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ANALYSIS OF SPUR GEAR BY USING COMPOSITE MATERIAL.

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ABSTRACT

To design the spur gear to study the Weight reduction and pressure sustain for Structural steel and composite materials Gearing is one of the most critical components in a mechanical power transmission system, and in most industrial rotating machinery. Apple piller is a device spur gear in a proposed project which is power transmission device in apple piller machine. Usually the spur gear material is structural steel and alloy steel has used. But here in the project we finding some new material for the spur gear which reduces weight reduction and pressure sustain. Automation tools will necessitate a refined application of gear technology, to design the spur gear model using designs software, to study the impact analysis for structural steel and composite materials and to study the torque loading for structural steel and composite materials. Finally, comparing and analyzing of the composite gear with existing structural steel gear is to be done.

Keywords—structural steel,carbon fiber,epoxy resin.

INTRODUCTION

Gearing is one of the most critical components in a mechanical power transmission system, and in most industrial rotating machinery. It is possible that gears will predominate as the most effective means of transmitting power in future machines due to their high degree of reliability and compactness.

Gear

A gear is a rotating machine part having cut *teeth*, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. .

5) Types of Gear-

1External vs internal gears

2 Helical Gears

3 Bevel Gears

4 Worm Gears

Nomenclature of Gear

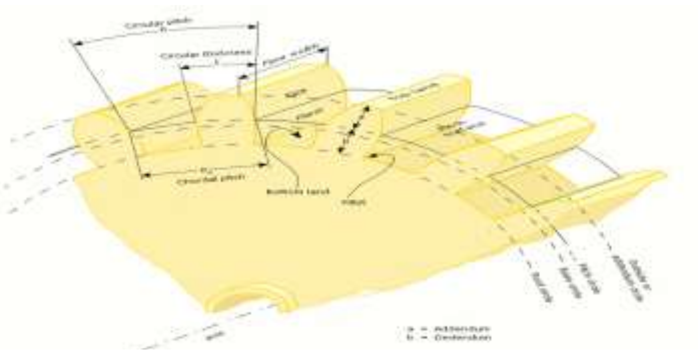


Fig 1.1

1. Pitch circle 2**. Pitch circle diameter 3. Pitch point 4. Pitch surface 5. Pressure Angle 6. Addendum7. Dedendum 8. Addendum circle 9. Dedendum Circle 10. Circular Pitch 11. Diametral pitch12. Module 13. Clearance 14. Total depth 15. Working depth 16. Tooth thickness 17. Tooth space 18. Backlash 19. Face of the tooth 20. Top land 21. Flank of the tooth 22. Face width 23. Profile 24. Fillet radius 25. Path of contact 26. Length of the path of contact 27. Arc of contact**

Spur gears

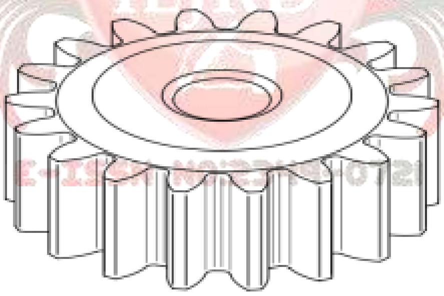


Fig 1.2

Composite Material.

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties.

The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.Primary functions of the matrix are to transfer stresses between the reinforcing fibers (hold fibers together) and protect the fibers from mechanical and/or environmental damages. A basic requirement for a matrix material is that its strain at break must be larger than the fibers it is holding. The primary functions of the additives (modifiers, fillers) are to reduce cost, improve workability, and/or impart desired properties. In this proposed project here the comparison between structural steel spur gear and composite materials. I.e. carbon fiber and epoxy resins spur gear will going to analyzed by analysis software ANSYS 15.0.

MATERIALS AND METHODOLOGY

Material

Structural steel

Structural steel is a material used for steel construction, which is formed with a specific shape following certain standards of chemical composition and strength. They can also be defined as hot rolled products, with a cross section of special form like angles, channels and beams/joints. .

