DESIGN IMPROVEMENT BY STATIC STRUCTURAL AND VIBRATION EXAMINATION OF A BEVEL GEAR FOR EPICYCLIC GEAR TRAIN IN PUGMILL

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Abstract-The initial requirement for a project work is to identify and understand the nature of the problem. The problem is related to the automobile engineering and the Production area. The Bevel gear has crucial terminology. The tooth contact analysis (TCA) is an important resource for the design of gear drives. The contact pattern, contact path and the function of transmission errors that are directly related to the performance. The contact pattern are directly related to Spiral angle. This paper is related to spiral angle of the spiral bevel gear. Spiral angle is made by pitch cone radius and path of gear. We also improve the material of the spiral bevel gear. The material used for Bevel gear is usually Medium Iron Steel having Carbon 2.1- 4.5 wt.%, Si (normally 1-3 wt. %)

Generate a three-dimensional solid CAD model, Solid Workbench 15.0 software is used as a design modeler. After the design modeling, the finite element model is generated using FEA software ANSYS. Then the engineering data tool is used to select various Gear materials that are 45C8, C55 and 40Cr4Mo3, then geometry is imported using —IGS file conversion on ANSYS. After this the model is converted into meshed model. Then the boundary conditions are applied. The structural analysis model is used for the analysis of Gears. The output parameter is Total Deformation. The life of the Gear is calculated in the terms of Directional deformation. Total 15 numbers of cases are generated for analysis. For vibration analysis, analysis is done on 6 different frequency modes.

Keyword- Spiral Bevel Gear, Mean Spiral Angle, Mean Radius of Pitch Cone, 45C8, C55 and 40Cr4Mo3, ANSYS

I. INTRODUCTION

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh withanother toothed part to transmit torque. Geared devices can change the speed, torque, anddirection of a power source. Gears almost always produce a change in torque, creating amechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission. The paper is based on spiral angle. Mean Spiral angle almost similar to helix angle on the helical gear.

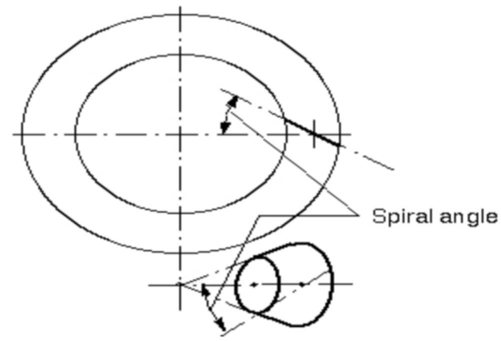


Fig.1 Spiral Bevel Gear

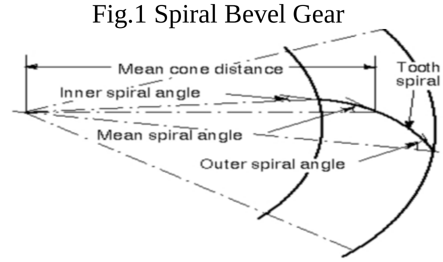


Fig.2 Line Diagram of mean spiral angle

$$\text{Mean Spiral Angle}=\arctan\left(\frac{a\pi rm}{l}\right)$$

Where

l is lead of the screw or gear.

r_m is mean radius of the screw thread or gear.

Spiral Angle directly dependents on two Basic parameters.

1st Mean cone distance

2nd Arc of gear/pinion teeth

On this paper we are change mean spiral angle. We have taken 5 different mean spiral angle on basis of reference papers.

II.GEOMETRIC MODELING AND SPECIFICATIONS OF SPIRAL BEVEL GEAR

Scientists draw on a variety of both qualitative and quantitative research methods, including experiments, survey research, participant observation, and secondary data. Quantitative methods aim to classify features, count them, and create statistical models to test hypotheses and explain observations. Qualitative methods aim for a complete, detailed description of observations, including the context of events and circumstances.

An experiment is a research method for investigating cause and effect under highly controlled conditions. When conducting an experiment, researchers will test a hypothesis. A hypothesis is a statement of how two or more variables are related. A survey is a research method in which subjects respond to a series of statements or questions in a questionnaire or an interview. Surveys target some population, which are the people who are the focus of research. Because populations are usually quite large, the researcher will target a sample, which is a part of a population that represents the whole.

