DESIGN AND ANALYSIS OF THE COMPOSITE SPUR GEAR

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ABSTRACT

To design the spur gear to study the weight reduction and stress distribution of cast steel and composited material. Gearing is one of the most critical components in the mechanical power transmission system and in the 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. In addition, the rapid shift in industry from heavy industry such as ship building to industries such as auto mobile manufacture and auto machine tools will necessitate a refined application of gear technology. To design the spur gear model using the PRO-E software. To study the impact analysis for cast steel and composite materials. To studythe torque loading for cast steel and composite materials. Finally, comparing and analyzing the composite gears with existing cast steel gear is to be done by using ANSYS 13.0.

Keywords: The Spur Gear, Torque Loading for Cast Steel and Composite Materials

I. INTRODUCTION

1. 1 Gear Technology

Gears are the most common means of transmitting power in the modern mechanical engineering world. They vary from a tiny size used in watches to theLarge gears used in watches to the large gears used in lifting mechanisms and speed reducers. They form vital elements of main and ancillary mechanisms in many machines such as automobiles, tractors, metal cutting machine tools etc. Toothed gears are used to change the speed and power ratio as well as direction between input and output[1].

1.2 Spur Gear

The spur gear is simplest type of gear manufactured and generally used for transmission of rotary motion between parallel shafts. The spur gear is the first choice option for gears except when high speeds, loads and ratios direct towards other options. Other gear types may also be preferred to provide more silent low-vibration operation. A single spur gear is generally selected to have a ratio range of between 1:1 and 1:6 with a pitch line velocity up to 25 m/s [6]. The spur g ear has an operating efficiency of 98-99%. The pinion is made from a harder material than the wheel.

A gear pair should be selected to have the highest number of teeth consistent with a suitable safety margin in strength and wear. The minimum number of teeth on a gear with a normal pressure angle of 20 degrees is 18. This is a cylindrical shaped gear in which the teeth are parallel to the axis. It has the largest applications and it is the easiest to manufacture.

They are simple in construction, easy to manufacture cost less. They have highest efficiency and excellent precision rating. They are used in high speed and high load application in all types of trains and a wide range of velocity ratios. Hence, They find wide applications right from clocks, household gadgets, motor cycles, Automobiles and railways to aircrafts.

Figure 1.3 Spur Gear

1.3. Gear Design Procedure

Following are the Formulas used in Gear Design

- Module =m
- Face width =b
- Number of teeth on pinion =Z1
- Number of teeth on gear = Z2
- Speed of pinion = N1
- Speed of gear =N2
- Gear ratio or Transmission ratio = v
- v = Z2 / Z1

1.4 Design of Spur Gear

Calculations

TORQUE (T) = 13.8kg-m@2500rpm

- T = 13.8 kg-m
- T = 13.8*10 N-m
- T = 138 N-m
- T = 138000 N-mm
- N = 2500 rpm.
- **POWER (P)** = 2*3.14*2500*T/60
- P = 2*3.14*2500*138/60
- P = 36128 Watt
- Power (P) = 36.128 K Watt.
- Torque (T) = F*(d/2)
- Where,
- F-load,
- d- Pitch circle diameter (z*m=180mm)T= F*(d/2)
- F = T/ (d/2)
- F = 138000/90
- Load (F) = 1533.33N

- Using Lewis equation,
- Tangential load, F =b*y*pc*σ b
- Pc = 3.14*module
- Pc = 31.4mm
- Y= Lewis form factor=0.134mm
- b = face width = 54mm
- The maximum allowable stress= 8.7413N/mm2.
- Ultimate tensile strength for cast steel = 540mpa Ultimate tensile strength for composite = 52mpa
- Allowable stress for cast steel = ultimate tensile strength/3
- = 540/3 = 180N/mm2> 8.7413N/mm2
- Allowable stress for composite = ultimate tensile strength/3
- = 52/3 = 17.33N/mm2>8.7413N/mm2
  - So, the design is safe.

