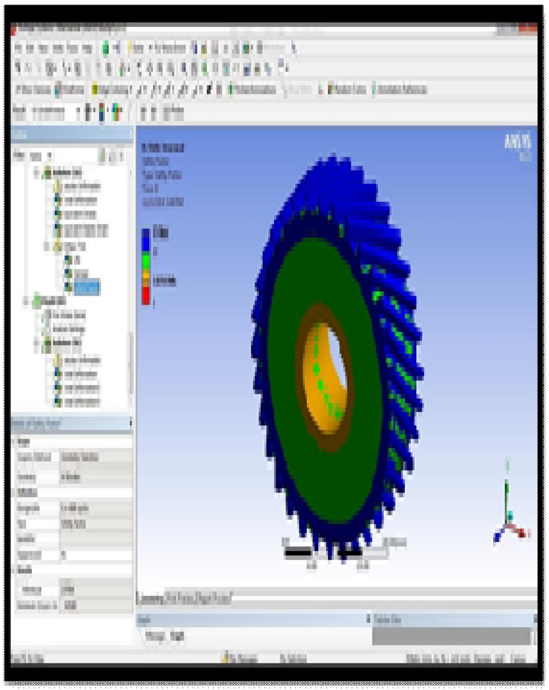
strain



Fatigue analysis of helical gear Life



Damage



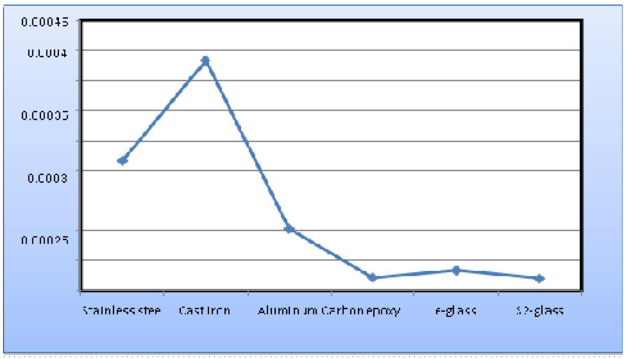
Safety factor

Static Analysis Results And Comparision

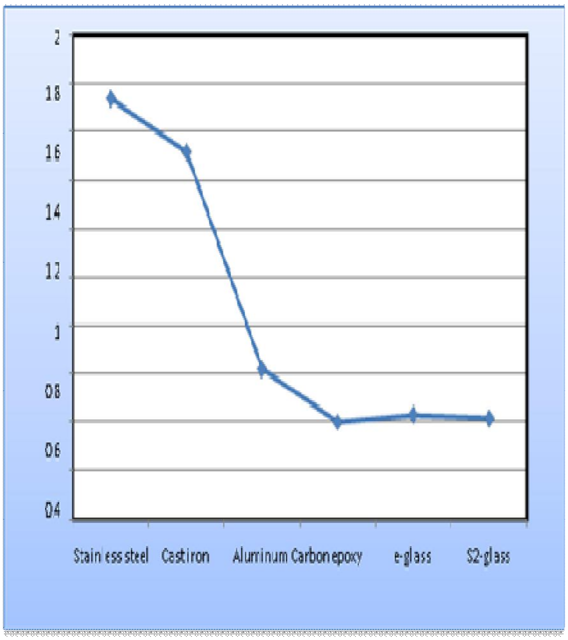
Materials	Deformation (mm)	Stress (MPa)	Strain	Damage	Safety factor	Cost per kg
Stainless steel	0.00021679	1.7365	$8.9974*10^{-6}$	23231	0.49641	100
Cast iron	0.00038289	1.5134	$1.3758*10^{-5}$	14027	0.56959	95
Aluminum	0.0001027	0.62244	$4.1497*10^{-6}$	1000	1.3849	120
Carbon epoxy	0.000021929	0.39871	$8.8606*10^{-7}$	1000	2.1619	250
e-glass	0.000034241	0.42827	$1.4976*10^{-6}$	1000	2.0269	200
S2-glass	0.000021121	0.41474	$7.6241*10^{-7}$	1000	2.0784	250

Theoretical Results And Comparision

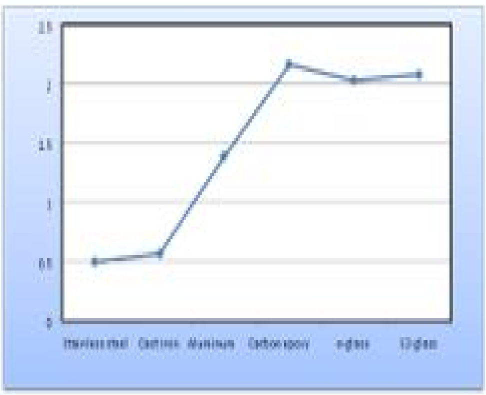
Materials	Deformation (mm)	Stress(MPa)	Strain	Safety factor	Cost per kg
Stainless steel	0.0001035	2.224	$9.314*10^{-6}$	0.97	100
Cast iron	0.0004752	2.647	$4.357*10^{-6}$	0.82	95
Aluminum silicon carbide	0.000648	1.945	$4.149*10^{-6}$	1.1178	120
Carbon epoxy	0.000194	1.325	$1.256*10^{-6}$	1.64113	250
e-glass	0.000453	1.645	$1.497*10^{-6}$	1.322	200
S2-glass	0.000391	1.845	$6.4*10^{-6}$	1.1786	250



Deformation



Strain



Safety Factor

Modal analysis Results and Comparision

Material	Mode shapes	Deformation (mm)	Frequency (Hz)
Stainless steel	1	6.5284	3197.7
	2	9.7714	3854.9
	3	9.7669	3855.8
Cast iron	1	6.7767	2534.7
	2	10.192	3021.7
	3	10.189	3022.3
Aluminum silicon carbide	1	10.844	4701.5
	2	16.259	5645
	3	16.252	5646.2
Carbon epoxy	1	13.549	10174
	2	20.314	12216
	3	20.306	12219
e-glass	1	13.185	8055
	2	19.738	9706.9
	3	19.729	9709
S2-glass	1	12.965	10898
	2	19.578	12867
	3	19.575	12869

IV. CONCLUSION

The helical gears are made up of stainless steel, cast iron which are producing high deformation, stress, strain values which results low safety factor and also having low strength, wear resistance and high friction. To overcome this problem the helical gear replace with aluminum silicon carbide, carbon epoxy, E-glass and S2-glass composite materials for minimizing the deformation, stress, strain values and improving the safety factor, strength and wear resistance and less friction due to this life time of the gear will be increased . Under this project the helical gear with involutes profile is designed with the help of CREO parametric software, and structural analysis is carried out by the ANSYS

By observing the static analysis, modal analysis and theoretical analysis the carbon epoxy material has less stress value compare with other materials and safety factor maximum value for carbon epoxy.

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