Analysis on Impact of Misalignments on Tooth Stresses in Hypoid Gear Sets

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gears. Hypoid gears are similar in appearance to spiral bevel gears. They differ from spiral-bevel gears in that the axis of the pinion is offset from the axis of the gear. On observation the hypoid gear seems to be similar in appearance to the helical bevel gears. This allows for more efficient intermeshing of the pinion and driven gear. Since the contact of the teeth is gradual, the hypoid gear is silent in operation as compared to the spur gears. These gears are usually used in industrial and automotive application and hence the material used is a metal like stainless steel. The hypoid bevel gears, mostly used at the main transmission of motor vehicles, are non-concurrent gears. Hypoid bevel gearings are spiral and are manufactured on the same machines as the concurrent spiral bevel gearings. Even if the relative slippery between the tooth profiles is relatively high, binding is not the main gear failure, because the gears are made of cemented steels, with high hardness, tooth profile has good finishing and good quality lubrication A major application of hypoid gears is in car differentials where the axes of engine and crown wheel are in different planes. In this thesis, the impact of misalignments on root stresses of hypoid gear sets is investigated theoretically with ANSYS. An experimental set-up designed to allow operation of a hypoid gear pair under loaded quasi-static misalignments is introduced. These experimental data is collected from journal paper. Structural analysis is done to verify the strength of the hypoid gear for alignment and misalignment. Software for modeling is PRO-E and for analysis is ANSYS.

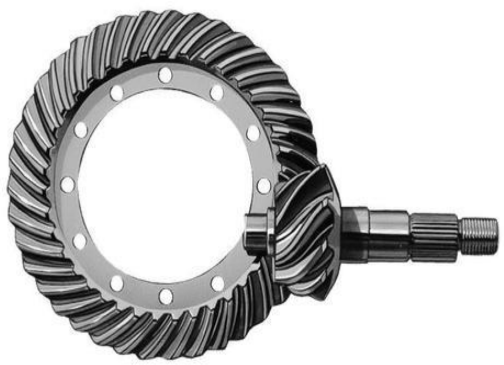
Keywords—PRO-E,ANSYS,STRUCTURAL ANALYSIS

I. Introduction

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. 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. Ease of Use

II. HYPOID BEVEL GEAR

These gears are also used for right angle drive in which the axes do not intersect. This permits the lowering of the pinion axis which is an added advantage in automobile in avoiding hump inside the automobile drive line power transmission. However, the non – intersection introduces a considerable amount of sliding and the drive requires good lubrication to reduce the friction and wear. Their efficiency is lower than other two types of bevel gears. These gears are widely used in current day automobile drive line power transmission.



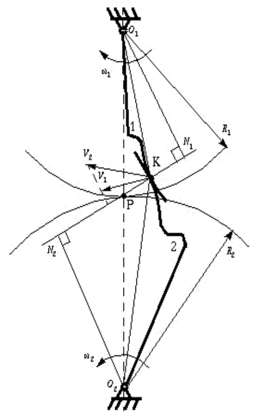
Hypoid bevel gear

III. LAW OF GEARING

A essential requirement of gears is the consistency of angular velocities or proportionality of position transmission. Rapid and/or high-power gear trains also require transmission at constant angular velocities in order to avoid problems. Constant velocity (i.e., constant ratio) motion transmission is defined as "conjugate action" of the gear tooth profiles. A geometric relationship might be determined for the form of the tooth profiles to provide conjugate action, which is summarized as the Law of gearing as follows:

N1: foot of the perpendicular from O1 to N1N2

N2: foot of the perpendicular from O2 to N1N2



Law of gearing

IV. TYPES OF GEAR TOOTH FAILURES

Generally several types of gear tooth failures occurs Due to speed and material properties such are