II. CALCULATIONS OF GEAR TOOTH PROPERTIES

Pitch circle diameter (p.c.d) = z*m = 18*10 = 180mm

Base circle diameter (Db) = D cos α

= 180*cos20

= 169.145mm

Outside circle diameter = (z+2)*m= (18+2)*10 = 200mm

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

Dedendum = Addendum + Clearance = 10+1.57 = 11.57mm

- Module = D/Z = 180/18 = 10mm
- Dedendum circle diameter = P.C.D -2*dedendum
- = 80-2*11.57= 156.86mm
- Fillet radius = Circular pitch/8 = 31.4/8 = 3.9mm
- Pitch circle diameter (Pc) = m*z = 10*18 = 180mm
- Hole depth = 2.25*m = 2.25*10 = 22.5mm
- Thickness of the tooth = 1.571*10 = 15.71mm
- Face width (b) = 0.3*180= 54mm
- Center distance between two gears = 180mm
- Diametral pitch = Number of teeth/P.C.D= 18/180= 0.1mm

III. PROPERTIES OF CAST STEEL

- ✓ Density = 7870 kg/m3
- ✓ Young modulus = 200 GPa
- ✓ Poisson's ratio = 0.29
- ✓ Tensile strength = 518.8 MPa
- ✓ Ultimate Tensile Strength = 540 MPa
- ✓ Yield Tensile Strength = 415 MPa
- ✓ Bulk modulus = 140 GPa

IV. COMPOSITE MATERIALS

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.

The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate.

properties of composites (50% carbon fibers in epoxy resin matrix)

- Density = 1800 kg/m3
- Young modulus = 450 G Pa
- Poisson’s ratio = 0.30
- Tensile strength = 52 M Pa

