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Design, Modeling and Optimization of Spur Gear Using Finite Element Analysis

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Abstract:-Gears are mainly used in the power or torque transmitting places. Other devices also there for transmitting the torque such as belt drive, chains drives because those have more disadvantages like slip. Gears are mainly used in lathes machines, automobiles and all torque transmitting units. Our project mainly deals with design, modeling and analysis of spur gear and Optimization of spur gear. For that we had considered a design problem and solved the problem with two different materials namely cast-iron, Steel for the same application. Then that designed Spur gear is modeled using Pro-E. Then we have done analyses on each gear namely, static analysis. Finally we have compared the results of cast iron spur gear with that of Steel gear and also compared the all spur gear with those optimized form of spur gear.

Keywords:- ANSYS, Optimized spur gear-1 (Cast iron), Optimized spur gear-2 (steel). PRO-E, Static analysis. Spur Gear-1 (cast iron), Spur Gear-2 (steel).

I. INTRODUCTION

A gear is a component within a transmission device that transmits rotational torque by applying a force to the teeth of another gear or device. A gear is different from a pulley in that a gear is a round wheel that has linkages ("teeth" or "cogs") that mesh with other gear teeth, allowing force to be fully transferred without slippage. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source. The most common situation is for a gear to mesh with another gear, but a gear can mesh with any device having compatible teeth, such as linear moving racks. The gear's most important feature is that gears of unequal sizes (diameters) can be combined to produce a mechanical advantage, so that the rotational speed and torque of the second gear are different from those of the first. In the context of a particular machine, the term "gear" also refers to one particular arrangement of gears among other arrangements (such as "first gear"). Such arrangements are often given as a ratio, using the number of teeth or gear diameter as units. The term "gear" is also used in non-geared devices that perform equivalent tasks:"...broadly speaking, a gear refers to a ratio of engine shaft speed to driveshaft speed. Although CVTs change this ratio without using a set of planetary gears, they are still described as having low and high "gears" for the sake of convention."

II. NOMENCLATURE

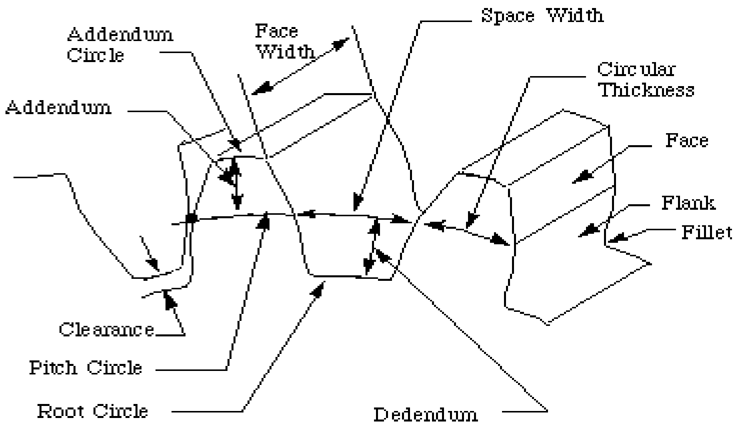

Figure 1: Spur gear nomenclature

III. COMMON ABBRIVATIONS OF SPUR GEAR

- n. Rotational velocity. (Measured, for example, in r.p.m.)
- ω Angular velocity. (Radians per unit time.) (1 r.p.m. = π/30 radians per second.)
- N. Number of teeth.

IV. TYPES OF GEARS

Figure 2: Types of gears

V. TOOTH PROFILE

A profile is one side of a tooth in a cross section between the outside circle and the root circle. Usually a profile is the curve of intersection of a tooth surface and a plane or surface normal to the pitch surface, such as the transverse, normal, or axial plane. The fillet curve (root fillet) is the concave portion of the tooth profile where it joins the bottom of the tooth space.