A. *Modeling of Spiral Bevel Gear*

Solid Works is a solid modeling, computer-aided-design (CAD) and Computer-aided engineering (CAE) computer program for creating 3D digital prototypes used in the design, visualization and simulation of products. Solid Works is 3D mechanical solid modeling design software developed by Massachusetts Institute of Technology to create 3D digital prototypes. It is used for 3D mechanical design, design communication, tooling creation and product simulation. This software enables users to produce accurate 3D models to aid in designing, visualizing and simulating products before they are built.

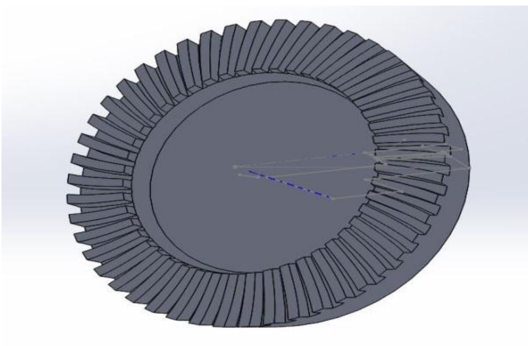


Fig.3 Spiral Bevel Gear 1

B. *General steps of Analysis*

1. Preparatory work prior to analysis:
   - Modeling
2. Preprocessor modeling through the preprocessor:
   - Defining: define Gear types, constants, material properties, etc.
   - Modeling: create model in work page; or build directly with external software, then import
   - Meshing: (to recommend smart grid divisions)
   - Checking: check that the model is correct before saving.
3. Solving by Solution:
   - Select the type of analysis; set analysis options
   - Apply additional load and constraints
   - Set load step options
   - Solving: (the default solver option can be used, if the load step has been set to select for solving, according to the load step options-solver)
4. Viewing results
   - After solving, review the model's analysis of data, deformation maps, stress map, displacement map, etc.

C. Gear materials and their properties

Table-1

S.no.	Material Grades / Properties	45C8	C55	40Cr4 Mo3	Units
1	Density	7850	7850	7850	kg/.m^3
2	Coefficient of Thermal Expansion	11	11	11	$\frac{\mu m}{m} - k$
3	Reference Temperature	20	20	20	C
4	Young's Modulus	2.00E+11	2.10E+11	2.10E+11	Pa
5	Poisson Ratio	0.3	0.3	0.3	Unitless
6	Bulk Modulus	1.67E+11	1.75E+11	1.75E+11	Pa
7	Shear Modulus	7.69E+10	8.08E+10	8.08E+10	Pa
8	Tensile Yield Strength	5.60E+08	4.50E+08	5.00E+08	Pa
9	Tensile Ultimate Strength	6.60E+08	7.50E+08	8.00E+08	Pa

D. *Geometry Specifications*

Table-2

S.No.	Parameter	Gear
1	Diametric Pitch (P)	0.142857143
2	Teeth (N)	47
3	Pitch Diameter (D)	329
4	Whole Depth (Ht)	15.318
5	Addendum (a)	7
6	Dedendum (b)	8.318
7	Clearance (c)	1.318
8	Circular Tooth Thickness (T)	10.99557
9	Pitch Angle (deg.)	76.82733779
10	Pitch cone Radius (Rc)	168.94526
11	Face Width (F)	56
12	Outside Diameter	332.19038
13	Back Cone Radius	721.85701
14	Virtual Number of Teeth	206.24486
15	Length X	128.46 mm
16	Length Y	332.3 mm
17	Length Z	332.21 mm
18	Volume	4.9339e+006 mm^3
19	Mass	38.731 kg
20	Centroid X	72.374 mm
21	Centroid Y	164.53 mm
22	Centroid Z	-3.6722e-004 mm
23	Moment of Inertia Ip1	4.6288e+005 kg·mm^2
24	Moment of Inertia Ip2	2.5684e+005 kg·mm^2
25	Moment of Inertia Ip3	2.5682e+005 kg·mm^2
26	Nodes	337251
27	Elements	212891

Table-3 mean spiral angle

S.No.	Radius of are of teeth flank	Angle
1	R_31	36.34
2	R_32	35.63
3	R_33	35.04

4	R_34	34.5
5	R_35	34.01

E. *Boundary conditions-*

We applied four Boundary conditions on spiral Bevel gear. These are Force, rotational velocity, Remote displacement Support and Motor power.

