Design and Analysis of Contact Stress Analysis of Xylon Coated Spur Gear Using Ansys Workbench

M. Karthick[1], K. Karthik*[1]

[1]Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai-600062, India.

karthick@veltech.edu.in, *karthikmeed@gmail.com,

Abstract:

Gear production is a labor-intensive, time-consuming procedure; hence it was desired to extend gear life. Contact stress and bending stress are hence the two key factors that affect gear failures. Many materials, such as xylon, (PTEF) polytetrafluoroethylene, and boron carbide, are used to increase the gear's lifespan with the intention of reducing contact stress. These materials are chosen because they are readily available and low-friction and they are compared to conventional gear. We have drawn in an analytical system and can observe the difference between 5 and 10 microns.

Introduction

Gear :A mechanical component called an agrarian distributes power from one shaft to another by way of the successful engagement of teeth in a successful contact. In comparison to the belt and chain drives, gear drives are more compact, run at faster speeds, and can be utilized in applications where accurate timing is required, belt or rope slipping is a frequent occurrence, or when transmitting motion or power between two shafts. Slipping causes the system's velocity ratio to decrease. In precision machinery where a specific velocity ratio is crucial, the only positive drive is through gears or toothed wheels.

Spur gear :

The simplest type of gear is a spur gear, which has teeth that are cut on the outer surface of a cylindrical blank in a parallel direction to the gear axis. Typically, there are two types of spur gear drives: exterior gears and internal gears. In the case of internal gears, teeth are only cut internally in the larger gear and the pinion still has external teeth as is customary. External gears have teeth cut into the external peripherals of both the pinion and the gear. To transfer power between parallel shafts, spur gears are used. The entire face-width of one gear will make contact with the complete face-width of its mate gear during engagement because the gear teeth are parallel to the axis. This causes noise, which gets louder as speed rises. As a result, spur gears are used for low-power transmission although being operated rather slowly. Spur gears may also be used in conjunction with pinion and rack gears to convert circular motion into linear motion. Spur gears are often produced with an involute profile and a pressure angle of 14.5 or 20 degrees, but 20-degree pressure angle gears are more commonly employed due to their great load-carrying capacity. They only place radial strains on their bearings because of the tooth structure, which is straight and parallel to the axis. The majority of machine tools, including hobbing machines, milling machines, gear shapers, broaching machines, etc., can create spur gears because of their straightforward structural design. Spur gears can occasionally be stamped and cast.

Spur gear materials:

When selecting the materials for toothed gears, it is necessary to ensure sufficient beam strength of the teeth and endurance of their surface layers. Based on the purpose and places of applications, gears made of various types of materials can be employed.

It is important to consider the beam strength of the teeth and the durability of their surface layers when choosing the materials for toothed gears. Gears composed of many types of materials can be used, depending on the purpose and locations of applications.

The materials that are most frequently used to make gears include, Ferrous metals, such as cast iron of various grades and alloy steels made of nickel, chromium, and vanadium, and Non-ferrous metals like titanium, bronze, brass, etc. Non-metals such as plastic-oriented materials like phenolic resins, nylon, Bakelite, mica etc. Steel can be extensively employed in various engineering applications among all the materials described above with adequate heat treatment. The pinion gear in a gear drive typically experiences more loading cycles than the wheel gear; as a result, the pinion should be constructed of stronger materials than the wheel.

Real Time Applications of Spur gear :

The gear transmission system is most widely used because of its high load carrying capacity, high efficiency, and compact layout. From the smallest timepieces and instruments to the biggest and most powerful machinery like lifting cranes, gears are employed in many different fields and under a variety of different conditions. Using gears of a diameter ranging from a few millimeters to many meters, they can be controlled to transmit power from negligibly small values to thousands of kilowatts. Some of the common applications of gears are Automobiles, rolling ill, and milling, machines.

Advantages:

Since gear drives are more compact than belt and chain drives, less installation area is required. High-efficiency gear drives are available. They are highly reliable and have a long service life compared to belt or chain drives, gear drives can convey more power. They are more powerful and offer a wider range of speed ratios than other drives. Due to the absence of slipping that could occur with belt drives, they have a constant speed ratio.

