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Modelling and Analysis of Chain Sprocket using Different Materials

M.Lohith Srikrishna Varma, I.Rama Pavan Kumar Varma, M.Hari Krishnam Raju

Abstract*: A chain sprocket is one of the essential segments of chain drive for transmitting power, starting with one shaft the non to next. To guarantee effectual power transmission, chain sprocket ought to be appropriately planned and made. As sprockets varies from number of teeth, material and measurements utilized in automobiles, machines and so on. This study involves the fundamentals of sprocket modelling through reverse engineering approach. In this examination sprocket is broke down utilizing finite element analysis for wellbeing and dependability. A cad model of chain sprocket is designed in Catia V5 part module. Pre-processing and post-processing operations are done in ansys workbench. We applied material properties of Aisi 4140, Gray cast-iron, carbon fiber and values for Von-Missies, total deformation, equivalent strains and stresses has been compared. Utilizing these advancements secluded examination on sprocket is performed for better material selection. Also knowledge on dimensioning, drafting, synthetic creation and material determination are discussed.

Index Terms: **Ansys, Chain sprocket,** ***Catia V5, Modelling, Materials, Reverse engineering.***

I. INTRODUCTION

A sprocket is a cogged wheel which has material projections over a rim, which operates by interlocking of projections, chain or belt drive mechanism. Sprockets are a toothed wheel which allows transferring power to adjoining pulleys or shafts. It is perceived that sprockets never engage directly since pulleys have smooth teeth. Sprockets are adopted where gear mechanism cannot be adopted for power transmission.

Typically sprockets entangled with chain drive installed in bicycles, motorized vehicles. The efficiency of Chain sprocket can be evaluated from first generation power transmission mechanisms.

Fig. 1: Chain drive sprocket

II. CHAIN SPROCKET

A chain sprocket is one of the essential segments of chain drive for transmitting power, starting with one shaft the non to next. All over the power is yield to essentially turning the chain, which can be used to lift or drag objects. In various conditions, a second device is set and the power is recovered by affixing shafts or focus focuses to this gear. In spite of the way that drive chains are much of the time direct oval circles, they can in like manner bypass corners by putting more than two riggings along the chain; adjusts that don't put control into the structure or transmit it out be usually identified as idler-wheels. By changing the broadness of the information and yield designs with respect to one another, the gear extent can be adjusted. For example, when bicycle pedals' device turn one time, it causes gear that drives wheels to turn more than single change.

III. REVERSE ENGINEERING

Extracting approximations from existing customary model of pulsar 180cc chain sprocket is made through reverse engineering. The acquired approximations are inserted in CAD modeling to make improved capabilities to present structure, which pulls out a new part design with best approach to do advanced modeling.

IV. CAD MODELLING

Computations of existing sprocket are obtained through reverse engineering. These values are dumped into CAD (Computer Aided Designing) to get a computer generated model.

A. CATIA

Catia (computer aided three dimensional interactive application) is imposed with computations of sprocketto get 3D model. Hence the conventional sprocket is converted to cad model using catia.

Information – Bajaj Pulsar 180 sprocket

Sprocket Diameter - 170 mm

Number of Teeth - 42

Chain pitch - 12.7 mm

Sprocket Width – 8.51 mm

Roller Thickness – 7.22 mm

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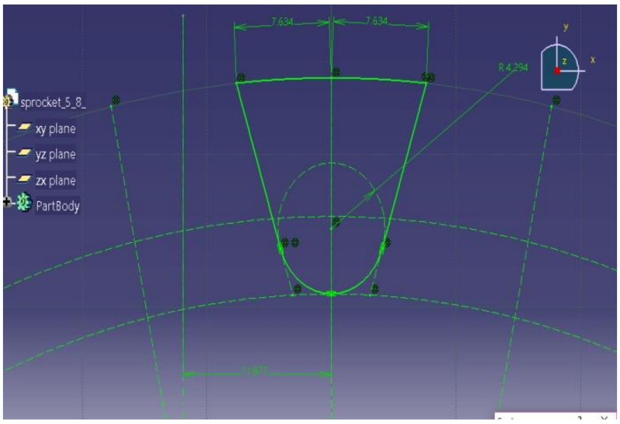

