DESIGN AND STRESS ANALYSIS OF SPUR GEAR

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Abstract - *A gear or "gear wheel" is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit power. Two or more gears working in tandem are called a transmission and produce a mechanical advantages through a gear ratio and thus may be considered a simple machine. gears are mostly used in the mechanical field for power transmission, this project report on stress analysis of spur gears. Spur gear made of cast iron is considered as the conventional model in this project. The conventional model is optimized with carbon fiber high modulus material and the analysis is carried out. Boundary constraints are defined and the total deformations for model are calculated and the results are tabulated.*

Key Words: spur gear, stress analysis, ANSYS, CATIA

1. INTRODUCTION

Spur gears are the simplest and most common type of gear. Their general form is a cylinder or disk. The teeth project radially, and with these straight-cut gears, the leading edges of the teeth are aligned parallel to the axis of rotation. These gears can only mesh correctly if they are fitted to parallel axles. The torque ratio can be determined by considering the force that a tooth of one gear exerts on a tooth of the other gear. Consider two teeth in contact at a point on the line joining the shaft axes of the two gears. The force will have both a radial and a circumferential component. Gears are a very useful simple machine.

A gear is component within a transmission device. Transmit rotational force to another gear or device. A gear is different from a pulley in that a gear is a round wheel. Mesh with other gear teeth, allowing force to be fully transferred without slippage. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source. Gears are a very useful simple machine. The most common situation is for a gear to mesh with another gear, but a gear can mesh with any device having compatible teeth, such as linear moving racks.

1.2. NEED OF ANALYSIS

The main purpose of gear mechanisms is to transmit rotation and torque between axes. The gear wheel is a machine element that has intrigued many engineers because of numerous technological problems arises in a complete mesh cycle. In order to achieve the need for high load carrying capacity with reduced weight of gear drives but with increased strength in gear transmission, design, gear tooth stress analysis, tooth modifications and optimum design of gear drives are becoming major research area. Gears with involute teeth have widely been used in industry because of the low cost of manufacturing.

2. LITERATURE REVIEW

PINAKNATH PEWANJI., This paper analyses the bending stresses characteristics of an involute spur gear tooth under static load condition s. The tooth profile is generated using catia and analysis is carried out by ansys software. The stress at the tooth root are evaluated analytically using existing theoretical models.

ANUJ NATH ET., This paper modeled the spur gear using pro-e software. The impact analysis for cast steel and composite materials are studied. Finally comparing and analyzing the composite gears with existing cast steel gear is to be done using ANSYS 13.0.

S.MAGENDRAN, K.M.EAZHIL ., This paper modeled the spur gear using solid works software. The weight reduction and stress distribution for cast steel and composite materials are studied. Finally compare and analyzing the spur gear using ansys software.

DEVENDRA SINGH ., In this paper modeled the spur gear and study about gear drive design and analysis is carried out with the help of pro-e and ansys and improve the static and dynamic characteristics of gear drive.

3. MATERIAL PROPERTIES

3.1. cast iron

Cast iron tends to be brittle, except for malleable cast irons. With its low melting point, good fluidity, castability, excellent machinability, resistance to deformation, and wear resistance, cast irons have become an engineering material with a wide range of applications, including pipes, machine and automotive industry parts, such as cylinder heads (declining usage), cylinder blocks, and gearbox cases (declining usage). It is resistant to destruction and weakening by oxidization.

Table 1 . properties of cast iron

Youngs modulus	1.88e+.11pa
Poisons ratio	0.3
Density	7197 kg/m^3

3.2. carbon fiber high modulus

High performance carbon fibers can be classed in three categories, high resistance (HR), intermediate modulus (IM) and high modulus (HM). The latter are often defined as those fibers with a modulus greater than 400 GPa. All these fibers are used in sports products, such as golf clubs and fishing rods, but the high modulus fibers are essentially found in aeronautical applications. However, over the last ten years the use of HM fibers has also developed for the masts of ocean racing yachts, and particularly for 60 foot Open Class multi-hulls. These structures are generally in composite sandwich, carbon composite facings on honeycomb core, of length around 30 meters and weighing around 450 kg, manufactured from prepare either in ovens under vacuum or autoclaves.

Table 2. properties of carbon fiber

Young's modulus	0.2
Poisons ratio	.2Mpa
Density	7.85e-006$\frac{kg}{mm^3}$
Thermal expansion	0.1/0 c

4. SPECIFICATION AND DESIGN CALCULATION

4.1. specification

Model = VMT (valve maintenance trailer)

Engine = 1198

Engine capacity = 1497cc

Maximum engine output = 117hp@6600 rpm

Maximum engine torque = 145 Nm @4600 rpm

Fuel tank capacity = 35 liters

Tyre size = 175/65 R1482T

Wheel base =2345 mm

Width =1680 mm

Length = 3610mm

Height =1500 mm

Calculation:

Torque (T) = 145000 N-mm

Speed (N) = 4600 rpm

Power (P) =2*3.14*N*$\frac{T}{60}$

= 2*3.14*4600*$\frac{145}{60}$

= 69.812 watt

Torque (T) = F*$\frac{d}{2}$

D = z*m

=25*3.5

= 87.5 mm

F = $^{T}/_{D/2}$

= 145000/43.75

=3314.28 N

The Maximum allowable stress = 8.7413 N/mm^2

Ultimate tensile strength for cast steel = 540mpa

Ultimate tensile strength for composite = 52map

Allowable stress for cast steel = ultimate tensile strength/3

= 540/3 = 180N/mm^2> 8.74134 N/mm^2

Allowable stress for composite = ultimate tensile strength/3

= 52/3 N/mm^2 >8.7413 N/mm^2

So, the design is safe.

4.2.calculation of gear tooth proprties

Pitch circle diameter =z*m = 25*3.5 =87.5 mm

Basc circle diameter = D*cos20

= 87.5*cos20

=82..145mm

Outside circle diameter =(z+2)*m =(25+2)*3.5 =94.5mm

Clearance = circular pitch/20 = 31.4/20 =1.57mm

Module =D/Z =87.5/25 =3.5mm

Thickness of the tooth =1.571*10 =15.71mm

Face width (b) = 0.3*87.5 =54mm

Center distance between two gears =180mm

Pitch circle diameter (pc) =m*z = 3.5*25 =87.50mm

dedendum =addendum + clearance =10 + 1.57 = 11.57mm.

diametral pitch =number of teeth/ pitch circle diameter

= 25/87.5 =0.28mm

5. MODELING AND ANALYSIS OF SPUR GEAR

5.1. Modeling

The spur gear modeling was done by using CATIA software based on spur gear design calculation and modeling diagram shown in fig 2.

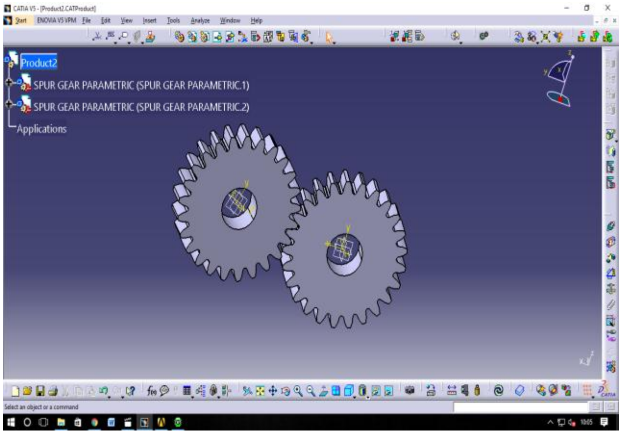

Fig 2. spur gear modeling in CATIA

5.2. Analysis

The stress analysis of spur gear was done by using ANSYS software, the ANSYS diagrams are shown in fig 3.