Fig 1.3 S.Steel

Composite Material

Carbon Fiber The principal purpose of the reinforcement is to provide superior levels of strength and stiffness to the composite. In a continuous fiber-reinforced composite, the fibers provide virtually all of the strength and stiffness. Even in particle reinforced composites, significant improvements are obtained. Carbon fibers display linear stress-strain behavior to failure, the increase in strength also means an increase in the elongation-to-failure. The commercial fibers thus display elongations of up to 2.2%, which means that they exceed the strain capabilities of conventional organic matrices. .

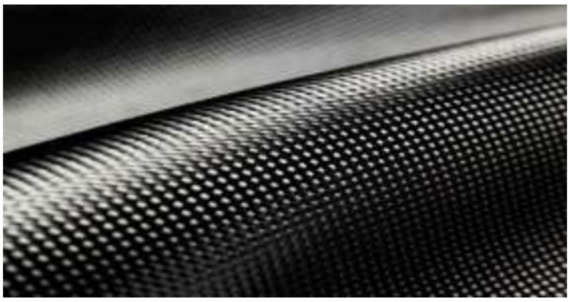


Fig 1.4 carbon fiber

Epoxy Resin :Epoxy resins are widely used in filament-wound composites and are suitable for molding prepress. They are reasonably stable to chemical attacks and are excellent adherents having slow shrinkage during curing and no emission of volatile gases. These advantages, however, make the use of epoxies rather expensive. Also, they cannot be expected beyond a temperature of 140ºC. Their use in high technology areas where service temperatures are higher, as a result, is ruled out. Epoxy-reinforced concrete and glass-reinforced and carbon-reinforced epoxy structures are used in building and bridge structures. The applications for epoxy-based materials are extensive and include coatings, adhesives and composite materials such as those using carbon fiber and fiberglass reinforcements. .

. Fig 1.5

Methodology

In methodology, theoretical analysis and finite element analysis methods are used to compare the result. The model of the structure steel and composite spur gear prepared in PROE software and then it is imported in ANSYS v15.0 for analysis. The theoretical analysis was carried out on spur gear. The theoretical results are then tabulated to compare the results with the obtained from FEM.

PROPERTIES AND CALCULATION

Properties of Structural Steel and Properties of Composites (50% Carbon Fibers in Epoxy Resin)

Properties	***Structural Steel***	***Composites (50% Carbon Fibers in Epoxy Resin Matrix***
Density	7800 kg/m^3	1800 kg/m^3
Young modulus	290 GPa	450 GPa
Poisson’s ratio	0.30	0.30

Tensile strength	250 MPa	52 MPa
Compressive strength	250 MPa	600 MPa
Bulk Modulus	1.66 PA	375 PA

Analysis with different module & loads:

Model- Apple Piller.

For Module= 3 mm

Tp= 21, t_g= 42, h=0.25×3, b_p= 32 mm, b_g=32mm, Tangent load=2500 N, E=2e11, myu= 0.3, d_p= 63mm, d_g=126 mm

For Pinion:

1) Width of Narrow Rectangular pressure distribution $\sqrt{\frac{2F\left(\frac{(1-v_1^2)}{E_1}+\frac{(1-v_2^2)}{E_2}\right)}{\pi L\left(\frac{1}{d_1}+\frac{1}{d_2}\right)}}$ = (t) = 1.38e-4 mm

2) Contact Pressure Pmax= 2×F/(pi×t×b)= 371163.58 N/mm2 = 371163.58 Mpa

3) Hertz Stress (Fh)=Pmax = 371163.58 Mp

4) Von mises Stress = 0.57×fh =211562.91 Mpa

5) Max shear stress = 0.30× fh= 111349.07 Mpa

6) Ortho shear stress= 0.25×fh= 92790.895 Mpa

For Gear:

1) Width of Narrow Rectangular pressure distribution

$\sqrt{\frac{2F\left(\frac{(1-v_1^2)}{E_1}+\frac{(1-v_2^2)}{E_2}\right)}{\pi L\left(\frac{1}{d_1}+\frac{1}{d_2}\right)}}$ = (t) = 1.38e-4 mm

2) Contact Pressure Pmax= 2×F/(pi×t×b)= 371163.58 N/mm2

3) Hertz Stress (Fh)=Pmax = 371163.58 Mpa

4) Von mises Stress = 0.57×fh=211562.91 Mpa

5) Max shear stress = 0.30× fh= 111349.07 Mpa

6) Ortho shear stress= 0.25×fh= 92790.895 Mpa **For Module= 3.5 mm**

Tp= 21, tg= 42 b_p=32 mm, b_g= 32 mm, Tangent load=2500 N, E=2e11, myu= 0.3, d_p=73.5mm, d_g=147 mm

For Pinion:

1) Width of Narrow Rectangular pressure distribution

$\sqrt{\frac{2F\left(\frac{(1-v_1^2)}{E_1}+\frac{(1-v_2^2)}{E_2}\right)}{\pi L\left(\frac{1}{d_1}+\frac{1}{d_2}\right)}}$ = (t) = 1.489e-4 mm

1)Contact Pressure Pmax= 2×F/(pi×t×b)= 333962.35 N/mm2 = 333962.35 Mpa

2)Hertz Stress (Fh)=Pmax = 333962.35 Mpa

Module in mm	Equivalent (Von-Mises) Stress (Max.) MPa	Pressure (Max.) Mpa	Friction Stress (Max.) MPa	Compreesive yield strength Mpa
3.0	6050.5	4135.2	827.04	600
3.5	5085.9	3697.1	739.42	600

3)Von miss Stress = 0.57×fh=109358.54 Mpa

4)Max shear stress = 0.30× fh= 100188.70 Mpa

5)Ortho shear stress= 0.25×fh= 83490.588 Mpa

For Gear:

1) Width of Narrow Rectangular pressure distribution

$$\sqrt{\frac{2F\frac{(1-v_1^2)}{E_1}+\frac{(1-v_2^2)}{E_2}}{\pi L\left(\frac{1}{d_1}+\frac{1}{d_2}\right)}} = (t) \quad = 1.489e\text{-}4 \text{ mm}$$

1) Contact Pressure Pmax= 2×F/(pi×t×b)= 333962.35 N/mm2 = 333962.35 Mpa

2) Hertz Stress (Fh)=Pmax = 333962.35 Mpa

3) Von missess Stress = 0.57×fh=109358.54 Mpa

4) Max shear stress = 0.30× fh= 100188.70 Mpa

5) Ortho shear stress= 0.25×fh= 83490.588 Mpa

RESULT AND DISCUSSION.

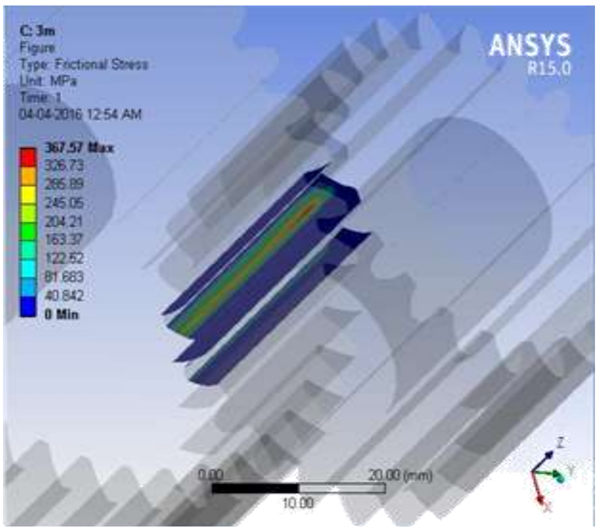
Analysis result of Structural steel spur gear and Composite materials spur gear (Carbon fiber and epoxy resins)

Applying Module of 3 mm and 3.5 mm with *Analysis result of Structural steel spur gear and Composite materials spur gear (Carbon fiber and epoxy resins)* and then behavior of each element is analyzed with different material properties.