Fig. 2: Sprocket tooth geometry

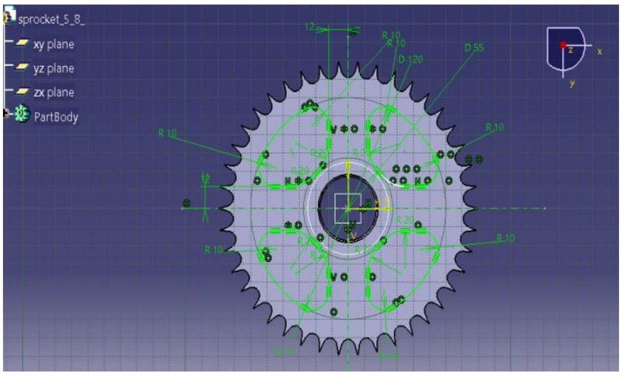

Fig. 3: Sketch of sprocket in catia

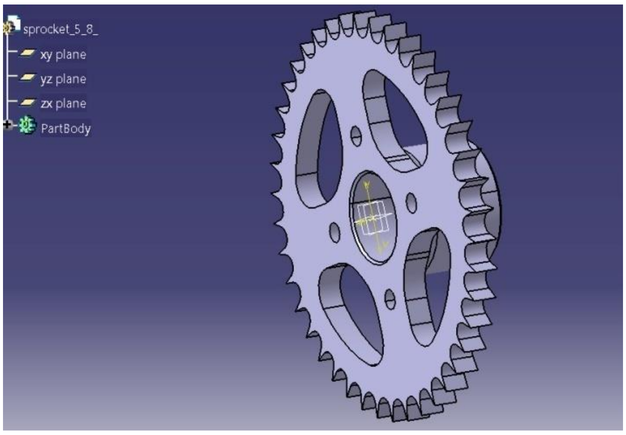

Fig. 4: Cad model of sprocket

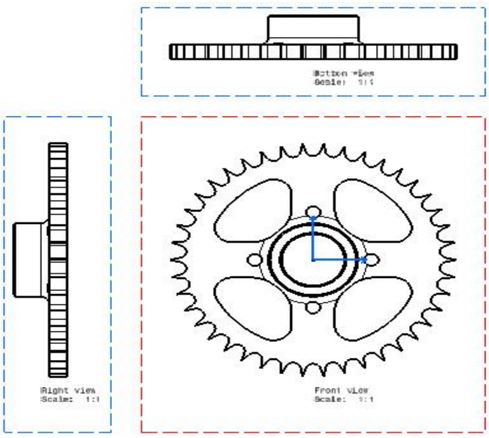

Fig. 4: Drafting image of sprocket

V. SPROCKET MATERIALS

A sprocket can be made of different materials based on required strength and service conditions. In this an examination is established on materials of iron family element, an alloy and a carbon element. This gives a better choice of sprocket based on application. As materials reduce in weight, noise and cost will improve efficiency of sprocket.

A. Gray Cast Iron

It is a cast iron in which carbon is in uncombined form of graphite flakes. Most gray cast iron contains 2.4 to 4.0 percent. The mechanical properties of grey iron are restrained by graphite flakes shape and size present in the microstructure and can be symbolized from the guidelines given by the ASTM.

Table 1: Material properties of Gray cast iron

Property	value
Youngs modulus, E	180 GPa
Poissons Ratio, v	0.21
Density, ρ	7.06-7.34*10^3
Yield stress,	98-290 MPa
Ultimate tensile stress	160-450 MPa

B. Alloy Steel AISI 4140

AISI 4140 is versatile alloy of molebdinum-chromium steel. Its composition gives high strength and hardness, which ensures good wear resistance, superior toughness desirable for gears and sprockets.

Table 2: Composition of alloy steel AISI 4140

Carbon	Silicon	Manganes e	Chromia m	Molybdinu m
0.36-0.44%	0.10-0.4 %	0.65-1.1%	0.75-1.2 %	0.15-0.35 %

Table 3: material properties of alloy steel AISI 4140

Property	value
Youngs modulus, E	190 - 210 GPa
Poissons Ratio, v	0.27-0.30
Density, ρ	7.85 gm/cm^3
Yield stress,	415 MPa
Ultimate tensile stress	655 MPa

C. Carbon Fiber Epoxy

Carbon fibers provide base for advancements in structural engineering. It is suitable for high performance applications due its characteristics like self–lubricating, thermal resistance and high tensile strength which are suitable for performance enhancement in sprockets.

