ISSN (e): 2250 – 3005 || Vol, 04 || Issue, 10 || October– 2014 ||
International Journal of Computational Engineering Research (IJCER)

Impact of Misalignments on Root Stresses of Hypoid Gear Sets

Avutu. Madhusudhana reddy[1], Gowthamtham reddy. Vudumula[2]

[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

ABSTRACT

The hypoid gears are a subtype of bevel 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. The main difference being that the planes of the input and the output gears are different . 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. 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 FEA. An experimental set-up designed to allow operation of a hypoid gear pair under loaded quasi-static conditions with various types of tightly controlled 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/Engineer and for analysis is Cosmos.

KEYWORDS : *Cosmos, FEA , Hypoid gears , PRO-E, Structural Analysis*

I. INTRODUCTION TO GEARS

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, magnitude, and direction of a power source. The most common situation is for a gear to mesh with another gear, however a gear can also mesh a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping.

II. NOMENCLATURE

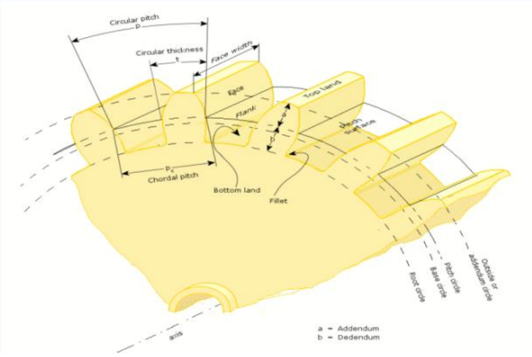

Fig.1 Nomenclature

III. INTRODUCTION TO HYPOID GEARS

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. The research on concurrent bevel gears lead to the development of an international standard ISO/DIN on bevel gear strength calculus. In the case of hypoid bevel gears there are less references and a gear strength standard is not yet developed. 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

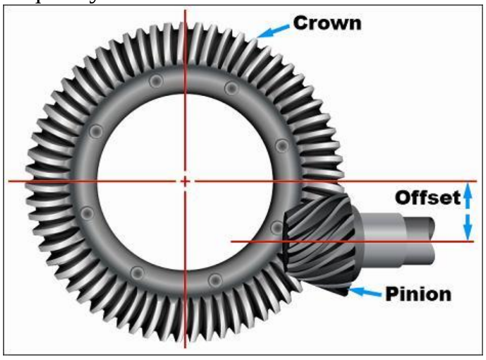

Fig.2 Hypoid gear

4.1 Hypoid Gear Materials

Gear composition is determined by application, including the gear's service, rotation speed, accuracy and more.

- **Cast iron** provides durability and ease of manufacture.
- **Alloy steel** provides superior durability and corrosion resistance. Minerals may be added to the alloy to further harden the gear.
- **Cast steel** provides easier fabrication, strong working loads and vibration resistance.
- **Carbon steels** are inexpensive and strong, but are susceptible to corrosion.
- **Aluminum** is used when low gear inertia with some resiliency is required.
- **Brass** is inexpensive, easy to mold and corrosion resistant.
- **Copper** is easily shaped, conductive and corrosion resistant. The gear's strength would increase if bronzed.
- **Plastic** is inexpensive, corrosion resistant, quiet operationally and can overcome missing teeth or misalignment. Plastic is less robust than metal and is vulnerable to temperature changes and chemical corrosion. Acetyl, delrin, nylon, and polycarbonate plastics are common.
- **Other** material types like wood may be suitable for individual applications.