Introduction to TORPO E :

By utilizing the software PRO-E 5, the specimens are modeled. With its distinctive features and adaptable user interface, the PRO-E 5 program makes modeling simple for users. Recent work has offered a number of methods for modeling the best gear design. It gives a computer design procedure for 20-degree pressure angle gearing that disregards scoring for gear-tooth tips. This program changes the diametral pitch, face width, and gear ratio to get a good design at the gear mesh characteristics, like addendum ratios and pressure angles, and it describes how to change a standard gear mesh to get a better gearset. Gay discusses how to adapt a basic gear set to balance this mechanism of failure with the pitting fatigue mode and how to score goals with gear. He modifies the gear and pinion addendum ratios to achieve the best design. To determine the ideal size of a standard armament, the most fundamental technique is to assess a particular design to ensure its acceptability. Optimization techniques for gearbox design are discussed with the goal of lowering size and weight. The gear strengths must take into account tiredness, especially how the AMA treats it (Amer- I can Gear Manufacturing Association).

Disadvantages:

Compared to other drives, gears require more intricate design and manufacturing processes. Due to incorrect manufacturing, excessive wear, or both, it generates noise at high speeds. Gears cannot be used for long-distance power transmission in places like flour mills, rice mills, etc. Unlike belt or chain drives, they need careful maintenance and sufficient lubrication.

Type of gear tooth profile:

The location on a circle's rim where a fixed straight line can be moved along without slipping. When a circle moves over the fixed circle created by a point on the circumference of a circle without slipping, the movement is referred to as an epicycloid. A hypocycloid is the curve that a point on the circumference makes when a circle rolls without slipping inside of a stationary circle, on the other hand. A point on a tangent that rolls without slipping on the circle or a point on a taut string that is unwound from a reel in combination with the toothed wheels form an involute tooth, also known as a base circle. The involute's trail is seen below: Let A serve as the involute's beginning point. By dividing the base circle into an equal number of pieces, such as AP1, P1, P2, P3, etc., the involute curve AR is produced. Any typical occurrence at any involute point is always off-topic, as consideration will show.

Ansys intro :

To resolve structural and heat transport engineering analyses, ANSYS, a multipurpose finite element computer tool, is employed. Static analysis, elastic, plastic, thermal, stress, stress-stiffened, large deflections, bilinear elements, dynamic analysis, model, harmonic response, linear time history, nonlinear time history, heat transfer analysis (conduction, convection, radiation), coupled to fluid flow, coupled to electric flow, structures, magnetic, etc. are all capabilities of the ANSYS solution to problems.

Fea :

The number of elements in this finite element analysis decreases the continuum's limitless degrees of freedom. The elements are thought to only be joined at their nodes. With more elements used, the accuracy of the solution increases. But with a greater number of with more elements used, the result becomes more accurate. However, more people participated.

Methodology :

Following are the processes by which the analyzing processes are done.

1. Importing to ANSYS Workbench
2. Generating Meshing
3. Applying Material Properties
4. Applying supports
5. Applying loads
6. Analyzing the Deformation and Stresses
7. Plotting the graph

Importing the model :

Importing the PRO-E.IGES file to the ANSYS software is done simply by going to the File menu choosing ‘Import File’ then clicking the generate icon. Afterward, the pro-e file is generated in Ansys. Then select the units, and material property, and apply mesh, load, and supports.