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Table 4: Material properties of carbon fiber epoxy

Property	value
E_{11}	190 GPa
E_{12}	7.7 GPa
G_{12}	4.2 GPa
V_{12}	0.3
$S_{t1}=S^{c}_{1}$	870 MPa
$S_{t2}=S^{c}_{2}$	54 MPa
S_{12}	30 MPa
P	1600 Kg/m^3

VI. FINITE ELEMENT ANALYSIS

Finite elements analysis is processed through Ansys-16.0 software tool. It has triple stage of problem evaluation. I.e. Pre-processing, Post-processing and solving for results.

A. Pre-processing

1. *Meshing*

It is the breaking of domain into polygonal or polyhedral elements to solve the problem using finite element analysis. The obtained mesh is called finite element mesh.

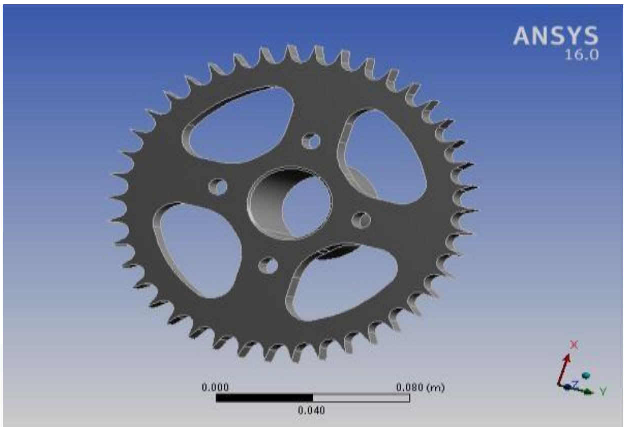

Fig. 6: Cad model before meshing

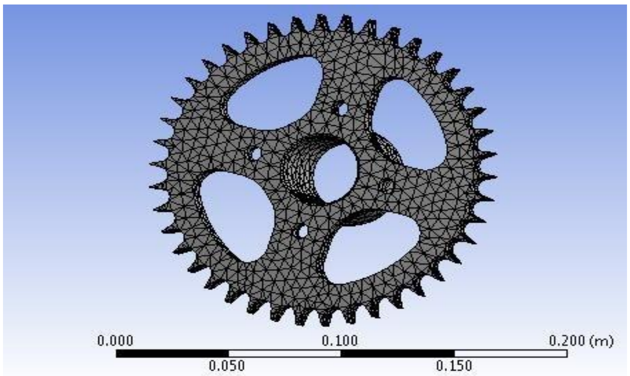

Fig. 7: Meshed cad model

No. of Node: 16990

No. of elements: 8412

2. *Boundary Conditions*

To get the solution some reference conditions to be applied to finite element analysis.
Boundary conditions for Sprocket pulsar 180

Fixed force -383 Nm

Gear extent = 26.93:1

Engine torque = 14.22 Nm @ 6500 rpm

Torque = T_e X G = 383 Nm

Standard Earth Gravity = 9.81 m/sec

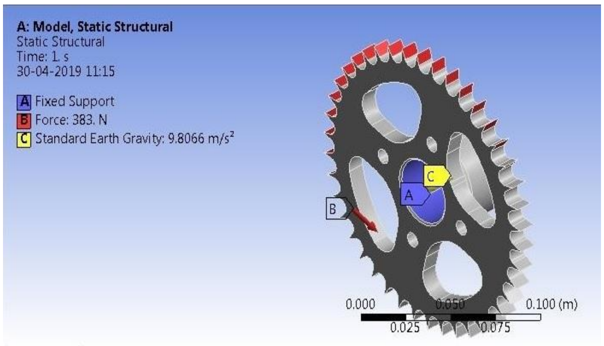

Fig. 8: Boundary conditions applied on sprocket

B. Post-processing

After pre-processing, the cad model is imported for analysis procedure of solving called post-processing. It calculates deformations, stresses and strains based on applied boundary conditions.