Table-4

S.No.	Parameter	Value
1	Force	903.95 N
2	Rotational Velocity	224.68 rpm
3	Remote displacement Support	Rotation about -x axis
4	Rotational Velocity of motor	960 rpm
5	Motor power	5 HP

III RESULT AND ANALYSIS

The Research paper based on two types of Analysis.
1. Static Structural
2. Vibration

F. *Static Structural-*

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, machinery, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis employs the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures.

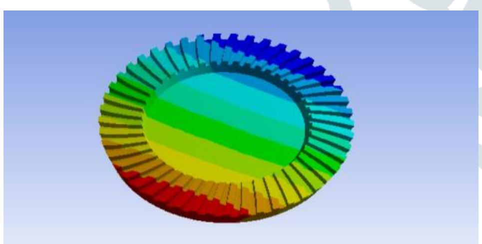
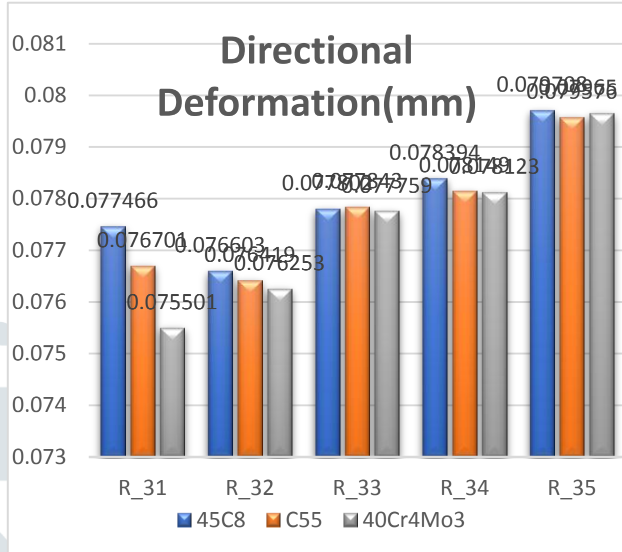


Fig.4

Table-5Directional Deformation Occurs in Various Case Studies

S. No.	Material	Radius of Pitch Cone	Directional deformation
1	45C8	R_31	**0.077466**
2	45C8	R_32	**0.076603**
3	45C8	R_33	**0.077802**
4	45C8	R_34	**0.078394**
5	45C8	R_35	**0.079708**
6	C55	R_31	**0.076701**
7	C55	R_32	**0.076419**
8	C55	R_33	**0.077843**
9	C55	R_34	**0.078149**
10	C55	R_35	**0.079576**
11	40Cr4Mo3	R_31	**0.075501**
12	40Cr4Mo3	R_32	**0.076253**
13	40Cr4Mo3	R_33	**0.077759**
14	40Cr4Mo3	R_34	**0.078123**
15	40Cr4Mo3	R_35	**0.07965**

Fig.2- Directional deformations in Structural Analysis



G. *Vibration Analysis-*

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The oscillations may be periodic, such as the motion of a pendulum or random, such as the movement of a tire on a gravel road.

Table 6

Case 1: Bevel Gear Analysis For 45C8 material and R_31

Mode No.	Frequency Range(HZ)	Total Deformation(mm)
1	2372.3	13.386
2	2372.3	13.386
3	2372.4	13.388
4	3502.3	9.5227
5	4766.8	14.537
6	4766.9	14.534

Table 6

Case 2: Bevel Gear Analysis For 45C8 material and R_32

Mode No.	Frequency Range(HZ)	Total Deformation(mm)
1	2371.9	13.382
2	2371.9	13.382
3	2371.9	13.387
4	3501.8	9.5241
5	4765.2	14.529
6	4765.3	14.523

