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"Software "ANSYS" Based Analysis on Replacement of Material of Sprocket Metal to Plastic Material PEEK"

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***Abstract* – In this study of the stress of chain, sprocket of motorcycle is compared with the sprocket of plastic material made by PEEK. It has been achieved by using software ANSYS, by applying pressure in to the model of sprocket made in the said software. Sprocket of stainless steel is considered as an object and input variables have been taken by the physical measurement by vernier caliper, screw gauge, and different measuring instruments. As per requirement it has been designed as per the design procedure in Pro-E. With the insertion of that model into the software ANSYS and checking the finite element structure in that software; with different properties of stainless steel we found different values of equivalent stress, and total deformation. With same model of sprocket, analysis has been carried out in software ANSYS with the different properties of PEEK (polyether ether ketone).**

Keywords- *Polyether ether ketone (PEEK) , Sprocket, PRO-E, ANSYS, Equivalent stress, Total deformation.*

I. INTRODUCTION

In this paper it is proposed to substitute the metallic gear of chain sprocket of motorcycle with plastic gears to reduce the weight and noise. For the purpose plastic material were considered namely Polyether ether ketone (PEEK) and their viability are checked with their counterpart metallic gear (Stainless steel AISI304). Based on the static analysis, the best plastic material is recommended for the purpose**.** A virtual model of spur gear was created in Pro-E. Model is imported in ANSYS for analysis by applying normal load conditions. After analysis a comparison is made among existing stainless steel spur gear. Based on the deflections and stresses from the analysis, we choose plastic as a substitute of metal.

Gear is nothing but a toothed wheel which is useful to transmit power from one shaft to another shaft. They are suitable when two machine parts are nearer to each other. They give exact ratio of transmission of motion, slip cannot takes place between gears, they are useful for high torque transmission. In spur gear teeth is parallel to axis of rotation. Spur gear transmit power from one shaft to another parallel shaft. *Spur gears* or *straight-cut gears* are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form (they are usually of special form to achieve constant drive ratio, mainly involute), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel shafts.

MATERIALS FOR GEARS

The selection of material used for the manufacturing of gears depends upon the strength and service conditions like wear and noise etc. The gears maybe manufactured from metallic or non – metallic materials. The cast iron is widely used for the manufacturing of gears due to its good wearing properties, excellent machinability and ease of producing complicated shapes by casting method. The non – metallic materials like wood, rawhide, compressed paper and plastics like Nylon, Acrylic and Polycarbonate etc are used for gears, especially for reducing weight and noise.

POLYETHER ETHER KETONE

Polyether ether ketone (PEEK) is a colorless organic polymer thermoplastic in the polyaryletherketone (PAEK) family.

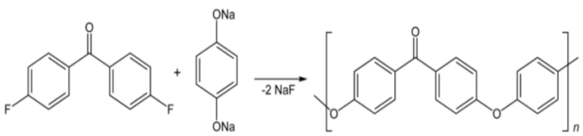

Fig. 1.1 - Structure of PEEK Material

Polyetheretherketone is the most attractive among high performance polymers, even if its use is limited by the high cost of supplying and processing and by the high sensibility to the molding processes. PEEK is generally used as matrix for high performance composites. Tribological components (such as bushes and gears) can be fabricated by injection molding of a PEEK matrix composite, filled with polytetrafluoroethylene (PTFE), graphite particles and carbon micro-fibers. The maximum amount of filler is generally limited to 30 wt% to avoid problems during injection; PTFE and graphite enhance the tribological behavior of the molded part, whereas the carbon fibers are responsible for the high mechanical performances. A disadvantage is the high price, which limits its application to high value items.

properties	
Density	1320 kg/m^3
Young’s modulus(E)	3.6 GPa
Melting point	~343 °C
Tensile strength (σ_t)	90-100 MPa
Glass temprature	143 °C

Table 1.1 - Properties of PEEK Material

SPROKETS

Sprockets are used in bicycles, motorcycles, cars, tracked vehicles other machinery. Either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc. Perhaps the commonest form of sprocket is found in the bicycle, in which the pedal shaft carries a large sprocket-wheel which drives a chain which in turn drives a small sprocket on the axle of the rear wheel.

THE FINITE ELEMENT METHOD (FEM)

The finite element method (FEM) is practical application often known as finite element analysis (FEA). It is a numerical technique for finding approximate solution of partial differential equation (PDE) as well as integral equation. The solution approach is based either on eliminating the differential equation completely (steady state problem), or rendering the PDE into an approximation system of ordinary differential equation, which are then numerically integrated using standard technique such as Euler’s method, Runge-kutta, etc.

In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied, but is numerically stable, meaning that error in the input and intermediate calculation do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, all with advantages and disadvantages. The finite element method is a good choice for solving partial differential equation over complicated domain (like cars and oil pipelines), when domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, when the solution lacks smoothness.