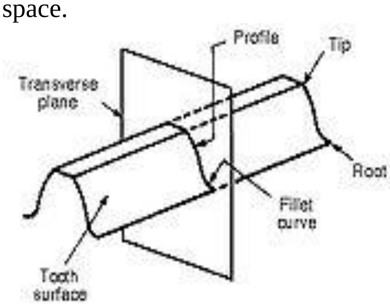

Figure 3: Tooth profile of spur gear

VI. PITCH

Pitch is the distance between a point on one tooth and the corresponding point on an adjacent tooth. It is a dimension measured along a line or curve in the transverse, normal, or axial directions. The use of the single word "pitch" without qualification may be ambiguous, and for this reason it is preferable to use specific designations such as transverse circular pitch, normal base pitch, and axial pitch.

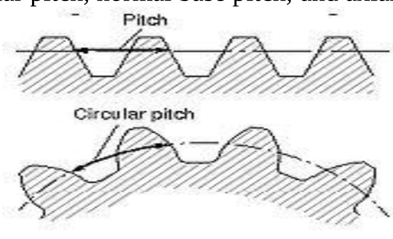

Figure 4: Pitch of spur gear

Diametral pitch (transverse) is the ratio of the number of teeth to the standard pitch diameter in inches.

$$P_d = \frac{N}{D} = \frac{25.4}{m} = \frac{\pi}{p}$$

- ***Normal diametral pitch, Pnd***

Normal diametral pitch is the value of diametral pitch in a normal plane of a helical gear or worm.

$$P_{\mathrm{nd}} = \frac{P_{\mathrm{d}}}{\cos\psi}$$

- ***Angular pitch, θN, τ***

Angular pitch is the angle subtended by the circular pitch, usually expressed in radians.

$$\tau = \frac{360}{z} \text{ degrees or } \frac{2\pi}{z} \text{ radians}$$

VII. DESIGN OF SPUR GEAR

- ***Design of spur gear for following specifications***:

Power to be transmitted: P = 20kw = 20000w
Pinion speed: n1=1400rpm
Gear ratio: I = 4
Gear speed = n2 = n1 / I
Let the arrangement may be external gearing

- ***Material selection*:**

Now the material for pinion and gear

Name	Material	σ_c	σ_b
Pinion	15Ni 2 Crl Mo 15	950	320
Gear	c 45	500	140
Pinion	Grade 20 (CI)	500	50
Gear	Grade 25 (CI)	600	60
Pinion	40 Ni 2 Crl Mo28	1100	400
Gear	C 45	500	140

Table 1: Material selection for spur gear & pinion

***Dimensions of spur gear*:**

Table 2: Dimensions of spur gear

VIII. MODELING OF SPUR GEAR

For modeling of a spur gear we used the PRO-ENGINEERING, it was developed by parametric technology corporation, USA and its latest version is PRO-E WILDFIRE.4 The RAM requirement for this software is 256MB and OS requirement to operate in WINDOWS *98/2000.*

Procedure of Modeling of spur gear in Pro-E:-

- Start → All programs → PTC→ Pro-E→ Pro-E
- Select the Part module and change the dimensions in to mm
- Drawn the first base circle
- Extruded the base circle up to required width
- Select the sketch and select the surface of the base circle
- Drawn the teeth and extruded up to the same width
- *By using pattern command in Pro-E generated the required number of teeth*

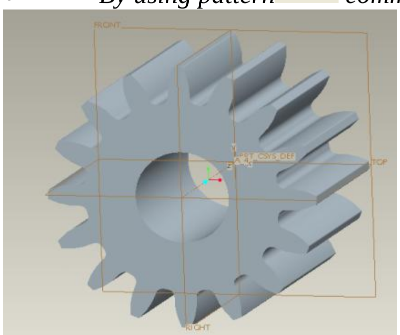

Figure 5: Spur gear model in ANSYS

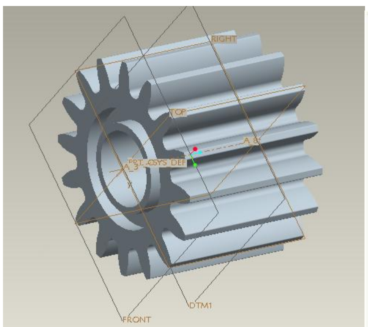

Figure 6 : Optimized spur gear model

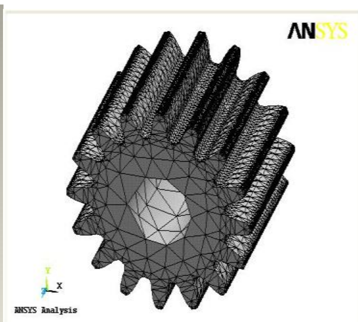

Figure 7 : Meshed Spur gear

IX. ANALYSIS OF SPUR GEAR

For doing analysis on the gear we used the ANSYS package, it is a general purpose finite element modeling package for numerically solving a wide variety of mechanical problems.