C. Solutions from FEA

1. *Gray Cast Iron FEA Results*

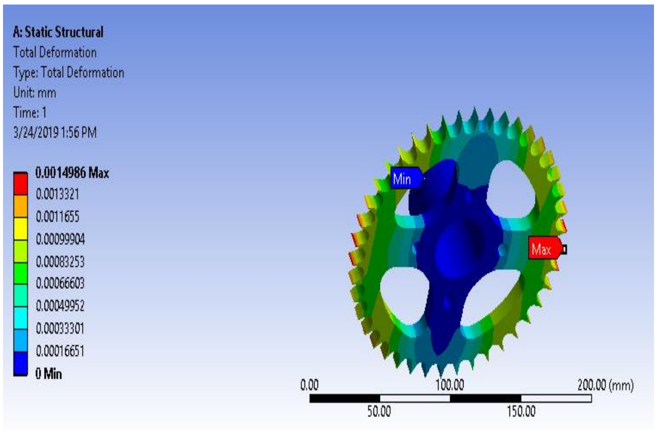

Fig. 9: Total deformation results in gray cast iron

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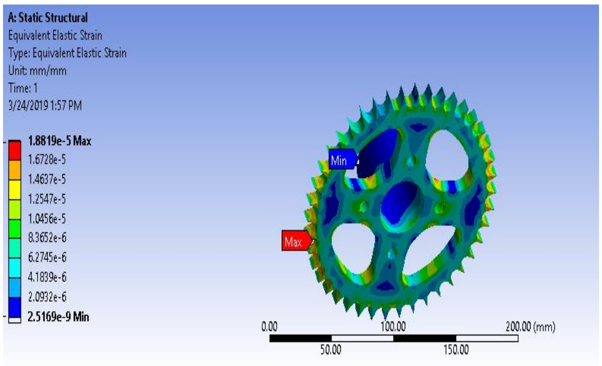

Fig. 10: Equivalent elastic strain results in gray cast iron

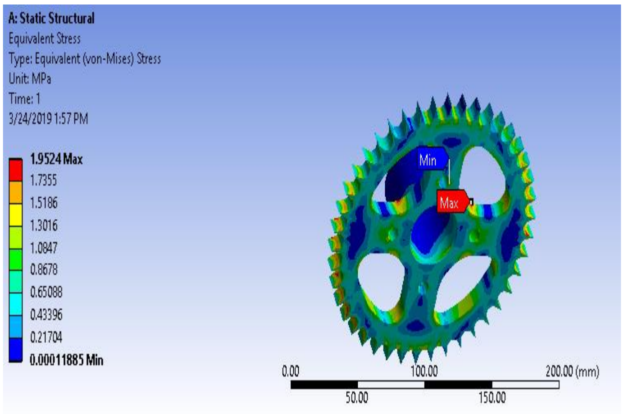

Fig. 11: Equivalent elastic stress results in gray cast iron

Table 5: Analysis results of Gray cast iron

Observation	Min	Max
Total deformation	0 mm	1.44986e-003 mm
Equivalent elastic strain	2.5169e-009 mm/mm	1.8819e-005 mm/mm
Equivalent stress	1.1885e-004 MPa	1.9524 MPa
Directional deformation	-4.3229e-004 mm	5.9835e-004 mm
Shear stress	-0.99206 MPa	0.96734 MPa

