Design and Analysis of Composite Spur Gear

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***Abstract*-To design the spur gear to study the weight reduction and stress distribution for cast steel and composite materials.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. In addition, the rapid shift in the industry from heavy industries such as shipbuilding to industries such as automobile manufacture and office 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 cast steel and composite materials. To study the torque loading for cast steel and composite materials. Finally, comparing and analyzing of the composite gear with existing cast steel gear is to be done.**

Keywords- Gear, Composite, Ansys, fibre, Epoxy

I. INTRODUCTION

1.1 Overview of Gear

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. In addition, the rapid shift in the industry from heavy industries such as shipbuilding to industries such as automobile manufacture and office automation tools will necessitate a refined application of gear technology. A gearbox as usually used in the transmission system is also called a speed reducer, gear head, gear reducer etc., which consists of a set of gears, shafts and bearings that are factory mounted in an enclosed lubricated housing. Speed reducers are available in a broad range of sizes, capacities and speed ratios. Their job is to convert the input provided by a prime mover (usually an electric motor) into an output with lower speed and correspondingly higher torque. In this, analysis of the characteristics of involute spur gears in a gearbox was studied using nonlinear FEM.

Gears are toothed members which transmit power/ motion between two shafts by meshing without any slip. Hence, gear drives are also called positive drives. In any pair of gears, the smaller one is called pinion and the larger one is called gear immaterial of which is driving the other. When pinion is the driver, it results in step down drive in which the output speed decreases and the torque increases. On the other hand, when the gear is the driver, it results in step up drive in which the output speed increases and the torque decreases. The increasing demand for quiet power transmission in machines, vehicles, elevators and generators, has created a growing demand for a more precise analysis of the characteristics of gear systems. In the automobile industry, the largest manufacturer of gears, higher reliability and lighter weight gears are necessary as lighter automobiles continue to be in demand. In addition, the success in engine noise reduction promotes the production of quieter gear pairs for further noise reduction. Noise reduction in gear pairs is especially critical in the rapidly growing field of office-automation equipment as the office environment is adversely affected by noise, and machines are playing an ever widening role in that environment. Ultimately, the only effective way to achieve gear noise reduction is to reduce the vibration associated with them.

Designing highly loaded spur gears for power transmission systems that are both strong and quiet requires analysis methods that can easily be implemented and also provide information on contact and bending stresses, along with transmission errors. The finite element method is capable of providing this information, but the time needed to create such a model is large. The prime source of vibration and noise in a gear system is the transmission error between meshing gears. Transmission error is a term used to describe or is defined as the differences between the theoretical and actual positions between a pinion (driving gear) and a driven gear. It has been recognized as a main source for mesh frequency excited noise and vibration.

Transmission error is usually due to two main factors. The first is caused by manufacturing inaccuracy and mounting errors. Gear designers often attempt to compensate for transmission error by modifying the gear teeth. The second type of error is caused by elastic deflections under load. Among the types of gearbox noise, one of the most difficult to control is gear noise generated at the tooth mesh frequency. Transmission error is considered to be one of the main contributors to noise and vibration in a gear set. This suggests that the gear noise is closely related to transmission error. If a pinion and gear have ideal involute profiles running with no loading torque they should theoretically run with zero transmission error. However, when these same gears transmit torque, the combined torsional mesh stiffness of each gear changes throughout the mesh cycle as the teeth deflect, causing variations in angular rotation of the gear body. Even though the transmission error is relatively small, these slight variations can cause noise at a frequency which matches a resonance of the shafts or the gear housing, causing the noise to be enhanced. This phenomenon has been actively studied in order to minimize the amount of transmission error in gears.

Gears are generally used in power and motion transmission work under different loads and speeds. Due to advantages of noiseless running, light weight, resistance to corrosion, ease of mass production, lower coefficients of friction, and the ability to run without external lubrication, the use of composite gears is continually increasing. These gears are especially preferred and successfully used in office machines, household utensils, in the food and automotive industries, and in textile machinery because of the above-mentioned advantages.

Gearing is an essential component of many machines, and the defect of gear is the important factor causing machinery failure. According to statistics, 80% of transmission machinery failure was caused by the gear, and gear failure was about 10% of rotating machinery failure, so gearbox monitoring for fault detection and diagnosis is one of the important tasks in industrial maintenance.