- Wear
- Fracture
- Scoring
- Surface fatigue
- Process related

V. LITERATURE REVIEW

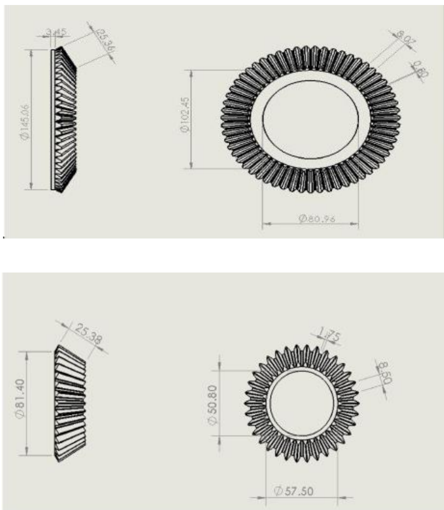
Dr. Hani Aziz Ameen Shaft misalignment is considered as one of the common repeated problems in most rotating machineries , which leads to generate vibrations and extra dynamic loads on transmitting gears teeth, also leads to non- uniformity in distribution of applied load along the meshing tooth face by being concentrated on one side of tooth face. The present work concentrated on the analysis of stresses generated on transmitting gear tooth, also studied the effect of misalignment angle on stress distribution and its concentration. This is important for the gear design and those who works in gear maintenance , because fracture is expected to initiate and propagate at locations of stress concentration . ANSYS program using finite element technique had been used, as this program is efficient and accurate tool in stress analysis

Avutu. Madhusudhana reddy The forces acting on the hypoid gear are calculated theoretically. Structural analysis and Modal analysis are done on the designed models to verify the stresses developed. The materials used are Steel and Aluminum Alloy. Analysis is done Solidworks. By observing the analysis results, the stresses are increased almost by double when the gears are misaligned. So it can be concluded the deviation angle of contact defined as a major contributor of increasing of stress on the tooth root thereby probably could lead to a fatigue initiation at the maximum stress region and finally leads to breakage of the gear. By comparing the results between two materials, the stress values are less when Aluminum alloy (6061) is used compared with that of steel and also its density is less, thereby reducing the weight of the gears.

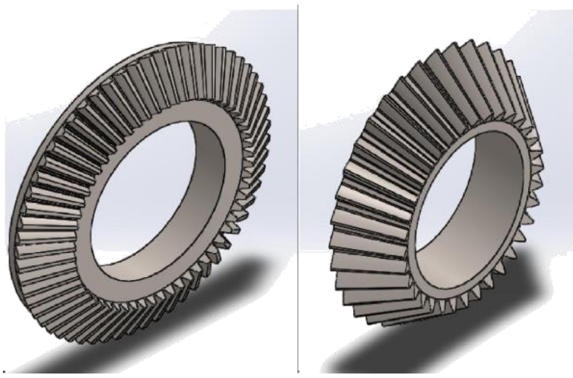
VI. MODELING AND ANSYS

MODELLING

Sketching and modeling process done in PRO-E (creo)version 2.0 with the followed specifications.



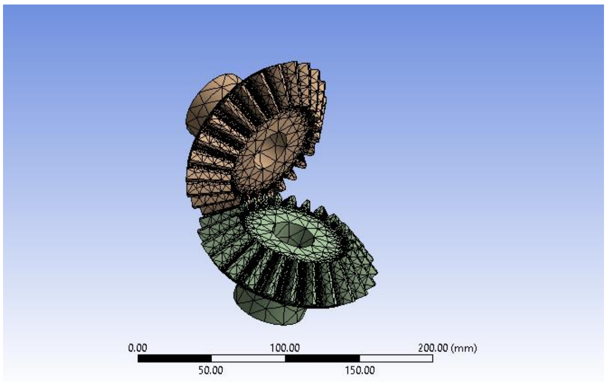
Sketches of 1.gear 2.pinion



CAD model of gear and pinion

ANSYS:

Considering cost, strength, ease of access taken into account the selected material for this design is **MILD STEEL and ALUMINUIM ALLOY 6062**