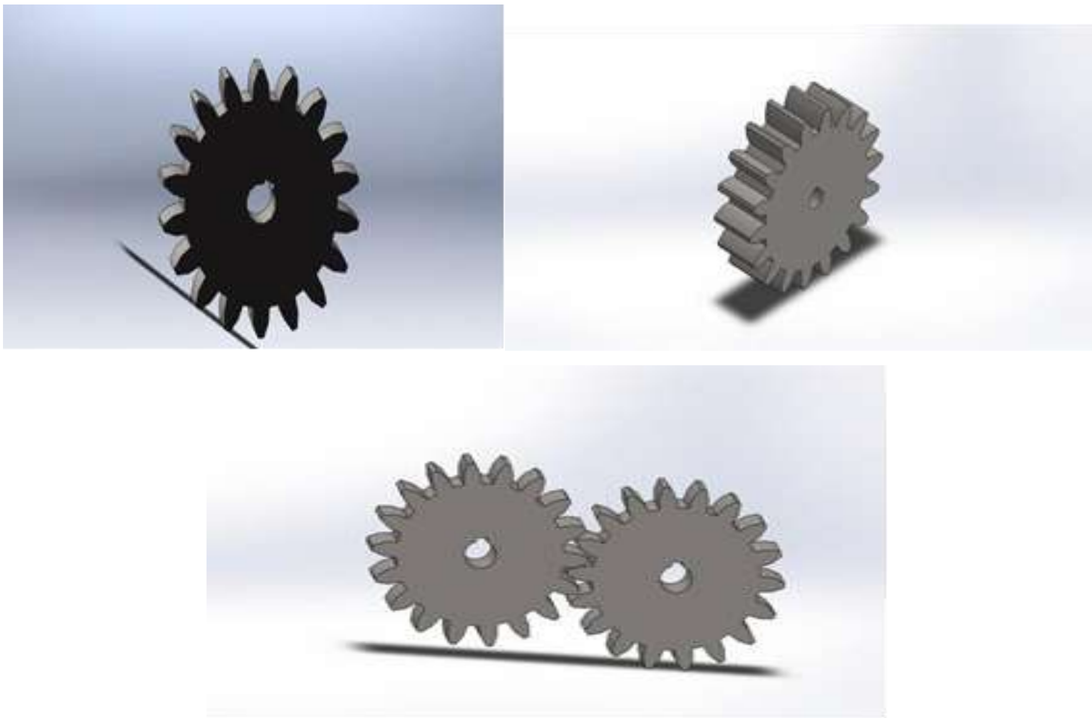

FIG 4.3 Spur Gear Models

V. TORQUES. RESULTS AND DISCUSSION

5.1 Analysis Results for Spur Gear in Various Materials

5.1.1 Reports for Cast Steel Spur Gear in Various

TORQUE T = 140N-m; SPEED N = 2500 rpm

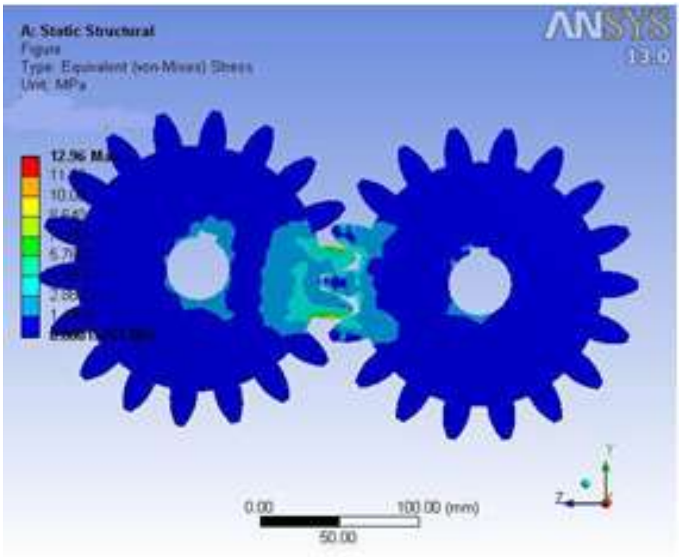

Fig 5.1 Von-Mises Stress Distribution of Spur Gear in Cast steel

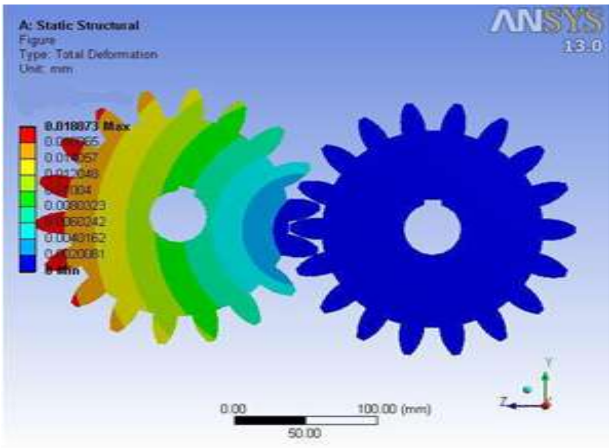

Fig 5.3 Total Deformation of Spur Gear in Cast steel

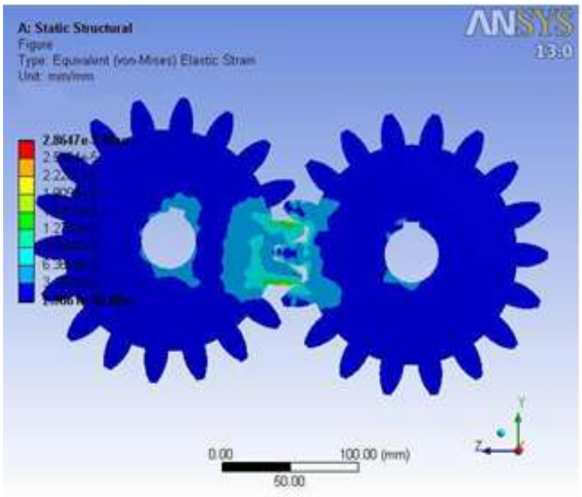

Fig 5.6 Von-Mises Stress Distribution of Spur Gear in Composite materials

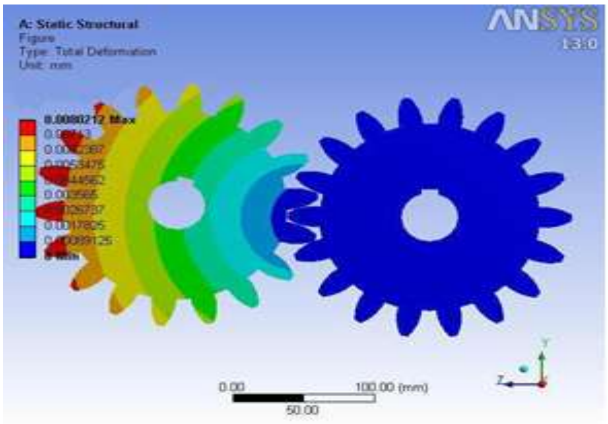

Fig 5.8 Total Deformation of Spur Gear in Composite materials

5.2 Comparison Table between Cast Steel and Composite Materials

FAILURE THEORIES	SPEED AND TORQUE	CAST STEEL			COMPOSITE MATERIALS			%DIFFERIANCE
	SPPED (IN RPM)	2500 RPM	2000 RPM	1500 RPM	2500 RPM	2000 RPM	1500 RPM	
	TORQUE (Nm)	140 Nm	170 Nm	230 Nm	140 Nm	170 Nm	230 Nm	
Von-mises stress (MPa)		12.960	15.737	21.292	12.891	15.654	21.179	0.5324
Von-mises strain		6.48 e-5	7.868 e-5	10.646 e-5	2.865 e-5	3.479 e-5	4.706 e-5	55.787
Total deformation(MPa)		18.073 e-3	21.945 e-3	29.691e-3	8.021e-3	9.740 e-9	13.178 e-9	55.619
Maximum shear stress (MPa)		7.376	8.956	12.117	7.342	8.915	12.062	0.4610
Strain Energy(MJ)		157.87 e-3	232.78 e-3	426.09 e-3	69.889 e-9	103.05 e-3	188.62 e-3	55.730

IV. CONCLUSION

- The literature survey of composite spur gear was performed. Then the study in weightreduction and stress distribution of spur gear for cast steel and composite materials has been done.
- On the basis of that study, the analysis of both cast steel and composite materials are analyzed in the application of gear box which is used in automobile vehicles. From these analysis we got the stress values for composite materials is less as compared to the cast steel spur gear.
- So from these analysis results, we conclude that, the stress induced, deformation and weight of the composite spur gear is less as compared to the cast steel spur gear.