1.2 Spur Gear

Fig1.1 Spur Gear

Spur Gears: -The spur gear is simplest type of gear manufactured and is 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. The spur gear 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, also, it is the easiest to manufacture.

They are simple in construction, easy to manufacture and 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.

II. LITERATURE REVIEW

The gear stress analysis, the transmission errors, and the prediction of gear dynamic loads, gear noise, and the optimal design for gear sets are always major concerns in gear design.

The polymer gear wear rate will be increased, when the load reaches a critical value for a specific geometry. The gear surface will wear slowly with a low specific wear rate if the gear is loaded below the critical one. The possible reason of the sudden increase in wear rate is due to the gear operating temperature reaching the material melting point under the critical load condition. Actual gear performance was found to be entirely dependent on load. A sudden transition to high wear rates was noted as the transmitted torque was increased to a critical value. This is to be associated with the gear surface temperature of the material reaching its melting point. That is for a given geometry of actual gear, a critical torque can be decided from its surface temperature calculation. [K. Mao, 2006]

The detailed analysis of the flash temperature for polymer composite gears and the heat partition between gear teeth problem is treated as an unsteady one where the intensity distribution and velocity of heat source changes as meshing proceeds. A numerical approximation is adopted using finite different method and the results are shown to be close to those found using semi-analytical method assuming no internal hysteresis and the material properties are constant. Blok's solution can be used to provide a quasi-steady approximation that is for mean flash temperature estimation. A numerical method has been developed in the current paper for polymer composite gear flash temperature prediction. [K. Mao, 2007]

Load carrying capacity and occurring damages of gears which are made of PC/ABS blends were investigated. PC is hard material and ABS is soft material. The usage of materials limits these drawbacks. However PC and ABS polymers combine each other, the PC/ABS blends have suitable mechanical properties for gear applications in the industrial areas. In this study, usability of PC/ABS composite plastic materials as spur gear was investigated. PC/ABS gears were tested by applying three different loading at two different numbers of revolutions on the FZG experiment set. [R. Yakut, 2009]

They have performed a theoretical analysis of a procedure to determine the Lewis Factor and also performed the contact analysis of spur gears to find the stress distribution between gear teeth. [J.L. Moya, A.S. Machado, 2007]

It is to establish a characterization method for seven polyamide (PA) grades to determine the major material to manufacture an automotive worm gear. The composite properties were measured according to the worm gear loadings: tensile strength, Young's modulus, abrasion and impact resistance. They were also correlated to the PA moisture absorption and its glass fiber (GF) reinforcement. The data from mechanical tests were applied in the finite element analysis (FEA) using the von Misses stress criterion. Before the rig tests of the PA worm gears, the injection process was evaluated, through the capillary rheometry. A higher difficulty to process PA 6/6 30% GF was found, due to its lower apparent viscosity. In the end, the influence of moisture absorption was as decisive to the gear's material selection as the GF to the pinion. The PA with the best performance were: PA 6 with 30% GF (gear) and with PA 60% GF (pinion). [M.H. Tsai, 1997]

III. OBJECTIVE

- The objective of the project is to reduce the stress distribution, deformation and weight of spur gear by using composite materials in the application of gear box.
- The designed composite spur gear is compared with the existing gear material, which is a cast steel spur gear.
- The tool which is used to analyses the composite and cast steel spur gear material is ANSYS.
- In this, the analyses of torque loading and stress induced are to be performed for both composite and cast steel materials.
- The final outputs of these analyses for both the materials are to be compared.
- From this comparison, the stress induced, deformation and weight for composite spur gear materials are to be less than that of the cast steel spur gear materials.

IV. PROJECT DESCRIPTION

4.1 Design of Spur Gear

The spur gear is simplest type of gear manufactured and is 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. The spur gear 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.