2. *Alloy Steel AISI 4140 FEA Results*

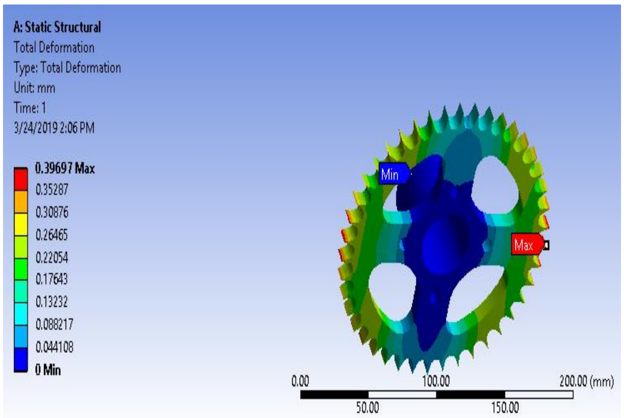

Fig. 12. Total deformation in Aisi 4140 alloy steel

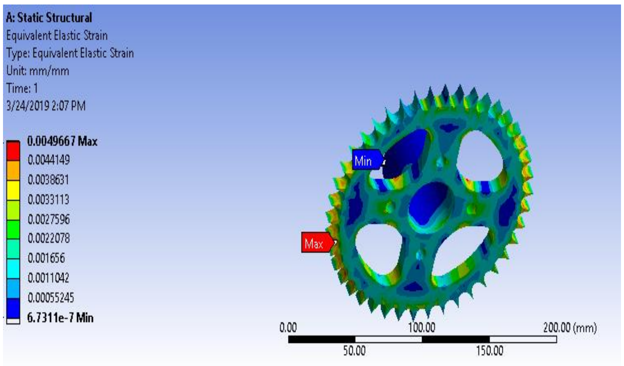

Fig. 13: Equivalent elastic strain in alloy steel Aisi 4140

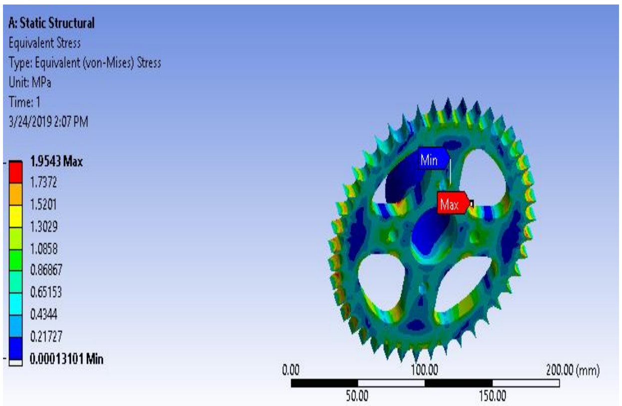

Fig. 14: Equivalent elastic stress result alloy steel Aisi 4140

Table 6: Analysis results of Aisi 4140 alloy steel

Observation	Min	Max
Total deformation	0 mm	0.39697 mm
Equivalent elastic strain	6.7311e-007 mm/mm	4.9667e-003 mm/mm
Equivalent stress	1.3101e-004 MPa	1.9543 MPa
Directional deformation	-0.11459 mm	0.15789 mm
Shear stress	-0.97009 MPa	0.97009 MPa

3. *Carbon Fiber Epoxy*

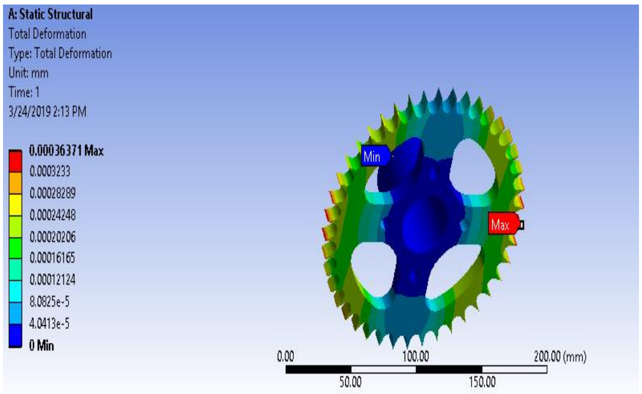

Fig. 15: Total deformation result in carbon fiber epoxy

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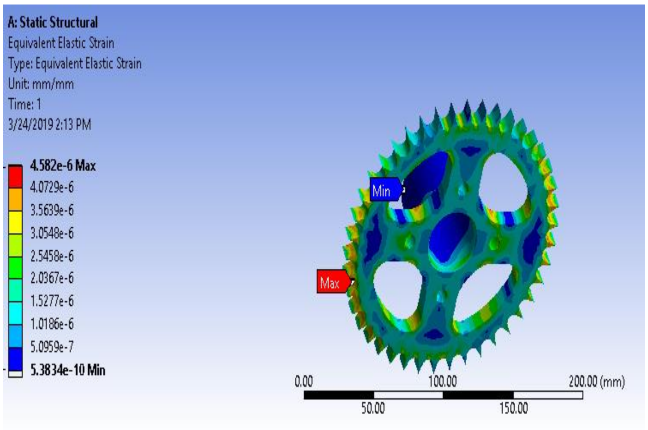