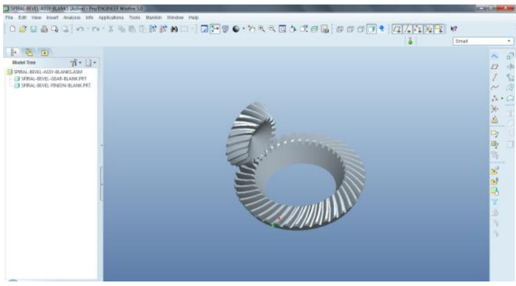

Fig.3 Assembly

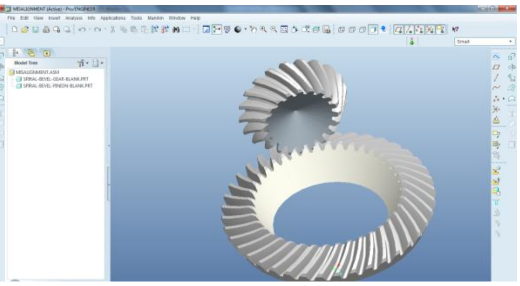

Fig.4 Misalignment

IV. INTRODUCTION TO FEA

Finite element analysis (FEA) is a fairly recent discipline crossing the boundaries of mathematics, physics, engineerin and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. The finite element method is comprised of three major phases: (1) **pre-processing**, in which the analyst develops a finite element mesh to divide the subject geometry into subdomains for mathematical analysis, and applies material properties and boundary conditions, (2) **solution**, during which the program derives the governing matrix equations from the model and solves for the primary quantities, and (3) **post-processing**, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacements and stresses), and derives and examines additional quantities (such as specialized stresses and error indicators).

V. ANALYSIS FOR HYPOID BEVEL GEAR – PERFECT MISALIGNMENT

5.1 STEEL

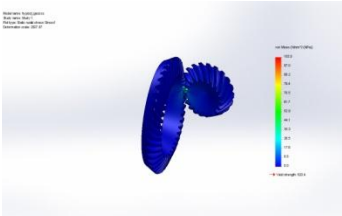
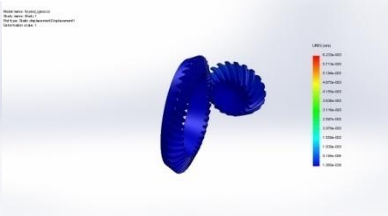
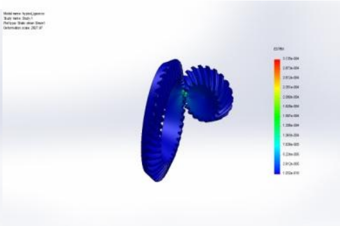

Fig.5 Hpiod igess – study 1 –stress **Fig.6 Hypiod igesss study 1 - 1- displacement** **Fig.7 Hpiod igesss – study strain**

5.2 ALUMINUM ALLOY

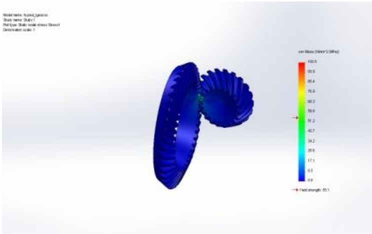
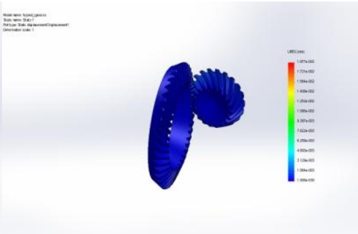
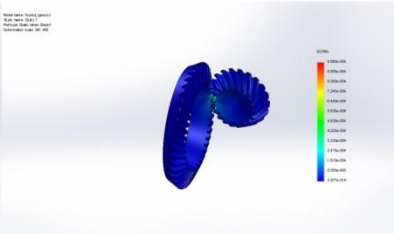

Fig .8 Hypoid igesss –study 1 –stress-stress **Fig.9 Hypoid igesss -study 1- Displacement** **Fig.10 Hypoid igesss - -study 1- strain –strain**

VI. PERFECT ALIGNMENT OF HYPOID BEVEL GEARS

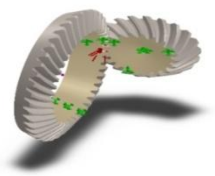

Fig.11 Assembly 2

6.1-STEEL

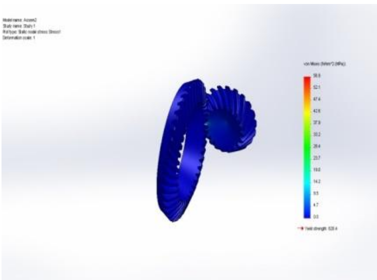
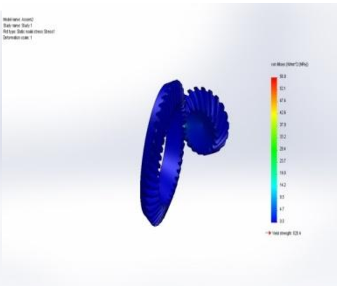
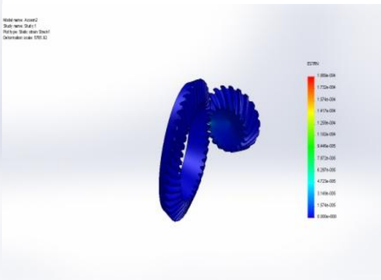