4.1.1.1 Module (M)

The module is the ratio of the pitch diameter to the number of teeth. The unit of the module is mili-metres. Below is a diagram showing the relative size of teeth machined in a rack with module ranging from module values of 0.5 mm to 6 mm

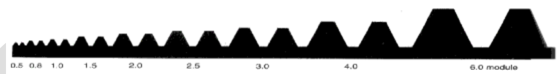


Fig 4.1 Module

The preferred module values are

0.5 0.8 1 1.25 1.5 2.5 3 4 5 6 8 10 12 16 20 25 32 40 50

4.1.1.2 NORMAL PRESSURE ANGLE

An important variable affecting the geometry of the gear teeth is the normal pressure angle. This is generally standardized at 20°. Other pressure angles should be used only for special reasons and using considered judgment.

- Reduction in the danger of undercutting and interference
- Reduction of slipping speeds
- Increased loading capacity in contact, seizure and wear
- Increased rigidity of the tooth
- Increased noise and radial forces.
-

4.1.1.3 Contact Ratio

The gear design is such that when in mesh the rotating gears have more than one gear in contact and transferring the torque for some of the time. This property is called the contact ratio. This is a ratio of the length of the line-of-action to the base pitch.

A contact ratio between 1 and 2 means that part of the time two pairs of teeth are in contact and during the remaining time one pair is in contact. A ratio between 2 and 3 means 2 or 3 pairs of teeth are always in contact. Such as high contact ratio generally is not obtained with external spur gears, but can be developed in the meshing of an internal and external spur gear pair or specially designed non-standard external spur gears.

$R_{go} = D_{go} / 2$..Radius of Outside Dia of Gear
$R_{gb} = D_{gb} / 2$..Radius of Base Dia of Gear
$R_{po} = D_{po} / 2$..Radius of Outside Dia of Pinion
$R_{pb} = D_{pb} / 2$..Radius of Base Dia of Pinion
p = circular pitch.
a = $(d_g + d_p)/2$ = center distance.

4.1.2 Specifications and Design Calculations

Specifications

Model = TATA SUPER ACE

Engine = TATA475 TCIC (BSIII)

Engine capacity =1405cc

Maximum engine output = 70hp@4500rpm

Maximum engine torque = 13.8 kg-m@2500rpm

Fuel tank capacity = 38 liters

Tyres = 165R14LT8PR

Wheel base = 2380mm

Width = 1565mm

Length = 4340mm

Height = 1858mm

Front track = 1340mm

Rear track = 1320mm

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/mm^2.

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/mm^2> 8.7413N/mm^2

Allowable stress for composite = ultimate tensile strength/3

= 52/3 = 17.33N/mm^2>8.7413N/mm^2

So, the design is safe.

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

4.2 Materials Selection

4.2.1 Cast Steel

Cast steel was the first type of steel that allowed alloys to be added to the iron. Prior to this method, manufacturers had not been able to get steel hot enough to melt. By heating blister steel in a clay crucible placed directly into a fire, Huntsman allowed the metal to reach up to 2900°F (1600°C). Melting allowed other elements, such as nickel, to be mixed into the metal, thus strengthening the steel.

Cast steel has a rough finish. It often has surface holes created by gas bubbling during the heating process. An elastic metal, this type of steel is very tough, having four times the tensile strength of cast iron. Tensile strength is how much pressure, created by pulling, an object can withstand before it breaks.

One concern when using cast steel is whether the surface holes extend into the interior of the metal. If so, these holes could create weaknesses that affect the soundness of the steel. Measuring the volume of water that can be poured into the holes will give a good indication of whether the holes extend far into the metal.

4.2.1.1 Properties of Cast Steel

Hardness

The hardness of cast steel varies depending on the mixture of carbon and other ingredients. The heat levels used when mixing the metal also affect the hardness of the finished metal product. Typically, lower levels of carbon and high alloy content result a softer metal. Higher levels of carbon with fewer added allows achieves a cast steel with greater hardness but lower yield strength, which is the flexibility of the metal.

Durability

Several tests are used to determine the strength and durability of cast steel before it starts to break down. These tests include impact tests, drop tests, tear tests and fracture tests. In this area, high carbon and low allow concentrations are actually detrimental.

Ductility

The ductility of steel is the measurement of how much molding or shaping it can take and how small the sheets can become without breaking down. This is determined largely by the material mixture of the cast steel and how it is formed. In general, quenched or tempered steel has higher ductility levels, or the ability to deform without breaking, than traditional annealed steel, which produces a softer metal.

Fatigue

The fatigue properties of cast steel represent how much pressure and use the steel can take before breaking down. The fatigue test of cast steel shows its predicted life.