Applying Material Properties :

Our next concern is to apply the material properties to the specimen. ANSYS 11is provided a large database for various materials

2. GENERATING VOLUME MESH :

1. CFX Mesh method
2. Generate Volume Mesh

Applying supports :

In mated gear one is Fixed supported and another one is Friction less Support

Applying moment :

The Moment is Applied to friction less Support Gear

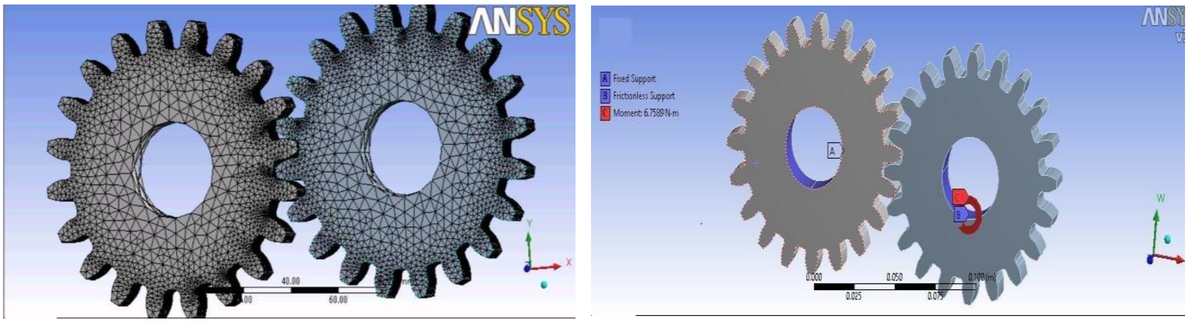


Figure 1. Total deformation for gear-1

3.RESULTS AND DISCUSSIONS:

Existing gear (Gear-1) analysis results

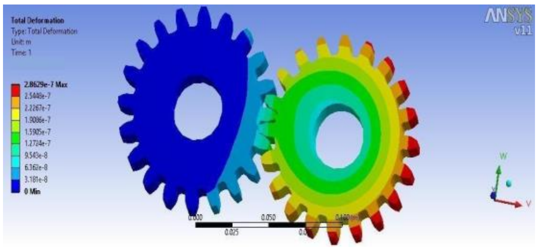
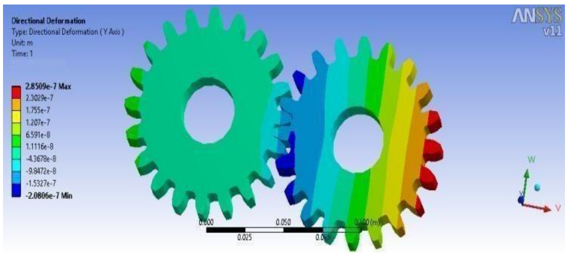


Figure 2. Total deformation for gear-1



Directional deformation for gear-1

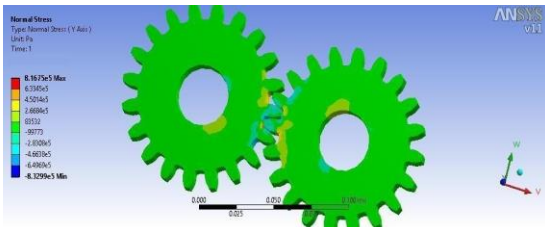
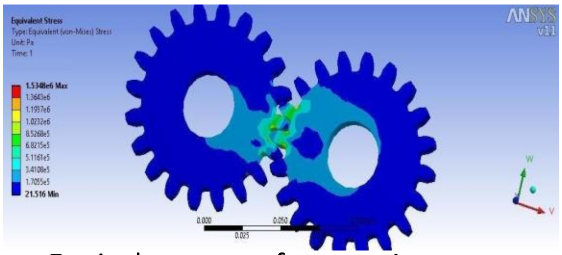


Figure 3.Normal stress for gear-1



Equivalent stress for gear-1

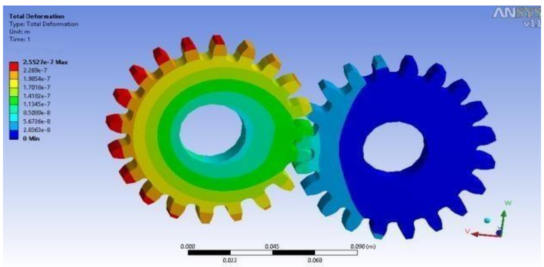
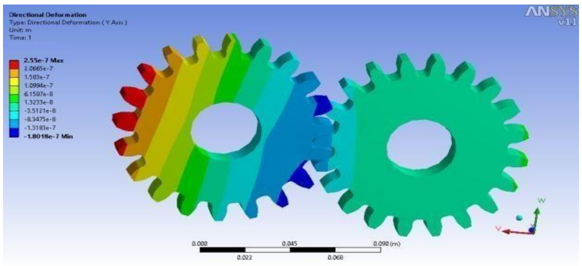