Fig.16: Equivalent elastic strain resultin carbon fiber

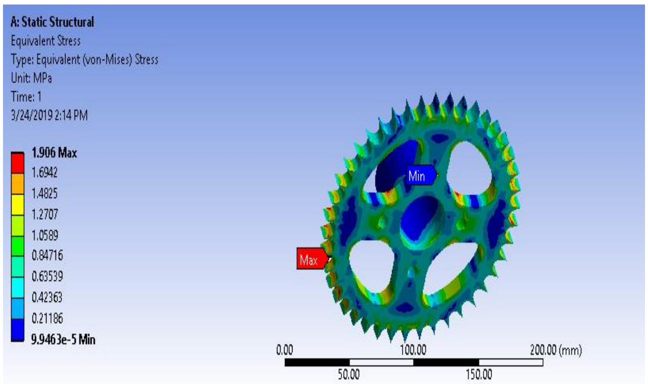

Fig. 17: Equivalent stress result in carbon fiber epoxy

Table 7: Analysis results of carbon fiber epoxy

Observation	Minimum	Maximum
Total deformation	0 mm	3.6371e-004
Equivalent elastic strain	5.3834e-010 mm/mm	4.582e-006 mm/mm
Equivalent stress	9.9463e-005 MPa	1.906 MPa
Directional deformation	-1.0455e-004 mm	1.4468e-004 mm
Shear stress	-0.9939 MPa	0.9701 MPa

VII. OBSERVATIONS

Table 8: FEA results of Gray Cast Iron

Results	Minimum value	Maximum value
Total deformation	0 mm	1.4986e-003mm
Equivalent elastic strain	2.5169e-009 mm/mm	4.582e-006 mm/mm
Equivalent Stress	1.1885e-004MPa	1.9524MPa

Table 9: FEA results of alloy steelAISI 4140

Results	Minimum value	Maximum value
Total deformation	0mm	3.9697e-004m
Equivalent elastic strain	6.7311e-007 mm/mm	4.9667e-003 mm/mm
Equivalent Stress	1.3101e-004MPa	1.9543MPa

Table 10: FEA results of Carbon Fiber Epoxy

Results	Minimum value	Maximum value
Total deformation	0 mm	3.6371e-004 mm
Equivalent elastic strain	5.3834e-010 mm/mm	4.582e-006 mm/mm
Equivalent Stress	9.9463e-005MPa	1.906MPa

By observing the above results and comparing the three materials results are discussed below.

- Total deformation value in carbon epoxy is 0.00036371 mm is less comparing to Gray cast iron and Aisi 4140 alloy steel.
- Equivalent elastic strain in Aisi 4140 alloy is 4.9697e-004 mm/mm is less compared to gray cast iron and carbon epoxy.
- Equivalent stress or von misses stress of Aisi 4140 alloy steel is 1.9543 MPa. Which indicates safer design as the material is ductile in nature.

VIII. CONCLUSION

From finite element analysis of above materials, stress values of Aisi 4140 and Carbon epoxy are in permissible limits for safer design. As compared to material properties, carbon epoxy is best suited for sprocket due to its low density, availability and less investment. Also Aisi 4140 alloy shown better results adjacent to Carbon epoxy, but in performance carbon epoxy crossed Aisi4140due to mass reduction, better lubrication and availability.

IX. FUTURE SCOPE

Different other composite materials can be used for analysis in Symmetric condition of the chain sprocket and can be analyzed for further investigation. In this project total deformation of chain sprocket, structural stress of chain sprocket, pressure between the chain and sprocket, directional stress and structural load sand its effect on fatigue life of chain sprocket were studied. The chain sprocket is subjected to various, thrust & dynamic loads, which simulated easily through CATIA & analysis because experimental calculation is complicated. For further investigation, regression analysis is suggestive.

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