Table *Analysis result of Structural steel spur gear*

Table *Analysis result of C.M spur gear*

Module in mm	Equivalent(Von-Mises) Stress (Max.) MPa	Pressure (Max.) Mpa	Friction Stress (Max.) MPa	Compreesive yield strength Mpa
3.0	2689.1	1837.9	367.57	250
3.5	2266.2	1644.8	328.95	250



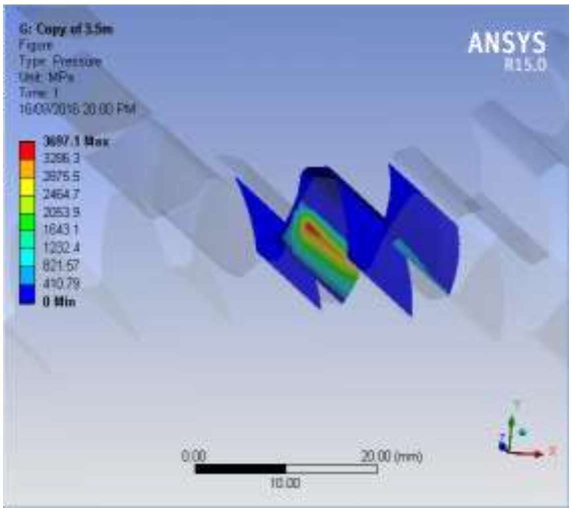

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Figure
Type: Pressure
Unit: MPa
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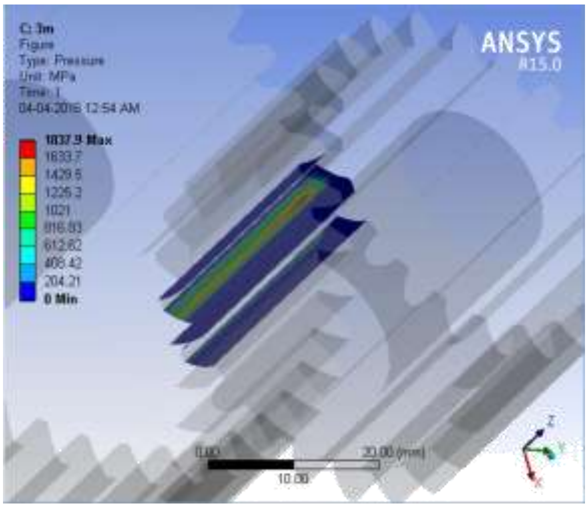
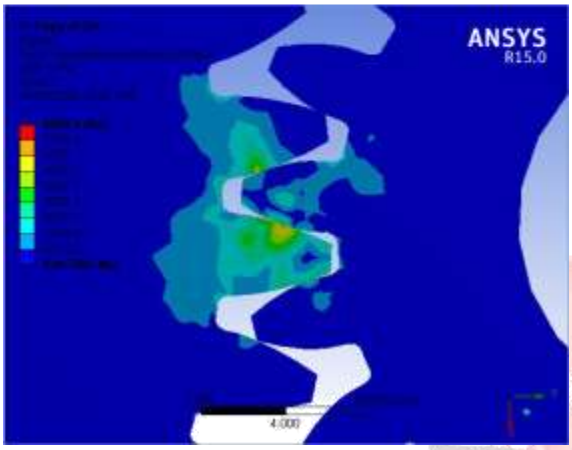
16/09/2016 20:00 PM
3697.1 Max
3286.3
2875.5
2464.7
2053.9
1643.1
1232.4
821.57
410.79
0 Min
ANSYS
R15.0
0.00
20.00 (mm)
10.00