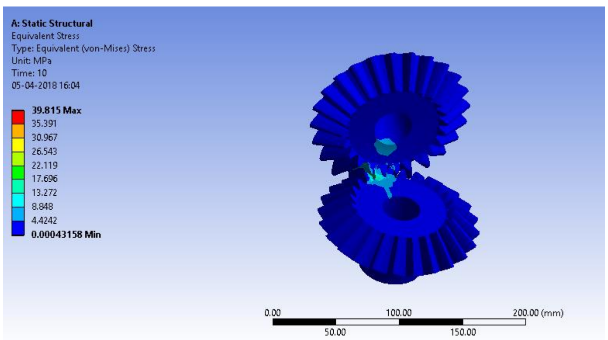


Meshing

VII. RESULTS

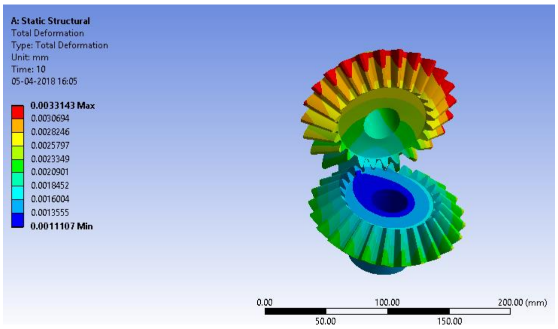
I.Misalignment results

1.Mild steel

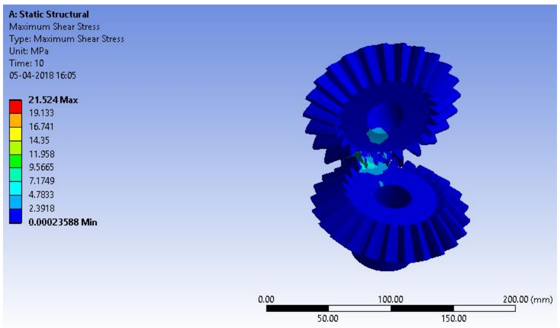


Developed Min stress 0.0004315 N/m^2

Max stress 39.815 N/m^2

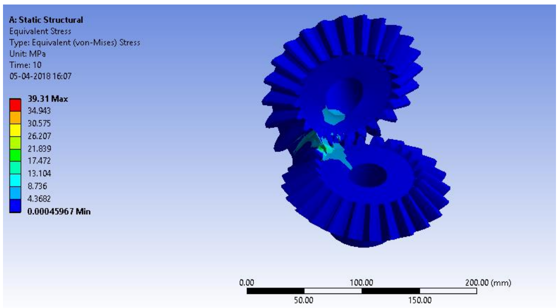


Min deformation 0.0011107 mm
Max deformation 0.0033143 mm

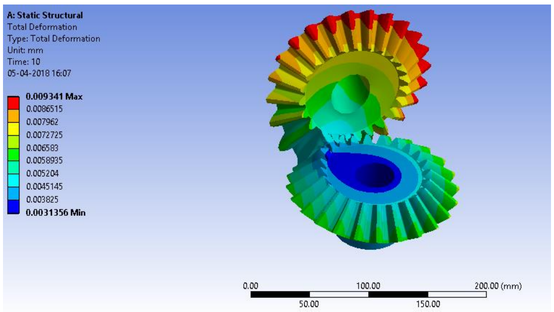


Developed Min shear stress 0.00023 N/m^2
Max shear stress 21.524 N/m^2

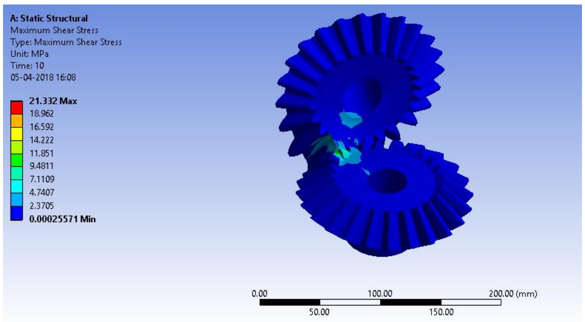
2.Aluminium alloy 6062



Developed Min stress 0.00045967 N/m^2
Max stress 39.31 N/m^2



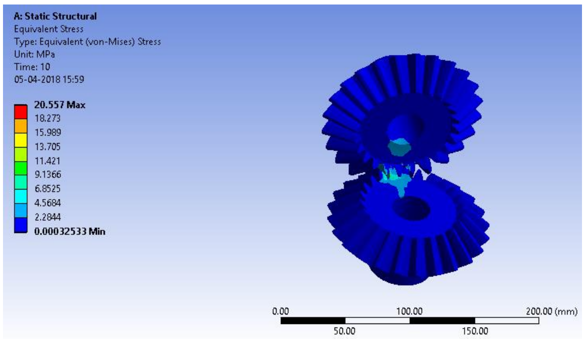
Min deformation 0.0031356 mm
Max deformation 0.009341 mm



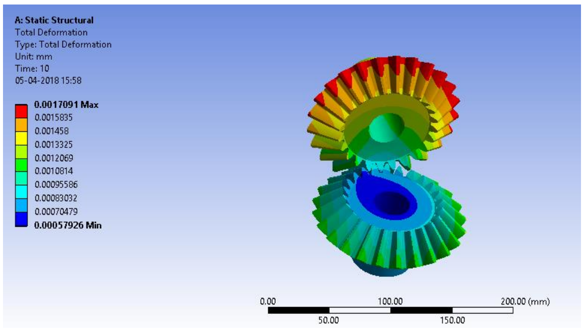
Developed Min shear stress 0.0002557 N/m^2
Max shear stress 21.332 N/m^2