4.2.1.2 The Advantage and Disadvantage of Cast Steel

One of the advantages of cast steel is the design flexibility, the designer of the casting have the greatest freedom of design choices, especially the complex shape and hollow cross-section parts.

Cast steel has the metallurgy manufacturing flexibility and strongest variability; you can choose a different chemical composition and control, adapted to the various requirements of different projects. By different heat treatment choice in the larger context of the mechanical properties and performance, and good weldability and workability.

Cast steel is a kind of isotropic material and can be made into the overall structural strength steel castings, thereby improving the reliability of the project. Coupled with the design and weight the advantages of short delivery time, price and economy has a competitive advantage.

The weight range of steel castings is larger. Little weight can be only a few dozen grams of molten mold precision castings, and the weight of large steel castings up to several tons, dozens of tons or hundreds of tons. Steel castings can be used for a variety of working conditions, and its mechanical properties superior to any other casting alloys, and a variety of high-alloy steel for special purposes.

Properties of Cast Steel

Density	= 7870 kg/m^3
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

4.2.2 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. Particulate composites have dimensions that are approximately equal in all directions. They may be spherical, platelets, or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuous fiber composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.

A fiber has a length that is much greater than its diameter. The length-to-diameter ratio is known as the aspect ratioand can vary greatly. Continuous fibers have long aspect ratios, while discontinuous fibers have short aspect ratios. Continuous-fiber composites normally have a preferred orientation, while discontinuous fibers generally have a random orientation.

Fibers produce high-strength composites because of their small diameter; they contain far fewer defects (normally surface defects) compared to the material produced in bulk. As a general rule, the smaller the diameter of the fiber, the higher its strength, but often the cost increases as the diameter becomes smaller. In addition, smaller-diameter high-strength fibers have greater flexibility and are more amenable to fabrication processes such as weaving or forming over radii.
Typical fibers include glass, aramid, and carbon, which may be continuous or discontinuous.

The continuous phase is the matrix, which is a polymer, metal, or ceramic. Polymers have low strength and stiffness, metals have intermediate strength and stiffness but high ductility, and ceramics have high strength and stiffness but are brittle. The matrix (continuous phase) performs several critical functions, including maintaining the fibers in the proper orientation and spacing and protecting them from abrasion and the environment.

In polymer and metal matrix composites that form a strong bond between the fiber and the matrix, the matrix transmits loads from the matrix to the fibers through shear loading at the interface. In ceramic matrix composites, the objective is often to increase the toughness rather than the strength and stiffness; therefore, a low interfacial strength bond is desirable.

There is a practical limit of about 70 volume percent reinforcement that can be added to form a composite. At higher percentages, there is too little matrix to support the fibers effectively.

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while the matrix which glues all the fibers together in shape and transfers stresses between the reinforcing fibers. Sometimes, fillers or modifiers might be added to smooth manufacturing process, impart special properties, and/or reduce product cost.

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.

4.2.2.1 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.

Fig 4.2 Carbon fiber

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.

Carbon fibers are available from a number of domestic and foreign manufacturers in a wide range of forms having an even wider range of mechanical properties. The earliest commercially available carbon fibers were produced by thermal decomposition of rayon precursor materials. The process involved highly controlled steps of heat treatment and tension to form the appropriately ordered carbon structure. Carbon fibers are also manufactured from pitch precursor for specialty applications. Pitch fiber properties typically include high modulus and thermal conductivity.

4.2.2.2 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 adherentshaving 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. The chemistry of epoxies and the range of commercially available variations allow cure polymers to be produced with a very broad range of properties. In general, epoxies are known for their excellent adhesion, chemical and heat resistance, good-to-excellent mechanical properties and very good electrical insulating properties.

Epoxy is a copolymer that is; it is formed from two different chemicals. These are referred to as the “resin” or “compound” and the “hardener” or “activator”. The resin consists of monomers or short chain polymers with an epoxide group at either end. Most common epoxy resins are produced from a reaction between epichlorohydrin and bisphenol-A. Two part epoxy coatings were developed for heavy duty service on metal substrates and use less energy than heat-cured powder coatings. Their low volatility and water cleanup makes them useful for factory cast iron, cast steel, cast aluminums applications and reduces exposure and flammability issues associated with solvent-borne coatings. They are usually used in industrial and automotive applications since they are more heat resistant than latex-based and alkyd-based paints.