Procedure of the analysis of the gear by using Ansys package:-

- Start → All programs → Ansys 8.0 → Ansys
- Move the mechanical tool bar(for easy doing of the analysis)
- Select the Ansys model i.e. static or modal , structural or thermal, and specify the dimensions that are used in the modeling, and give the analysis name
- Move to setup mode to the model mode import the IGES file of that gear
- Apply the material properties and mesh the object
- After meshing move to the loads menu and constrain the inner circle that is lie on the shaft.
- Apply the loads on the gear
- Click on Solve now Seen the results.

X. RESULTS

- ***Spur gear-1:-***

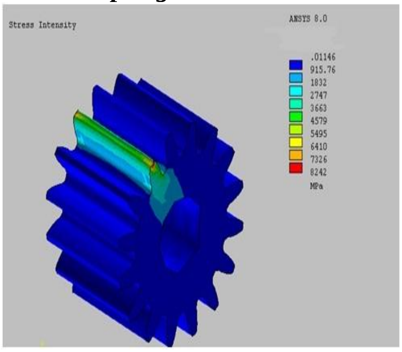

Figure 8 : Stress intesity

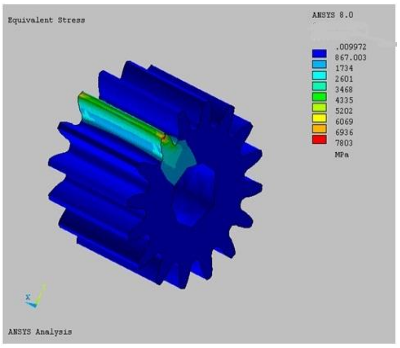

Figure 9 : Equivalent stress

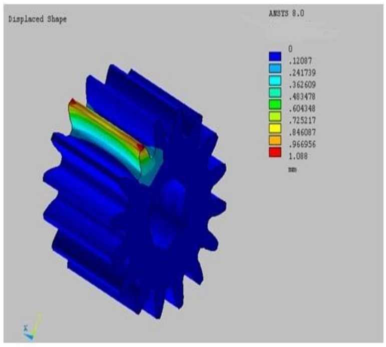

Figure 10 : Displaced shape

- ***Optimized spur gear-1:-***

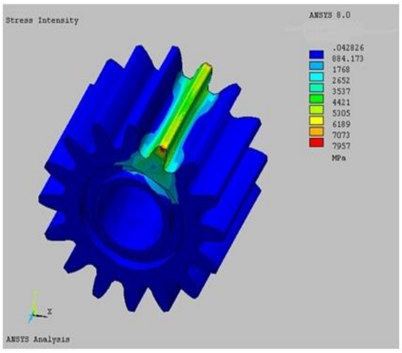