C: 3m
Figure
Type: Pressure
Unit: MPa
Time: 1
04-04-2016 12:54 AM
1837.9 Max
1633.7
1429.5
1225.3
1021
816.83
612.62
408.42
204.21
0 Min
ANSYS
R15.0
0.00
20.00 (mm)
10.00


ANSYS
R15.0
4.000

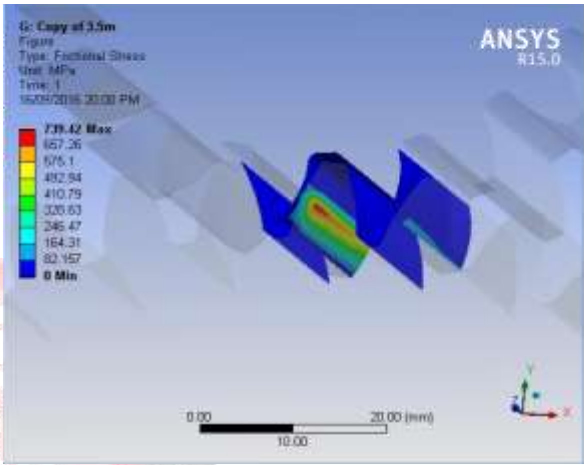

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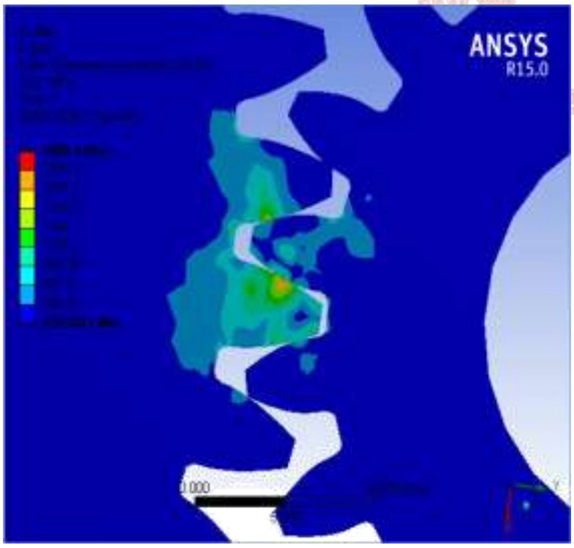
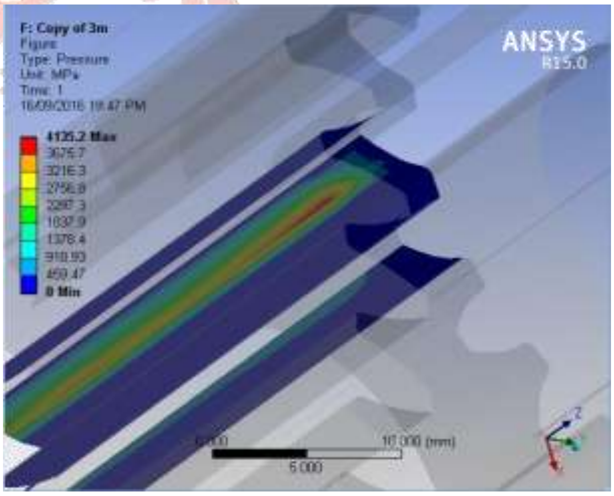
Figure
Type: Frictional Stress
Unit: MPa
Time: 1
16/09/2016 20:00 PM
739.42 Max
657.26
575.1
492.94
410.79
328.63
246.47
164.31
82.157
0 Min
ANSYS
R15.0
0.00
20.00 (mm)
10.00


ANSYS
R15.0
0.000


F: Copy of 3m
Figure
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Unit: MPa
Time: 1
16/09/2016 19:47 PM
4135.2 Max
3675.7
3216.3
2756.8
2297.3
1837.9
1378.4
918.93
459.47
0 Min
ANSYS
R15.0
0.000
10.000 (mm)
5.000