II.alignment results

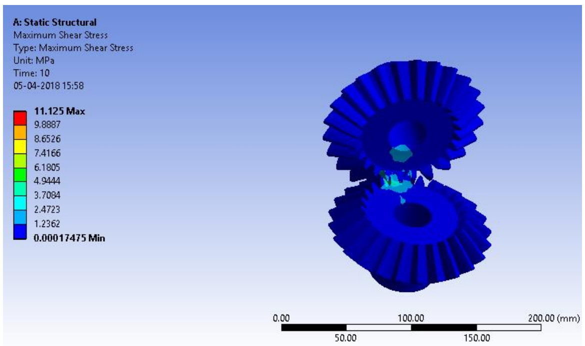
1.Mild steel



Developed Min stress 0.00032533 N/m^2
Max stress 20.557 N/m^2

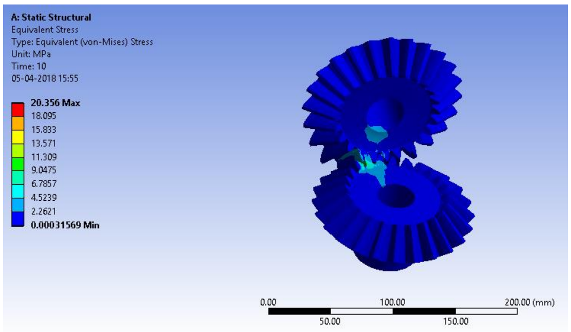


Min deformation 0.00057926 mm
Max deformation 0.0017091 mm

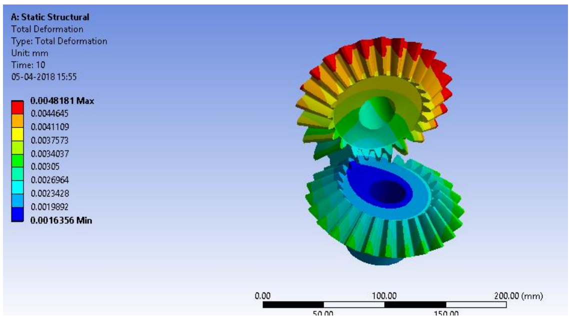


Developed Min shear stress 0.00017475 N/m^2
Max shear stress 11.125 N/m^2

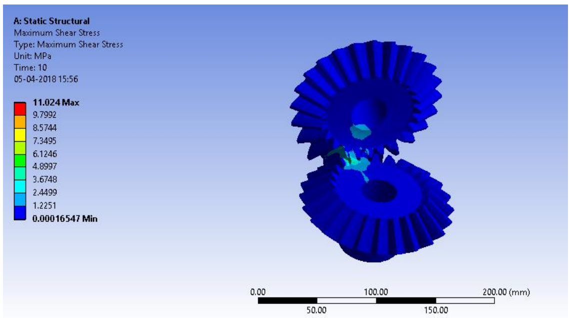
2.Aluminium alloy 6062



Developed Min stress 0.00031569 N/m^2
Max stress 20.356 N/m^2



Min deformation 0.0016356mm
Max deformation 0.0048181mm



Developed Min shear stress 0.00016547 N/m^2
Max shear stress 11.024 N/m^2

VIII. OVERVIEW RESULTS

Type	Material	Results		
		Stress (Mpa)	Deformation(mm)	Shear stress (MPa)
Misalignment	Mild steel	39.81	0.0033143	21.524
	Aluminum alloy 6061	39.31	0.009341	21.332
Alignment	Mild steel	20.557	0.0017091	11.125
	Aluminum alloy 6062	20.356	0.0048181	11.024

IX. CONCLUSION

- In this project , the impact of misalignments on root stresses of hypoid gears is investigated. 3D modeling is done in Pro/Engineer. Two models with perfect alignment and misalignment are designed.
- The forces acting on the hypoid gear are calculated theoretically. Structural analysis and Modal analysis are done on the designed models to verify the stresses developed. The materials used are Mild steel and Aluminum Alloy 6061. Analysis is done ANSYS
- By observing the analysis results, the stresses are increased almost by double when the gears are misaligned. So it can be concluded the deviation angle of contact defined as a major contributor of increasing of stress on the tooth root thereby probably could lead to a fatigue initiation at the maximum stress region and finally leads to breakage of the gear.
- By comparing the results between two materials, the stress values are less when Aluminum alloy (6062) is used compared with that of steel and also its density is less, thereby reducing the weight of the gears. By reducing the weight, mechanical losses will be reduced. The gear will perform more efficiently and the life time of the gear also increased.