Figure 4. Total deformation for gear-2



Equivalent stress for gear-2

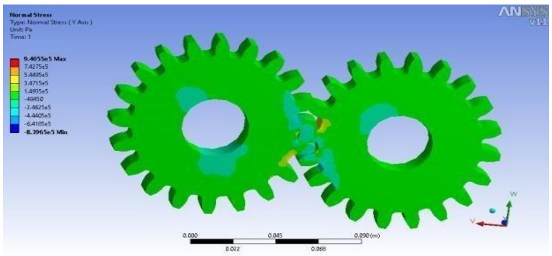
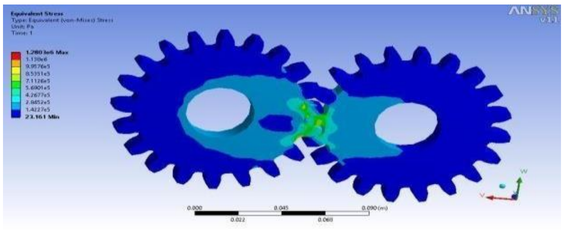


Figure 5. Normal stress for gear-2



Equivalent stress for gear-2

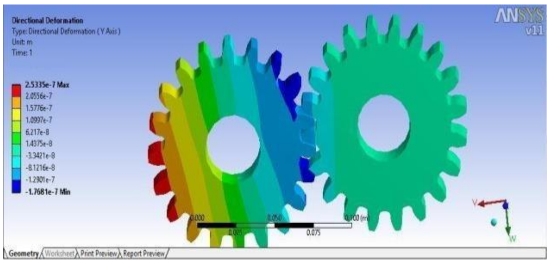
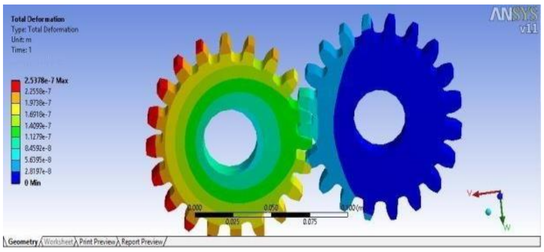