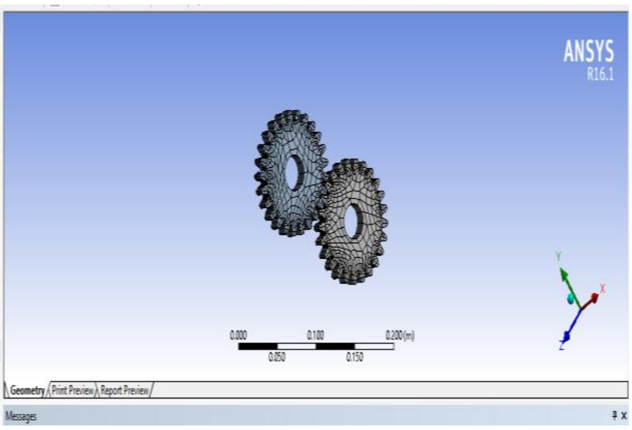

Fig 3. Mesh view of spur gear in ANSYS workbench

6. RESULTS

6.1 Results of cast iron

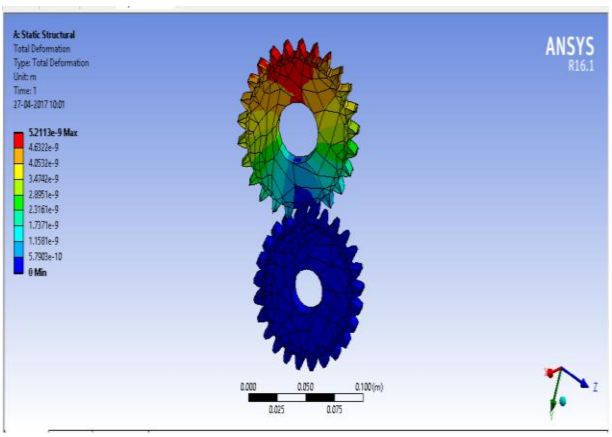

fig. 4. cast iron-total deformation

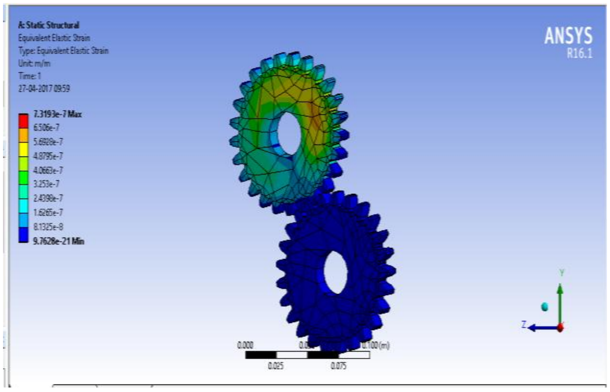

Fig.5. cast iron –equivalent elastic strain

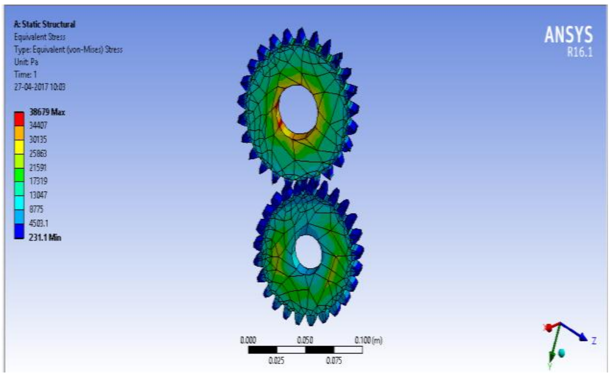

Fig. 6. cast iron-equivalent stress

6.2 Result of carbon fiber high modulus

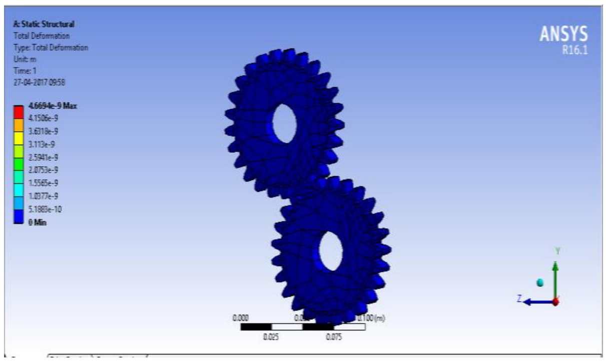

fig.7. carbon fiber-total deformation

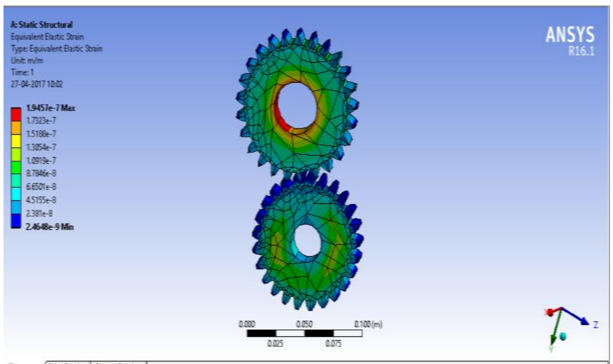

Fig.8. carbon fiber-equvalent elastic strain

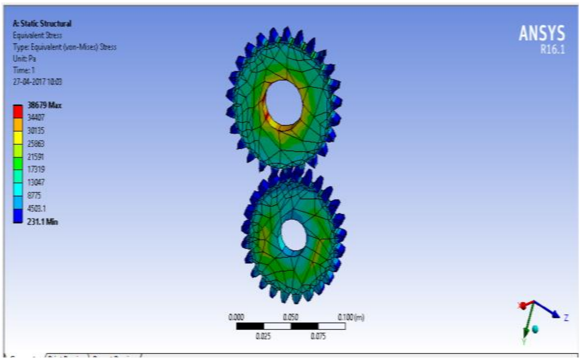

Fig.9. carbon fiber-equivalent stress

Table 3. result of analysis of cast iron

CAST IRON	MIN	MAX
Total deformation (m)	0	0.010307
Equivalent Elastic Strain(m/m)	9.765611e-7	2.39
Equivalent stress	6.11679	179.2

Table 4. result of analysis of carbon fiber high modulus

CARBON FIBER HIGH MODULUS	MIN	MAX
Total deformation (m)	0	0.0047467
Equivalent Elastic Strain(m/m)	2.9338e-7	0.00044866
Equivalent stress	0.11735	179.46

7. CONCLUSION

Experimental results from testing the spur gear under moment are listed in the Table. Analysis has been carried out by optimizing the material such as carbon fiber high modulus. The results such as total deformation, equivalent elastic strain and equivalent stress for each material are determined. Comparing the optimized materials and the conventional material, carbon fiber high modulus material has the low values of total deformation, stress and strain. Hence it is concluded that carbon fiber high modulus material is suitable for the spur gear manufacturing.

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