Fig.12 Assem2-Study 1-Stress-Stress1 **Fig.13 Assem2-Study1-Displacement** **Fig.14 Assem2-Study 1-Strain**

6.2 ALUMINUM ALLOY

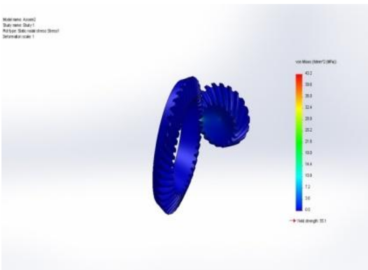
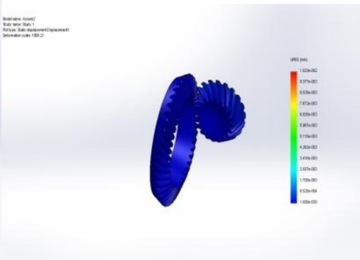
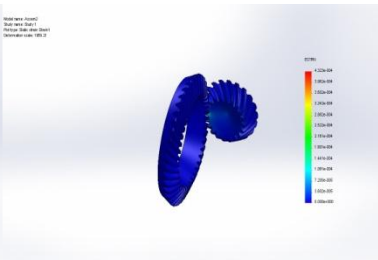

Fig.15 Assem2-Study 1-Stress-Stress1 Fig.16 Assem2-Study 1-Displacement- Fig.17 Assem2-Study1-Strain-

Displacement1 Strain1

VII. RESULTS TABLE

TYPE	MATERIAL	RESULTS		
		DISPLACEMENT(mm)	STRESS(N/mm^2)	STRAIN
MISALIGNMENT	STEEL	6.233E-003	105.8	3.135e-002
	ALUMINUM ALLOY	1.877E-002	102.5	9.660e-004
ALIGNMENT	STEEL	3.411E-003	56.9	1.889e-004
	ALUMINUM ALLOY	1.023E-002	43.2	4.323e-004

Table.1 results

VIII. CONCLUSION

In this thesis, 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 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. By reducing the weight, mechanical losses will be reduced. The gear will perform more efficiently and the life time of the gear also increased.

REFERENCES

[1]. PAPER 1 - The Stress Distribution of Gear Tooth Due to Axial Misalignment Condition by M.R. Lias, T.V.V.L.N. Rao, M. Awang and M.A. Khan

[2]. Experimental and numerical analysis of the effect of gear center distance variation and misalignment error on the dynamic behavior of narrow-faced spur gear drives by Mohamed Ben Amara, Mohamed Maatara and Aref Maaleja

[3]. An analytical method to calculate misalignment in the journal bearing of a planetary gear system by Pralay Kumar Das, Shiam Sunder Gupta

[4]. Design and simulation of meshing of new type of worm-gear drive with localized contacts by Inhwan Seol, Soonbae Chung

[5]. DETECTION OF A GEAR COUPLING MISALIGNMENT IN A GEAR TESTING DEVICE by François Combet, Nadine Martin, Pierre Jaussaud, François Léonard

[6]. Al-Hussain, K.M. and I. Redmond, 2002. Dynamic response of two rotors connected by rigid mechanical coupling with parallel misalignment. J. Sound Vibr.,

[7]. Ali , S.M.J. and O.D. Mohammad, 2008. Load sharing on spur gear teeth and stress analysis when contact ratio changed. Eng. Tech. J.

[8]. Ameen, H.A., 2010. Effect of shaft misalignment on the stresses distribution of spur gears. Eng. Tech. J.

[9]. Ariatedja, J.B. and O. Mamat, 2011. A semi-elliptical crack modeling and fracture constraint on failure diagram. J. Applied Sci.

[10]. Atanasovska, I. and V. Nikolic, 2000. The analysis of the factor of load distribution over tooth pairs in mesh in respect of contact stress of tooth flanks. J. Tech. Mech. Eng.,