The large family of epoxy resins represents some of the highest performance resins of those available at this time. Epoxies generally out-perform most other resin types in terms of mechanical properties and resistance to environmental degradation, which leads to their almost exclusive use in aircraft components. As a laminating resin their increased adhesive properties and resistance to water degradation make these resins ideal for use in applications such as boat building. Here epoxies are widely used as a primary construction material for high-performance boats or as a secondary application to sheath a hull or replace water-degraded polyester resins and gel coats.

Properties of Composites (50% Carbon Fibers in Epoxy Resin Matrix)

Density	= 1800 kg/m^3
Young modulus	= 450 GPa
Poisson’s ratio	= 0.30
Tensile strength	= 52 MPa
Compressive strength	= 600 MPa

Epoxy resins are easily and quickly cured at any temperature from 5°C to 150°C, depending on the choice of curing agent. One of the most advantageous properties of epoxies is their low shrinkage during cure which minimizes fabric print-through and internal stresses. High adhesive strength and high mechanical properties are also enhanced by high electrical insulation and good chemical resistance. Epoxies find uses as adhesives, caulking compounds, casting compounds, sealants, varnishes and paints, as well as laminating resins for a variety of industrial applications.

4.3 Static Structural Analysis

4.3.1 Introduction

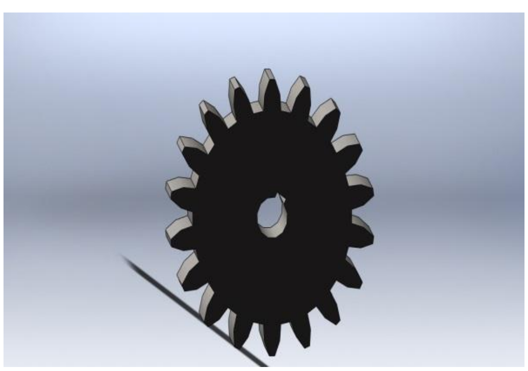
A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. A static structural load can be performed using the ANSYS or ANSYS WORKBENCH solver. The types of loading that can be applied in a static analysis include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (nonzero) displacements
- Temperatures (for thermal strain)

Design software offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial and standard pipe work and complete wiring definitions. Tools are also available to support collaborative development.

A number of concept design tools that provide up-front Industrial Design concepts can then be used in the downstream process of engineering the product. These range from conceptual Industrial design sketches, reverse engineering with point cloud data and comprehensive free-form surface tools.

The Spur Gear models are created by using Solid works software. The models are shown below.