Figure 11 : Stress intesity

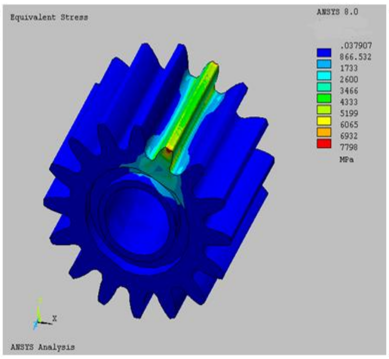

Figure 12 : Equivalent stress

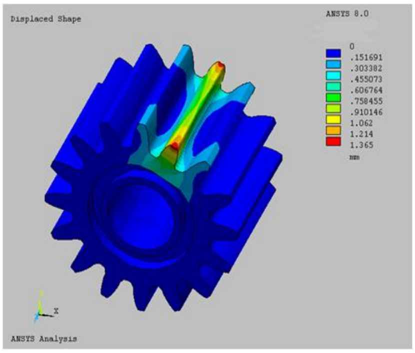

Figure 13 : Displaced shape

- ***Spur gear -2 :-***

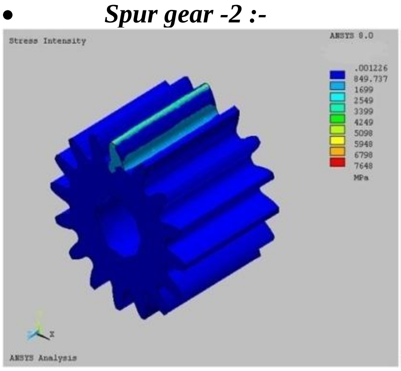

Figure 14 : Stress intesity

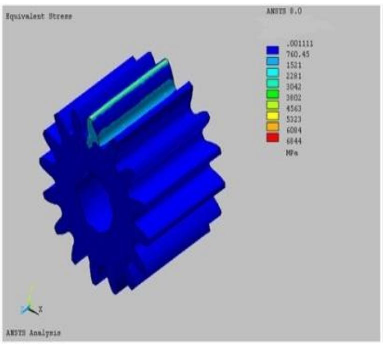

Figure 15 : Equivalent stress

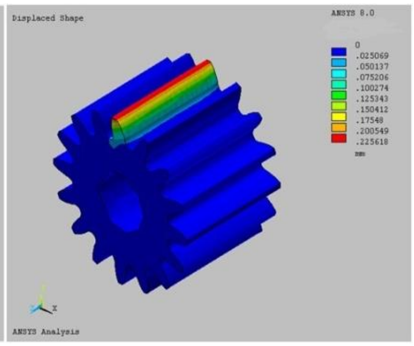

Figure 16 : Displaced **shape**

- ***Optimized spur gear -2:-***

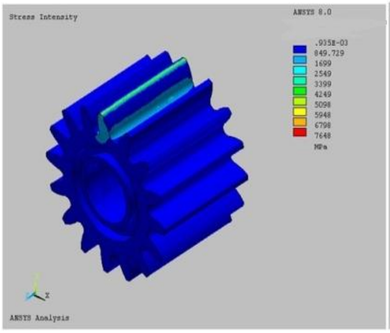

Figure 17 : Stress intesity

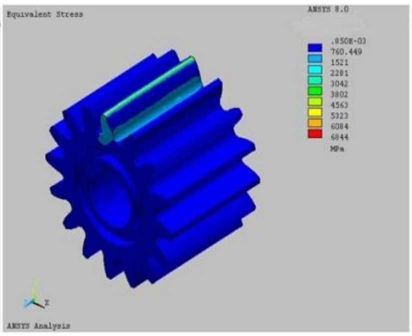

Figure 18 : Equivalent stress

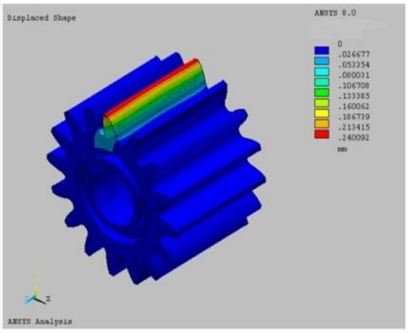

Figure 19 : Displaced shape

- ***Stress intensity at various nodes of spur gear-1 & optimized spur gear-1:-***

Nodes	Gear 1	Optimized gear 1
1	875.58	870.63
2	53.258	70.534
3	119.83	164.36
4	23.266	38.266
5	0.15805	0.2905
6	0.22677	0.2443
7	0.15083	0.1921
8	0.12224	0.1256
9	27.007	36.221
10	164.99	198.74