II. Methodology

In this dissertation work, a three dimensional model of sprocket have been considered for further investigation .The field data obtained by actual experimentation have been compared with numerical simulation results by using ANSYS.

III. Calculations

THEORETICAL CALCULATIONS OF CONVENTIONAL STAINLESS STEEL SPUR GEAR

In the present analysis the maximum torque, allowable stress and tangential load of the spur gear are calculated based on the desired chain sprocket of motorcycle specifications and are as following below:

SPECIFICATIONS OF 4 STROKE PETROL ENGINE

Power (P) = 9 kW = 9000watt

Speed (N) = 4500 RPM

$P = 2\pi NT/60$

$9*10^3 = 2\pi*1500*T/60$

$T = 19.0985 N.m$

$T = F*(d/2)$

$F = T/(d/2)$

(d=160mm)

$= 19.0985*10^3/80$

$= 238.732$ N

$F = \sigma w*b*P_c*yp$

Face width (b) = 4 mm

Circular pitch(P_c)= $\pi D/T = \pi*160/41 = 12.259$

Lewis form factor Yp=0.154-0.912/T = 0.1318 (T = 41)

$\sigma w = F/ b*P_c*yp$

$= 238.732 /4*12.259*0.1318$

$= 36.93$ N/mm^2

FOR STAINLESS STEEL AISI 304

Factor of saifty = Ultimate Tensile stress/ working stress

= 505/36.93

= 13.67

Here 13.67 > 1.5

So the design is safe for AISI 304 Stainless steel

FOR PEEK (POLYETHER ETHERKETONE)

Factor of saifty = Ultimate Tensile stress/ working stress

= 100/36.93

= 2.70

Here 2.70 > 1.5

So the design is safe for PEEK

Module (m)	D/T	160/41	3.90
Addendum	0.8* Module	0.8*3.90	3.12 mm
Dedendum	1 * Module	1*3.90	3.90mm
Pressure angle (α)			20 degree
Tooth thickness(t)	1.5708 *Module	1.5708 *3.90	6.126mm
Whole depth	1.60* Module	1.60 * 3.90	6.24mm
Fillet radius	0.4 * module	0.4*3.90	1.56mm
No. of Teeth			41

Table 3.1 - Geometric details of desired spur gear

FINITE ELEMENT ANALYSIS OF SPUR GEAR

Finite element modeling is a method to represent the geometric model in terms of a finite number of element and nodes, nodes -63178, no of element-37744. It is actually a numerical method to find out the solution for a complex region defining a continuum. Solutions obtained by this method are rarely exact. However, errors in the approximate solution can be minimized by increasing the number of equations till the desired accuracy obtained. This is an alternative to analytical methods that are used for getting exact solution of analysis problems. The solution of general problem by finite element method always follows an orderly step-by-step process. for analysis in ANSYS. The loading conditions are assumed to be static.