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2. Impact of Misalignments on Root Stresses of Hypoid Gear Sets Avutu. Madhusudhana reddy1 , Gowthamtham reddy. Vudumula2 1 PG student, Department of Mechanical Engineering, Vikas College of Engineering & Technology, Nunna 2 Guide (Asst.prof), Department of Mechanical Engineering, Vikas College of Engineering & Technology, Nunna, Vijayawada, AP, INDIA
3. Cheng and Lim (1998-2001) proposed a hypoid gear mesh model based on unloaded and loaded contact analysis
4. Jiang and Lim (2002) derived a NLTV dynamic model for hypoid gear pair torsional vibration and investigated the nonlinear response through both analytical and numerical solutions
5. Hassan (2009) presented the study which deals with contact stresses of gears consideringcontact ratio, approach angle, recess angle, length of contact

6. Patel et al. (2010) developed a three dimensional deformable-body model of spur and helicalgear.
7. Cheng Zhe and Hu Niaoqing (2011) studied the causes of planetary gear system tooth defect due to excessive stress conditions

AUTHOR DETAILS:

First Authour: P.Shiva Charan received B.Tech Degree in Mechanical Engineering from Swami Ramananda Tirtha Institute of Science & Technology in 2016. He is currently M.Tech student in Mechanical Engineering department,Machine Design stream in Holy Mary Institute of technology & science and his research interested area in the field of Design and Construction.

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Third Author: Ayub Ashwak working as an Assistant Professor in Holy Mary Institute of Technology & science. His qualification is master in mechanical engg and my specialization is advance design and manufacturing from Osmania University.he did his masters project on tube hydroforming and title is parametric studies on tube hydrofoming process by using ansys software

he have 10 yrs.experience I that 4 yrs production side and 6 yrs teaching side.His areas of interest include finite element analysis,machine design and manufacturing,hydraulics and pneumatics and composite materials.He has published papers in several international journal proceedings and conference proceedings.