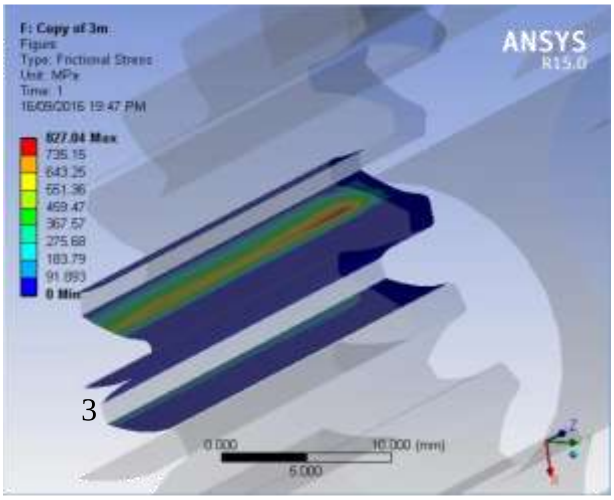
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Figure
Type: Frictional Stress
Unit: MPa
Time: 1
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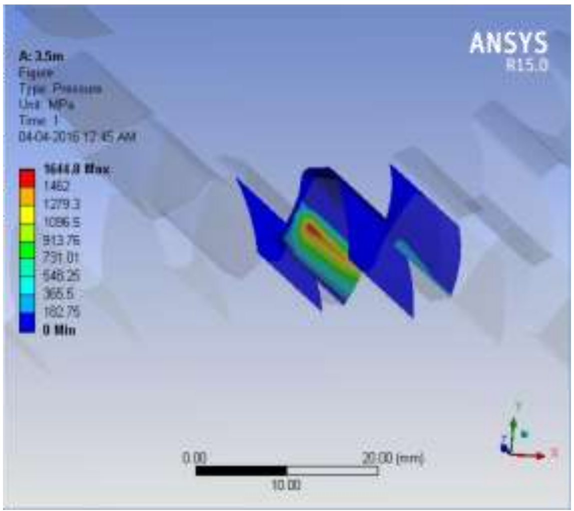
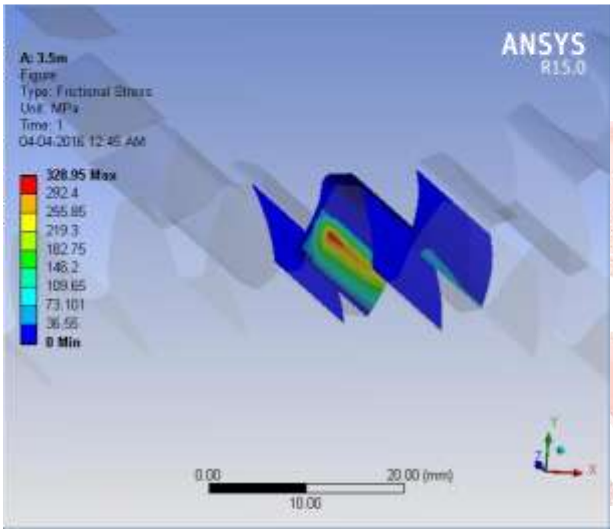
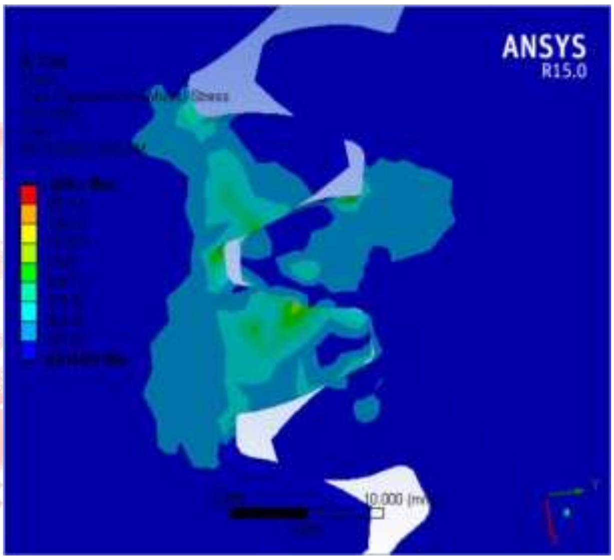
827.04 Max
735.15
643.25
551.36
459.47
367.57
275.68
183.79
91.893
0 Min
ANSYS
R15.0
3
0.000
10.000 (mm)
5.000