Table 7

Case 3: Bevel Gear Analysis For 45C8 material and R_33

Mode No.	Frequency Range(HZ)	Total Deformation(mm)
1	2371.4	13.383

2	2371.4	13.383
3	2371.5	13.382
4	3501.2	9.527
5	4763.9	14.524
6	4764	14.522

Table 8
Case 4: Bevel Gear Analysis For 45C8 material and R_34

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2371	13.381
2	2371	13.381
3	2371.1	13.383
4	3500.6	9.5295
5	4762.5	14.519
6	4762.6	14.516

Table 9
Case 5: Bevel Gear Analysis For 45C8 material and R_35

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2370.7	13.382
2	2370.7	13.382
3	2370.8	13.379
4	3500.2	9.5309
5	4761.5	14.511
6	4761.6	14.512

Table 10
Case 6: Bevel Gear Analysis For 45C8 material and R_31

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2430.9	13.386
2	2430.9	13.386
3	2431	13.388
4	3588.8	9.5227
5	4884.6	14.537
6	4884.6	14.534

Table 11
Case 7: Bevel Gear Analysis For 45C8 material and R_32

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2430.5	13.382
2	2430.5	13.382
3	2430.5	13.387
4	3588.3	9.5241
5	4882.9	14.529
6	4882.9	14.523

Table 12
Case 8: Bevel Gear Analysis For 45C8 material and R_33

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2430	13.383
2	2430	13.383
3	2430.1	13.382
4	3587.6	9.527
5	4881.6	14.524
6	4881.6	14.522

Table 13
Case 9: Bevel Gear Analysis For 45C8 material and R_34

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2429.6	13.381
2	2429.6	13.381
3	2429.6	13.383
4	3587.1	9.5295
5	4880.2	14.519
6	4880.2	14.516

Table 14
Case 10: Bevel Gear Analysis For 45C8 material and R_35

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2429.2	13.382
2	2429.2	13.382
3	2429.3	13.379
4	3586.6	9.5309
5	4879.1	14.511
6	4879.2	14.512

Table 15
Case 11: Bevel Gear Analysis For 45C8 material and R_31

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2430.9	13.386
2	2430.9	13.386
3	2431	13.388
4	3588.8	9.5227
5	4884.6	14.537
6	4884.6	14.534

Table 16
Case 12: Bevel Gear Analysis For 45C8 material and R_32

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**
1	2430.5	13.382
2	2430.5	13.382
3	2430.5	13.387
4	3588.3	9.5241
5	4882.9	14.529
6	4882.9	14.523

Table 17
Case 13: Bevel Gear Analysis For 45C8 material and R_33

Mode No.	**Frequency Range(HZ)**	**Total Deformation(mm)**

1	2430	13.383
2	2430	13.383
3	2430.1	13.382
4	3587.6	9.527
5	4881.6	14.524
6	4881.6	14.522

Table 18
Case 14: Bevel Gear Analysis For 45C8 material and R_34

Mode No.	Frequency Range(HZ)	Total Deformation(mm)
1	2429.6	13.381
2	2429.6	13.381
3	2429.6	13.383
4	3587.1	9.5295
5	4880.2	14.519
6	4880.2	14.516

Table 19
Case 15: Bevel Gear Analysis For 45C8 material and R_35

Mode No.	Frequency Range(HZ)	Total Deformation(mm)(mm)
1	2429.2	13.382
2	2429.2	13.382
3	2429.3	13.379
4	3586.6	9.5309
5	4879.1	14.511
6	4879.2	14.512

IV.CONCLUSION

1. Structural Analysis shows that minimum deformation occurs in Bevel Gear, when the Gear is made by Medium Carbon Steel 40Cr4Mo3 Material and Design R_31. It shows that Medium Carbon Steel 40Cr4Mo3 Gear material have 5% less deformation as compared to the existing gear material.
2. Vibration Analysis shows that minimum deformation occurs at maximum frequency in Spiral Bevel Gear, when the Gear is made by C55 material with R_32 Radius of pitch cone It shows that Medium Carbon Steel C55 gear material have 3% less deformation as compared to the existing gear material with Radius of pitch Cone.

V.REFERENCES

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