CONTACT STRESS ANALYSIS IN DESIGN MODIFICATION OF HELICAL GEARS\

ASIF MAHALDAR (M.Tech) B.L.D.E.A's V.P. Dr. P.G. Halakatti College of Engineering and Technology Vijayapura
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S.R.KATTIMANI (BE, M.Tech) Asst professor B.L.D.E.A's V.P. Dr. P.G. Halakatti College of Engineering and Technology Vijayapura

ABSTRACT:

Helical gear is a popular type of gear having its teeth cut an angle, known as helix angle thus allowing for more gradual and smoother meshing between gear wheels. Helical gears are better choice when the loads are heavy, the speeds are high, or the noise level must be kept low. Contact stresses occurring in the gear tooth is one of the main reasons for gear tooth failure. The main objective of this project is to analyze the contact stresses with different helix angles and coefficient of friction. The commercial finite element software ANSYS is used for analysis. The results obtained from ANSYS values are compared with theoretical values.

CHAPTER-1

1. INTRODUCTION:

The gears in a transmission are analogous to the wheels in a crossed, belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage. When two gears mesh, if one gear is bigger than the other, a mechanical advantage is produced, with the rotational speeds, and the torques, of the two gears differing in proportion to their diameters. Gear is an essential component in many machine parts; its application varies from small geared motor to and complicated aerospace accessories. Human has been familiar about the idea that the repeated bending of wood or metal back and forth with high amplitude could rupture it. He found that the repeated stress can produce fracture with stress within elastic limit of material. The fatigue analysis for structure designing relies on approach which has been progressed over the last 100 years or so. The very first fatigue analysis has been done by German mining engineer, W.A.S. Albert who performed number of repeated loading test on iron chain. Fatigue is the most important failure mode to be considered in a mechanical design. Fatigue is the process of continuous localized permanent structural change appearing in a material subjected to fluctuating stress conditions. If the loading limit does not exceed the elastic limit, the body will regain its original state. Designer should have a good knowledge of analytical and empirical techniques to get effective results in averting failure. Mechanical failure is observed mainly due to fatigue design therefore fatigue becomes an obvious design, consideration for many structure such as aircraft, rail cars, automotive suspension, Vehicle frame and bridges In normal conditions, contact fatigue is one of the most common failure modes for gear tooth surfaces. Gear tooth interaction causes adhesive wear throughout the life of gear drive.

The main aim of this study is to predict contact fatigue crack initiation resulting from high stresses or strains during the meshing process. These contact stresses are generally at their highest at some distance under the surface, where initial cracks are most likely to appear. In order to increase the bending fatigue strength at the tooth root fillet of gears, gears with high pressure angle and positive addendum modification factor are generally adopted. Bharat Gupta et. al. has considered contact stress, the deciding factor to determine the required dimension of gears. Thorough studies of contact stress developed between the different mating gears are mostly important for gear design. Analytic methods of calculating gear contact stresses use Hertz's equations, which were originally derived for contact between two cylinders

Helical Gears

The teeth on helical gears are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement.

This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears. For this reason, helical gears are used in almost all car transmissions.

Figure 1.2 Helical Gear

Chapter 2

Literature Review:

- **Vicky Lad, Dr. L. P. Singh [2016].[1]** DESIGN MODELLING AND ANALYSIS OF HELICAL GEAR USING CATIA, ANSYS AND AGMA PARAMETERS, Gears are used to transmit the power between two shafts. In the gear design several stresses are present in it when they transmit the power. During transmitting the power the bending stress is considered as the main cause for failure of gear. In this paper bending stress can be calculated by using analytical method which is calculated by the AGMA (American Gear Manufacturing Association) calculation and the model is designed in CATIA V5 and saved in IGES format and then imported in the ANSYS 17 software where it can be analyzed. The main objective of this study has to investigate the stresses induced in gear tooth profile. This can be achieved by changing such design parameter in the existing design. The results are then compared with both the AGMA and ANSYS procedure.
- **A.Y Gidado, I. Muhammad, A. A. Umar** [2] [2014] Design, Modeling and Analysis of Helical Gear According Bending Strength Using AGMA and ANSYS, In this paper one of the principal failure modes are studied based on the calculation of bending stress. Helical gears are widely used in industry where the power transmission is required at heavy loads with smoother and noiseless operation. To estimate the bending stress, three- dimensional solid models for different face width are generated by Pro/Engineer that is a powerful and modern solid modeling software and the numerical solution is done by ANSYS, which is a finite element analysis package. The analytical investigation is based on Lewis stress formula. In this paper a helical gear was modeled on Pro engineer wildfire 4.0 and stress analysis part is done on ANSYS 11.0. The results are then compared with both AGMA and FEM procedures.
- **K. NARESH, C. CHANDRUDHU** [3] [2016] DESIGN AND

ANALYSIS OF HELICAL GEAR. Helical gears are widely used in industry where the power transmission is required at heavy loads with smoother and noiseless operation. Helical gear are generally used to transmit power or torque for transmission at very high speed when compared to other kind of gear transmissions this application are explain the design the helical gear with defined specification. It's have an involving modern design, specific character, specific materials, with consideration of analysis of force, and its mechanical properties. In this project we design the helical by using solid works 2016 premium and perform the analysis by using solid works simulation by using different materials and different loads applied on it.

- **Mohit Singh, Waris Khan, Sanjeev Kumar** [4] [2016] STRUCTURAL ANALYSIS OF COMPOSITE MATERIAL HELICAL GEAR UNDER DIFFERENT LOADING CONDITION. In this work an attempt has been made to replace the metallic gears of steel alloy with the composites. The composites consider were the Aluminum Silicon carbide composite Carbon fiber epoxy composites and carbon fiber silicon carbide ceramic composite . Efforts have also been carried out for modeling of the transmitting power gear assembly on creo 3.0 and fem based structural behavior of different material were studied. Ansys 14.0 is used the analysis tool in the present work to determine the total deformation , von misses stress and the natural frequencies at various mode. Composite gears offer improved properties over steel alloys and these can be used as better alternative for replacing metallic gears.

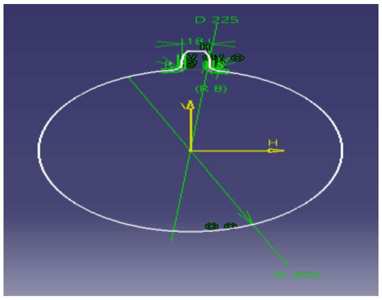
- **Khaldoon F. Bretheea,b, Dong Zhenc, Fengshou Gua, Andrew D. Ball** [5] [2017], Helical gear wear monitoring: Modeling and experimental validation, The model consists of an 18 degree of freedom (DOF) vibration system, which includes the effects of the supporting bearings, driving motor and loading system. It also couples the transverse and tensional motions resulting from time-varying friction forces, time varying mesh stiffness and the excitation of different wear severities. Vibration signatures due to tooth wear severity and frictional excitations were acquired for the parameter determination and the validation of the model with the experimental results. The experimental test and numerical model results show clearly correlated behavior, over different gear sizes and geometries. The spectral peaks at the meshing frequency components along with their sidebands were used to examine the response patterns due to wear. The paper concludes that the mesh vibration amplitudes of the second and third harmonics as well as the sideband components increase considerably with the extent of wear and hence these can be used as effective features for fault detection and diagnosis.