Figure 6. Normal stress for gear-3



Equivalent stress for gear-3

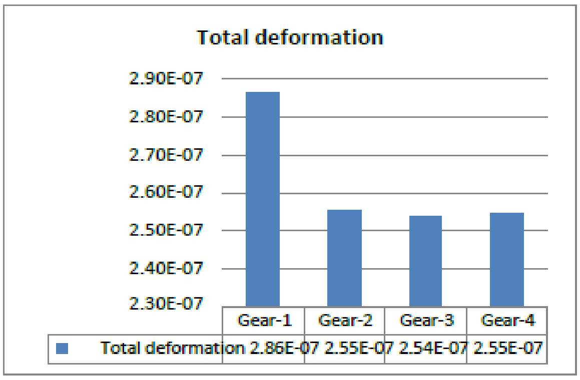


Fig-6.29- Total deformationbar chart

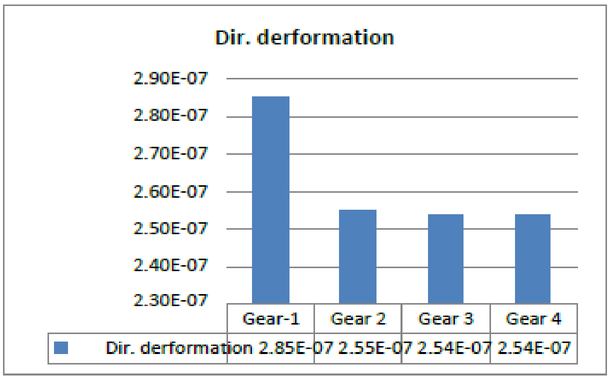


Fig-6.30- Directional deformation bar chart

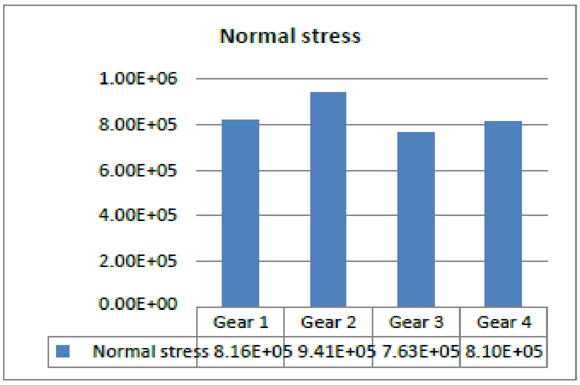


Fig-6.31- Normal stress bar chart

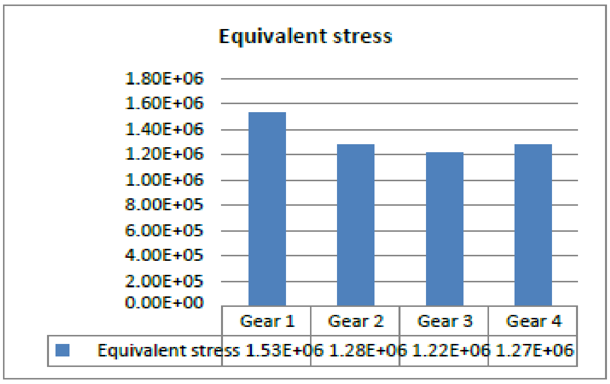


Fig-6.32- Equivalent stress bar chart

Figure 7. Root fillet radius modification results

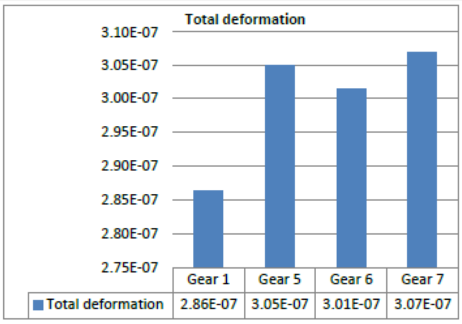


Fig-6.33- Total deformationbar chart

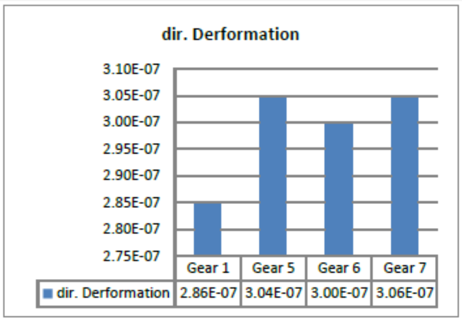


Fig-6.34- Directional deformation bar chart

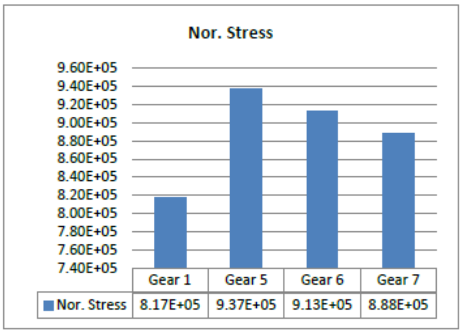


Fig-6.35- Normal stress bar chart

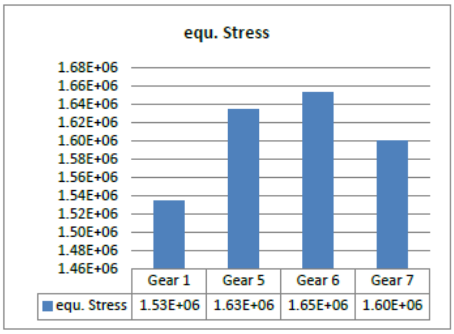


Fig-6.36- Equivalent stress bar chart

Figure 8. Top land fillet radius modification

According to the results and above chart increasing the top land fillet radius the stresses and deformation values are increases at every point. But in the root fillet radius 2.05mm the stresses and deformation value is less as compare to all other and existing gear. This gear has better control then all other gears.