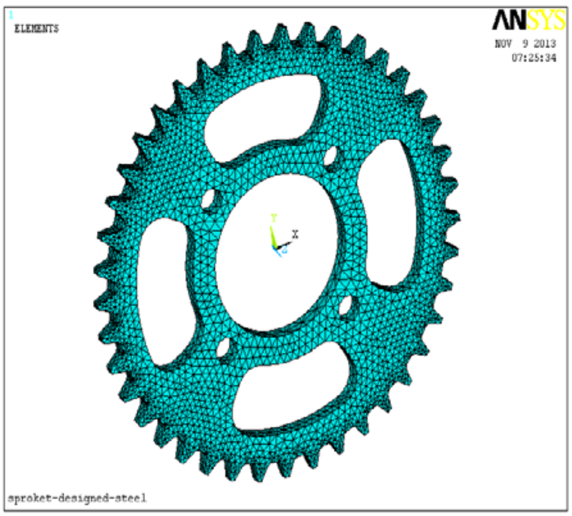

Fig. 3.1 Sproket with steel mesh

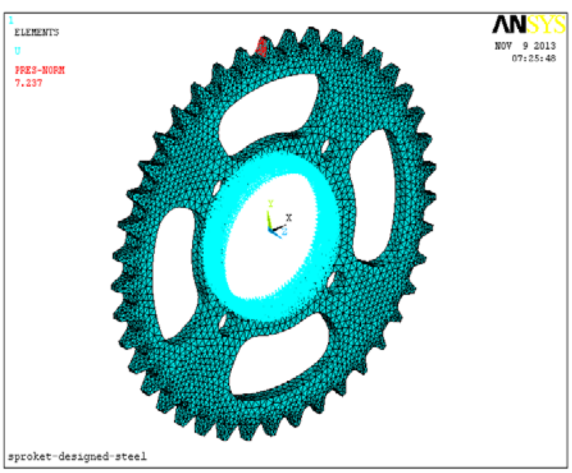

Fig. 3.2 Sproket with steel load

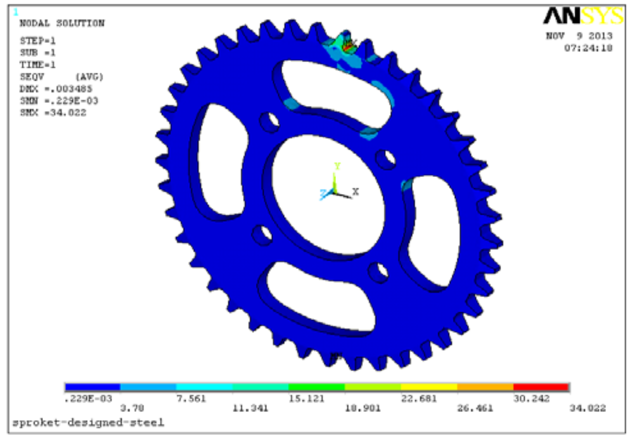

Fig.3.3 Sproket with steel von mises stress

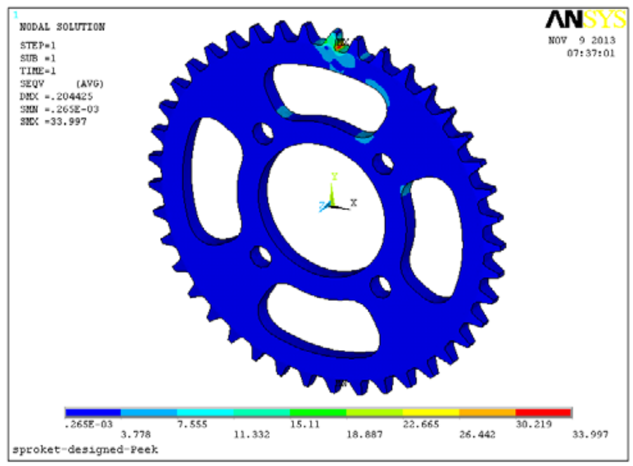

Fig.3.4 Sproket with PEEK von mises stress

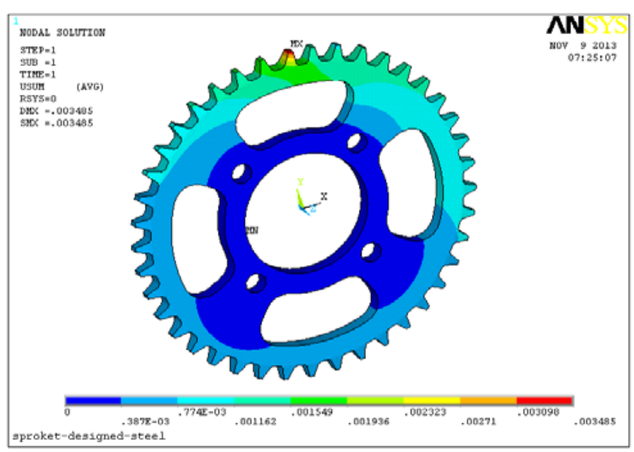

Fig.3.5 Sproket with steel displ usum

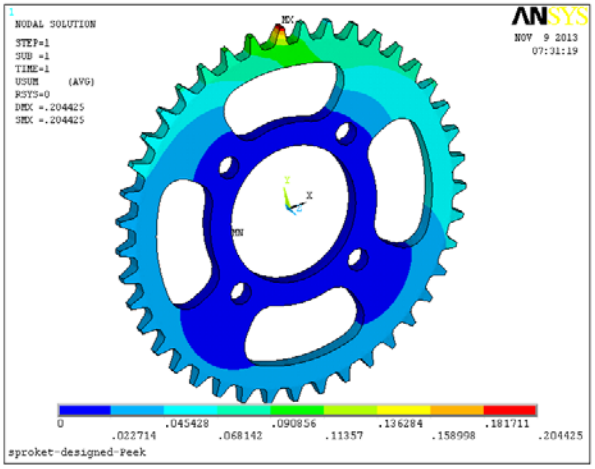

Fig.3.6 Sproket with PEEK displ usum

IV. RESULTS

Working stress is 36.93 theoretically for sprocket where P=9kW, and N=4500 rpm with 41 no. of teeth.

S.No.	Allowable stress by Lewis formula Mpa	Sprocket material	Von-mises stress (ANSYS) Mpa	Difference
1	36.93	SS 304	34.022	7.8%
2		PEEK	33.997 = 34	7.9%

Table 4.1 Analysis Data for SS304 & PEEK

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