- **Wenliang Li n, Weiyang Lin, Jinyong Yu, [6] [2016] Predicting contact characteristics for helical gear using support vector machine.** Friction force and friction torque are important factor in dynamics characteristics of transmission system. But, it is very difficult to measure friction force and friction torque. Numerical method is very complex to consult the mathematic model and take more time to calculate. A method was proposed, numerical algorithm and support vector machines were combined to predict the friction force and the friction torque of helical gear. First, numerical method was constructed to calculate contact characteristics. Then the results were adopted as inputs for support vector machines to predict friction force and friction torque. The conclusion shows the results are direct utilization which came from the output of support vector machines. Since the results are available directly from the output of the numerical method. The proposed method provides the possibility to predict friction force and friction torque in Engineering.

- **Nitin Kapoor, Virender Upneja, Ram Bhool and Puneet Katyal** [7]. The main objective of this paper is to developed parametric model of differential Gearbox by using CATIA-V5 under various design stages. It is observed that Glass filled polyamide composite material is selected as best material for differential gearbox and is found to suitable for different revolutions (2500 rpm, 5000 rpm and 7500 rpm) under static loading conditions. Comparisons of various stress and strain results using ANSYS-12 with Glass filled polyamide composite and metallic materials (Aluminum alloy, Alloy Steel and Cast Iron) are also being performed and found to be lower for composite material.

3. **Modeling of helical gear:**

CATIA (Computer Aided Three-dimensional Interactive Application) (in English typicallyarticulated /) is a multi-stage CAD/CAM/CAEbusiness programming suite created by the Frenchorganization Dassault Systems coordinated byBernard Charles. Written in the C++ programmingdialect, CATIA is the foundation of the DassaultSystems programming suite.



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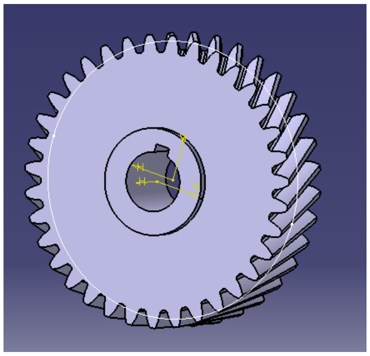

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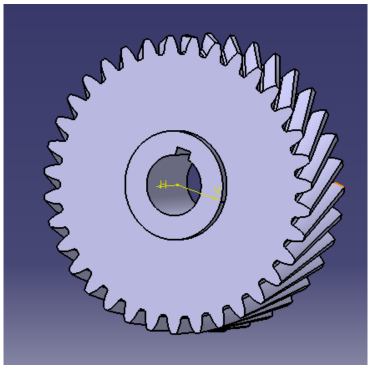

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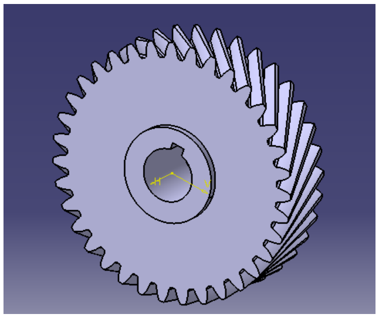

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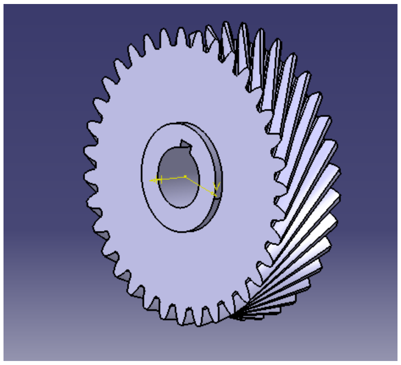


4 **Ansys:**

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems

2. Apply operating loads or other design performance conditions.

3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.