CONCLUSIONS:

discretize, and evaluate spur gear with the same gear parameters other than the tooth height. The profile is altered, examined, and contrasted with current equipment. When compared to the present gear, the stresses created in the designed gear are lower. The result shows that the modified tooth has better control in the displacement. Therefore, an increase in tooth depth within a certain range assures that the vibration's magnitude may be effectively controlled. As a result, it is recommended that the root fillet radius be increased as a useful method of profile adjustment to lessen the stresses and vibration that are created in the gears. Spur gear having the same gear parameters except the gear tooth height has been generated, discretized, and analyzed by FEA software. The profile is modified, analyzed, and compared with existing gear. The stresses induced in the redesigned gear are lesser when compared to the existing gear. The result shows that the modified tooth has better control over the displacement. Hence an increase in the tooth depth within a limit ensures that the control of the magnitude of the vibration is effective. Therefore, the increase of root fillet radius is suggested as an effective way of profile modification to reduce the stresses and vibration induced in the gears.

Reference:

1. Carl C Osgood: Fatigue Design, 1st edition, Wiley-Interscience, 1970, New York.
2. Kramberger J., Sraml M., Potrc I., Flasker J.: Numerical calculation of bening Fatigue Life odf Thin-rim Spur Gears, J. Engineering fracture mechanics 71(4–6)(2004) 647
3. Glodez S., Abersek B., Flasker J., Zen Z.: Evaluation of Service Life of Gears in Regard to Pitting, J. Engineering fracture mechanics, 71 (2004) 429
4. Akata E., Altmbalik M.T., Can Y.: Three Point Load Application in Single Tooth Bending Fatigue Test for Evaluation of Gear Blank Manufacturing Methods, Int. J. Fatigue 26 (2004) 785
5. Zeping Wei: Stresses and Deflection in Involute Spur Gears by Finite Element Method, M.Sc. Thesis, University of Saskatchewan, Saskatchewan, 2004
6. Litvin F.L., Kim D.H.: Computerized Design, Generation and Simulation of Meshing of Mod- ified Involute Spur Gears with Localized Bearing Contact and Reduced Level of Transmission Errors, ASME J. Mech. Des. 119 (1997) 96
7. Cheng-Kang Lee: Manufacturing Process for a Cylindrical Crown Gear Drive with a Con-trollable Fourth Order Polynomial Function of Transmission Error, J. Mater. Processing Technology 209 (2009) 3
8. Seol H.I., Kim D.H.: The Kinematic and Dynamic Analysis of Crowned Spur Gear Drive,Computer Methods in Applied Mechanics and Engineering, 167(1–2) (1998) 109
9. Litvin F.L.: Gear Geometry and Applied Theory, Prentice Hall, 1994,Englewood Cliffs, NJ
10. Hunglin Wang, Hsu-Pin Wang: Optimal Engineering Design of Spur Gear Sets, Mechanisms and Machines theory, l29 (7) (1994) 1071
11. ANSYS, Release11.0, Structural Analysis Manual, ANSYS, 2007, USA
12. Tae Hyong Chong, Jae Hyong Myong, Ki Tae Kim: Tooth Modification of Helical gears for Minimization of Vibration and Noise, Int.J. Korean Society of Precision Engineering, 2 (4) (2001) 5
13. Lin Liu, Pines D.J.: The Influence of Gear Design Parameters on Gear Tooth Damage Detection Sensitivity, ASME J.Mechanical Design, 124 (2002) 794
14. Davis J.R.: Gear Materials, Properties and Manufacture, ASM International, 2005, (oh) Boresi A.P., Schmidt R.J.: Advanced Mechanics of Materials, 2003, John Wiley & Sons Inc.Hyperworks, version 9.0, Altair Engineering Inc.