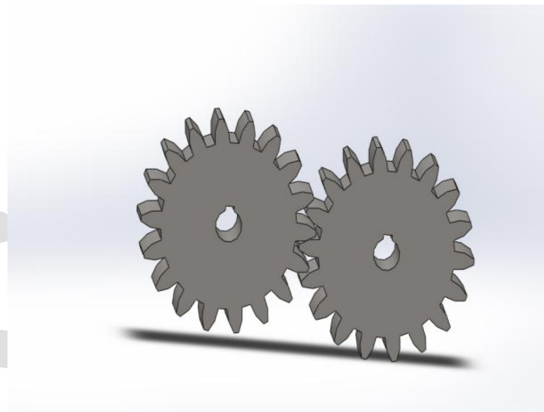


Fig 4.3 Spur gear models

V. RESULTS AND DISCUSSION

5.1 Analysis Results for Spur Gear in Various Materials

5.1.1 Reports for Cast Steel Spur Gear in Various Torques

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

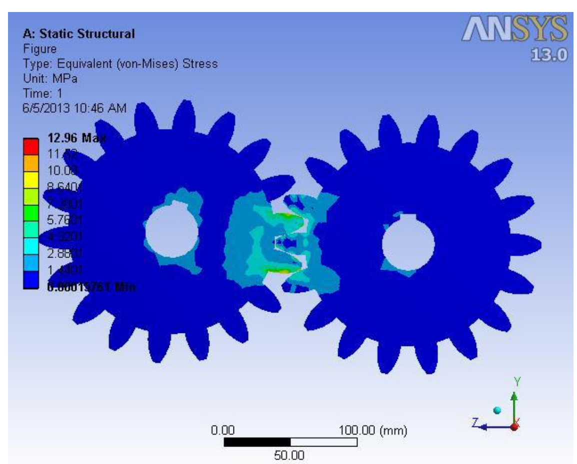


Fig 5.1 Von-Mises Stress Distribution of Spur Gear in Cast steel

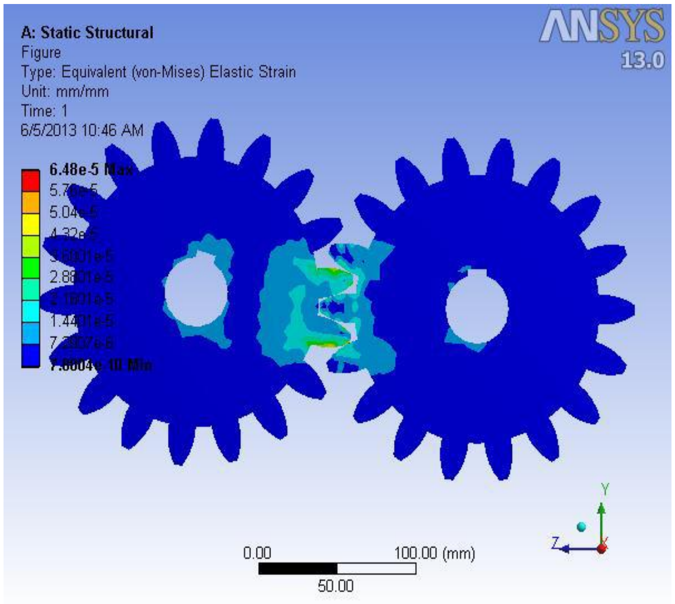


Fig 5.2 Von-Mises Strain Distribution of Spur Gear in Cast steel

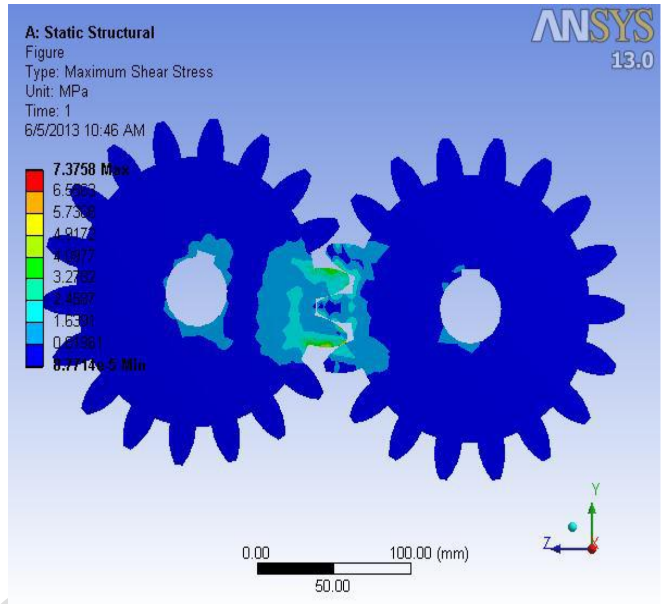


Fig 5.4 Maximum shear stress of Spur Gear in Cast steel

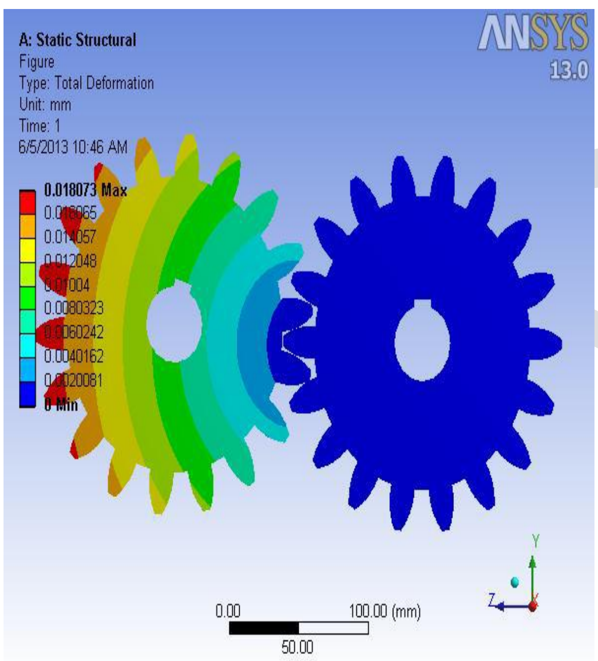


Fig 5.3 Total Deformation of Spur Gear in Cast steel

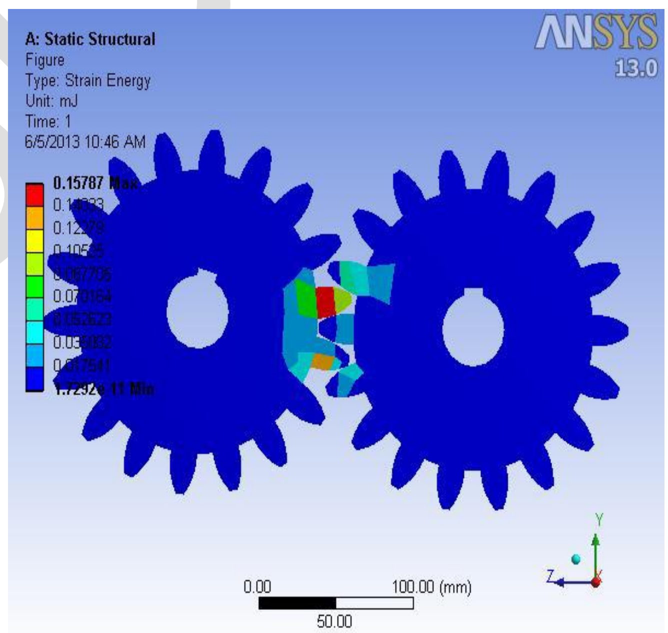


Fig 5.5 Strain energy of Spur Gear in Cast steel