4. Optimize a design early in the development process to reduce production costs.

5. A typical ANSYS analysis has three distinct steps.

6. Pre Processor (Build the Model).

- **Material Data**

Gray Cast Iron:

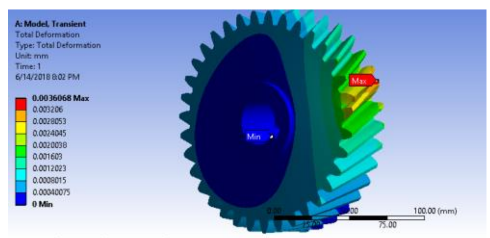
Density	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
7.2e-006 kg mm^-3	1.1e+005	0.28	83333	42969

15 degrees:

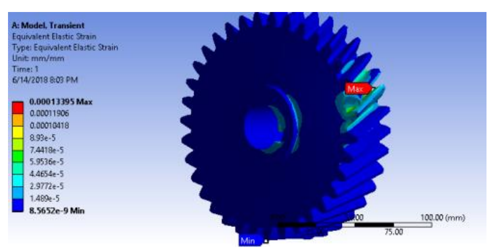
Gray Cast Iron:

Object Name	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Shear Elastic Strain*	*Equivalent Stress*
Minimum	0. mm	-2.2422e-004 mm	8.5652e-009 mm/mm	-3.0245e-005 mm/mm	9.4217e-004 MPa
Maximum	3.6068e-006 m	3.0624e-003 mm	1.3395e-007 m/m	5.8256e-005 mm/mm	14.638 MPa

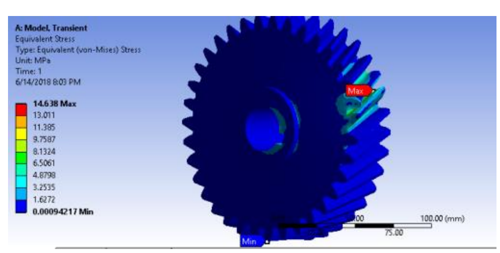
Total Deformation



Equivalent Elastic Strain



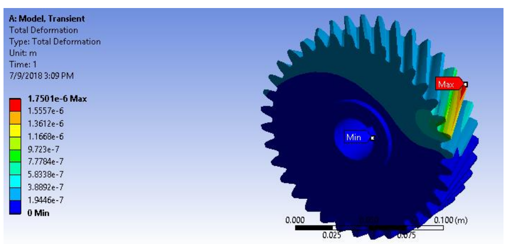
Equivalent Stress



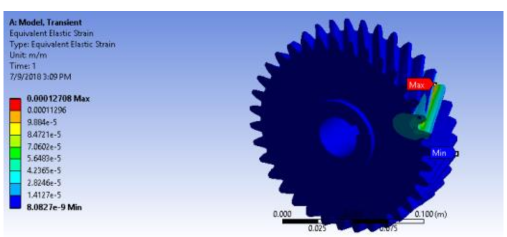
18 degrees:

Object Name	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Shear Elastic Strain	Equivalent Stress
Minimum	0. m	-5.8938e-007 m	8.0827e-009 m/m	-1.5495e-005 m/m	889.1 Pa
Maximum	1.7501e-006 m	4.8188e-007 m	1.2708e-004 m/m	3.6159e-005 m/m	1.3863e+007 Pa

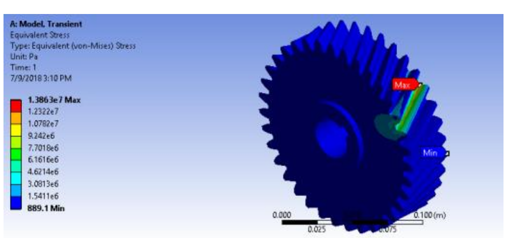
Total Deformation



Equivalent Elastic Strain



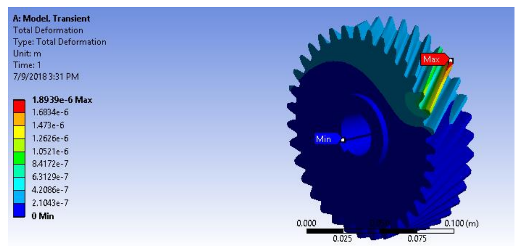
Equivalent Stress



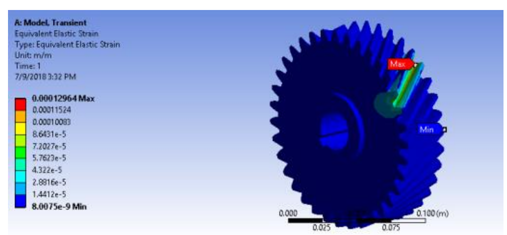
24 degrees:

Object Name	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Shear Elastic Strain	Equivalent Stress
Minimum	0. m	-7.1758e-007 m	8.0075e-009 m/m	-3.8937e-005 m/m	668.69 Pa
Maximum	1.8939e-006 m	5.8371e-007 m	1.2964e-004 m/m	2.046e-005 m/m	1.3952e+007 Pa

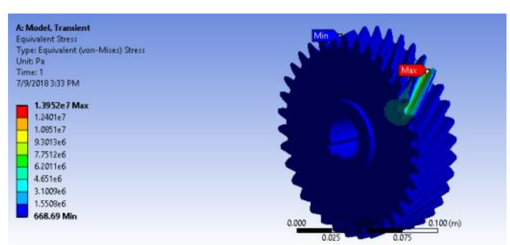
Total Deformation



Equivalent Elastic Strain



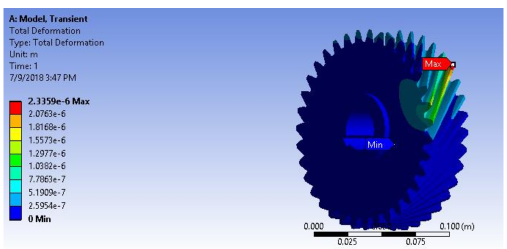
Equivalent Stress



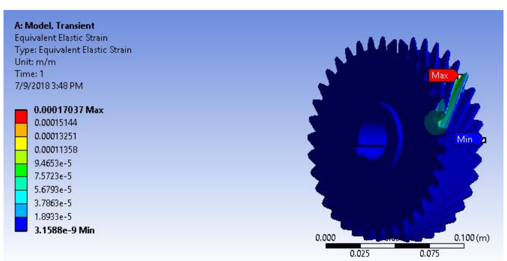
36 degrees:

Object Name	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Shear Elastic Strain	Equivalent Stress
Minimum	0. m	-1.0382e-006 m	3.1588e-009 m/m	-4.5521e-005 m/m	347.47 Pa
Maximum	2.3359e-006 m	1.2253e-006 m	1.7037e-004 m/m	2.3584e-005 m/m	1.8413e+007 Pa

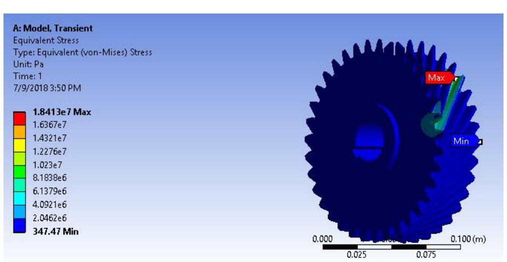
Total Deformation



Equivalent Elastic Strain



Equivalent Stress



Conclusion:

Using the ansys applying friction for various angles with loads like obtained the above results By observing that

- Highest deformation is obtained for 1.7501e-006 m 18 degrees for stainless steel, lowest deformation for 15 degrees 3.6068e-006 m.
- High Equivalent Elastic Strain is obtained 1.3395e-007 m/m for 15 degrees lowest Equivalent Elastic Strain for 18 degrees 1.2708e-004 m/m
- For 6371.4 N 1st load High Equivalent Stress is obtained 24 degrees Gray cast iron 9.9612e+008 Pa lowest Equivalent Stress is 15 degrees: Stainless Steel1.1068e+007 Pa.
- High Equivalent Stress is obtained 36 degrees Gray cast iron 1.8413e+007 Pa. lowest Equivalent Stress is 15 degrees 14.638 MPa

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