A: 3.5m
Figure
Type: Pressure
Unit: MPa
Time: 1
04-04-2016 12:45 AM
1644.8 Max
1462
1279.3
1096.5
913.76
731.01
548.26
365.5
182.75
0 Min
ANSYS
R15.0
0.00
20.00 (mm)
10.00


A: 3.5m
Figure
Type: Frictional Stress
Unit: MPa
Time: 1
04-04-2016 12:45 AM
328.95 Max
292.4
255.85
219.3
182.75
146.2
109.65
73.101
36.55
0 Min
ANSYS
R15.0
0.00
20.00 (mm)
10.00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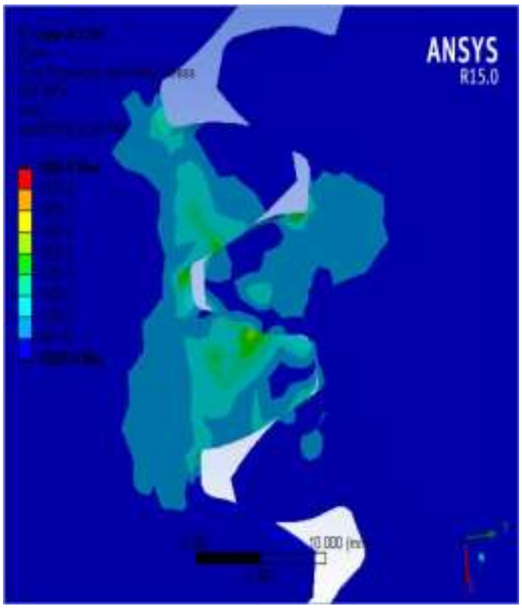
ANSYS
R15.0

CONCLUSION

From the above result formulated from simulation and analysis of structural steel and composite material i.e. carbon fiber and epoxy resin composite for the spur gear material in apple piller the following conclusion has been made.
1] as the density of composite of carbon fiber and epoxy resin is less than structural steel near about 75% that gives extreme weight reduction in case of composite material we shown effective result in power transmission.
2) From the properties it also seen that compressive strength of composite material is greater than structural steel near about 50% means composite material sustain against more compressive stress.
3) from the table it also seen that pressure sustainability in composite material is more means in the structural steel maximum pressure sustainable is found to be 1897.9 mpa while in composite material of carbon fiber and epoxy resins is found to be more i.e. maximum limit is 4135.28mpa
4) The stresses generated in composite material also seen to be more in composite material i.e. composite material is more reliable for the higher stress generated during working of spur gear than structural steel spur gear material.
5) But there is a small drawback in case of frictional stress which produced more stress in composite material than structural steel which wear and tear losses but it not affects that much.
6) Form above the conclusion it seems that carbon fiber and epoxy resins is a better alterative than the structural steel to replace as a spur gear material.

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Acknowledgement is an expression of enlightened appreciation and reorganization actuated by gratitude towards those whose valued help and thoughtfulness punctuates any undertaking till it witness a fruitful end.

Getting a project done reflects the proverbial saying "success is a marathon and not a sprint". For participating in a marathon one needs to be dedicated and persevere for the cause. Dedication and perseverance when supported by inspiration and guidance leads to success.

Last but not least I also acknowledge the help of family, colleagues, friends and all those who have encouraged and helped me directly or indirectly with my work but whose contribution I may have failed to mention inadvertently.

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