- So, Composite materials are capable of using in automobile vehicle gear boxes up to 1.5KN in the application of Tata super ace model instead of existing cast steel gears with better results.

VII. SCOPE FOR FUTURE WORK

- Various composite materials can be applied instead of currently used materials.
- The input conditions can be varied to parameters like pressure, temperature etc.
- A study on wear, friction and temperature effects can be extended

REFERENCES

[1] Sakiyama T. et al. (2003). Fundamental Vibration of rotating Cantilever blades with pre-twist. Journal of Sound and Vibration, Volume 271, Issues 1–2, 22 March 2004, Pages 47-66

[2] Vishwanatha R H, Syed Zameer, Mohamed Haneef "Finite Element Structural Integrity Analysis of First Stage Gas Turbine Rotor Blade Assembly Under Thermo- Mechanical Loads", IJIRSET Vol. 3, Issue 10, October 2014

[3] Avinash V. Sarlashkar, Girish A. Modgil, Mark L. Redding, "BladeProTM: An ANSYS-Based Turbine Blade Analysis System" Impact Technologies, LLC, Rochester, NY 14623, U.S.A

[4] L.Moroz, L.G.Romanenko, "Vibration Analysis of Low Pressure Stages of Large Steam Turbines with ANSYS", Burlington, MA 01803

[5] H HYoo, S.Seo, K.Huh"The effect of a concentrated mass on the modal characteristics of a rotating cantilever beam" *Journal of Mechanical Engineering Science,August 1, 2009 223: 1767-1775*

[6] Gouthamkumar N., Veena Sharma, R. Naresh. "Disruption based gravitational search algorithm for short term hydrothermal scheduling" Expert Systems with Applications, Vol. 42, pp. 7000–7011, 2015.

[7] Ion V.Ion,Jorge Martins,KrisztinaUzuneanu and AnibalPortinha, "Performaces Analysis of a Gas Turbine Plant with Coated Blades",

[8] S S Rao, "The Finite Element method in Engineering", BH Publications, New Delhi, 3rd Edition, pp.166 – 555,1999.

[9] K.L.Meena, Dr.A.Manna, Dr.S.S.Banwait, Dr.Jaswanti, "An Analysis of Mechanical Properties of the Developed Al/SiC-MMC's" American Journal of Mechanical Engineering, 2013, Vol. 1, No. 1, 14-19

[10] philipdowson and derrick bauer, Thesis on "Selection of materials and material related process for steam turbines in these oil and petrochemical industry