5.1.2 Reports for Composite Spur Gear in Various Torques

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

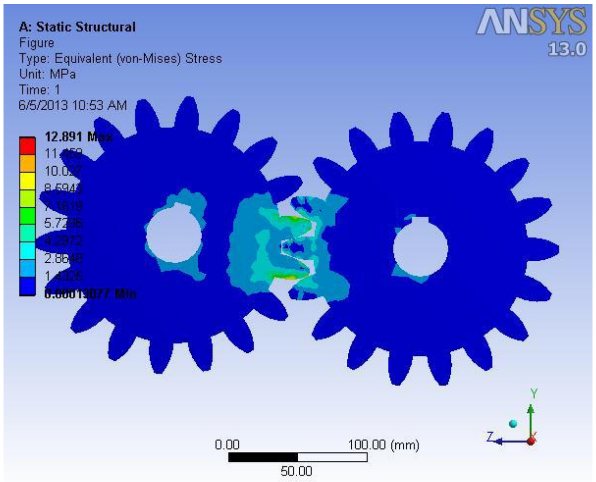


Fig 5.6 Von-Mises Stress Distribution of Spur Gear in Composite materials

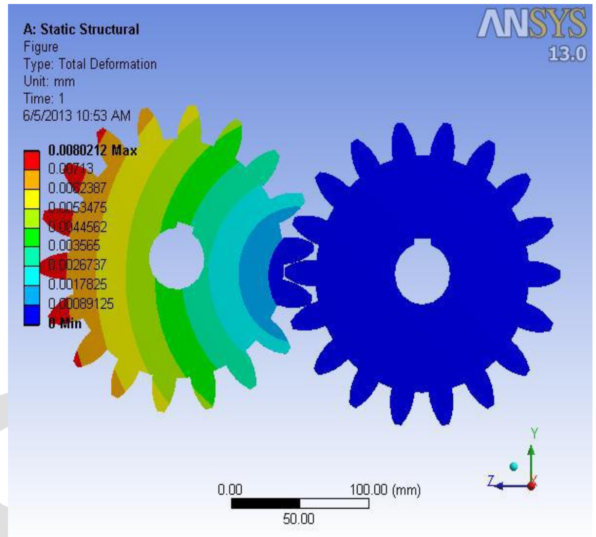


Fig 5.8 Total Deformation of Spur Gear in Composite materials

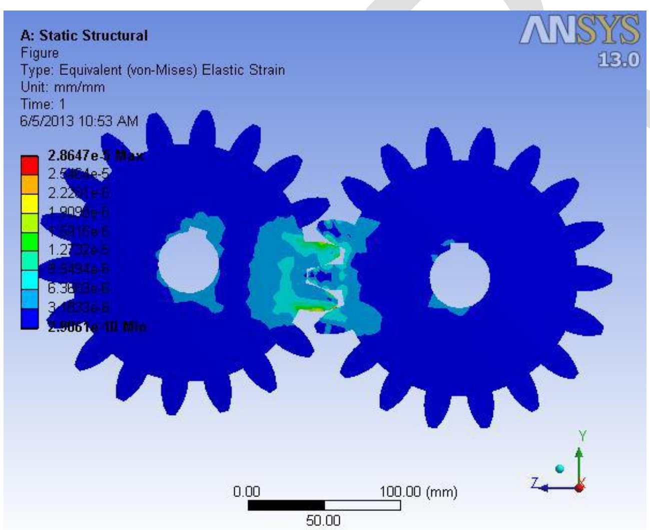


Fig 5.7 Von-Mises Strain Distribution of Spur Gear in Composite materials

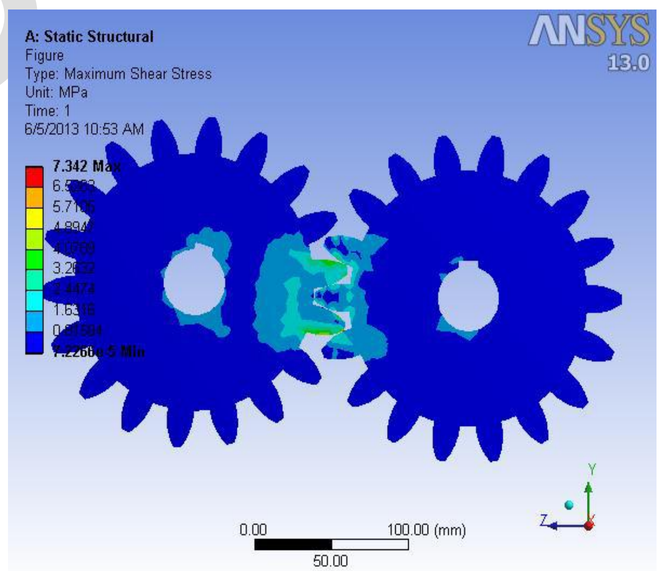


Fig 5.9 Maximum shear stress of Spur Gear in Composite materials

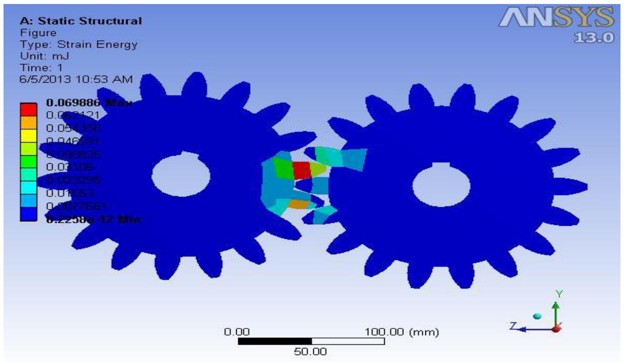


Fig 5.10 Strain energy of Spur Gear in Composite materials

5.2 Comparison Table between Cast Steel and Composite Materials

5.1 Comparison table between cast steel and composite materials

FAILURE THEORIES	CAST STEEL			COMPOSITE MATERIALS			% DIFFERENCE
	2500 rpm	2000 rpm	1500 Rpm	2500 rpm	2000 rpm	1500 Rpm	
	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	6.480 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 (mm)	18.073 e-3	21.945 e-3	29.691 e-3	8.021 e-3	9.740 e-3	13.178 e-3	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-3	103.05 e-3	188.62 e-3	55.730

VI. CONCLUSION

- The literature survey of composite spur gear was performed.
- Then the study in weight reduction 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.

6.1 *Scope for Future Work*

The future work can be carried out by:

- 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.

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