Table 3 : Stress intensity at various nodes

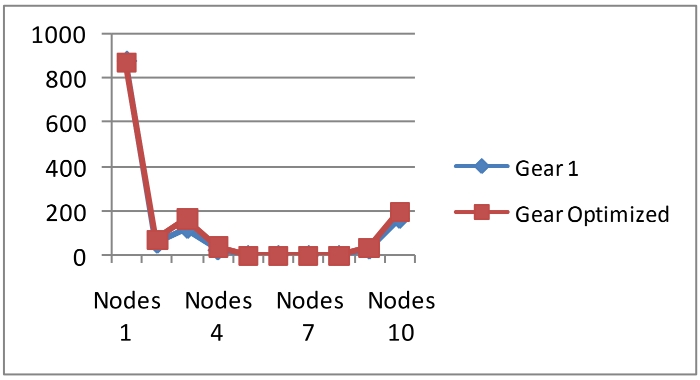

Figure 20 : Graph of Stress intensity at various nodes

- ***Displacement at various nodes of spur gear-1 & optimized spur gear-1:-***

Node	Gear 1	Optimized gear 1
1	0.73586E-01	0.21619
2	0.45589E-01	0.66989
3	0.15234E-01	0.67067
4	0.10473	0.20325
5	0.85683E-02	0.33646
6	0.83893E-02	0.22492
7	0.0000	0.10805E-01
8	0.0000	0.11520E-01
9	0.44275E-03	0.70366E-02
10	0.23275E-03	0.430366E-02

Table 4: Displacement at various nodes

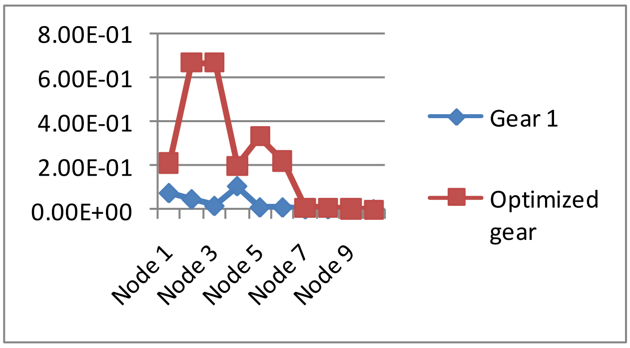

Figure 21 : Graph of displacement at various nodes

- ***Stress intensity at various nodes of spur gear-2 & optimized spur gear-2:-***

Node	Gear 2	Optimized Gear 2
1	36.323	28.470
2	98.450	111.65
3	90.362	74.833
4	11.997	13.690
5	79.198	0.11455
6	28.221	79.156
7	12.785	27.545
8	79.927	10.083
9	73.413	89.911
10	9.5644	19.805

Table 5: Stress intensity at various nodes

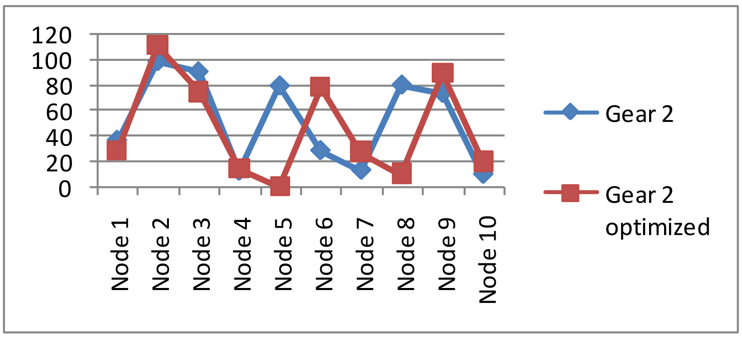

Figure 22 : Graph of Stress intensity at various nodes

- ***Displacement at various nodes of spur gear-2 & optimized spur gear-2:-***

Nodes	Gear 2	Optimized gear-2
1	-0.44237E-02	-0.76087E-02
2	-0.24669E-02	-0.74698E-02
3	-0.22876E-02	-0.73825E-02
4	-0.22682E-02	-0.72983E-02
5	-0.27974E-02	-0.51112E-02
6	-0.30259E-02	-0.39618E-02
7	-0.27512E-02	0.32916E-02
8	-0.16268E-02	-0.16581E-02
9	-0.80061E-03	-0.14701E-03
10	-0.75958E-03	-0.44774E-04

Table 6: Displacement at various nodes

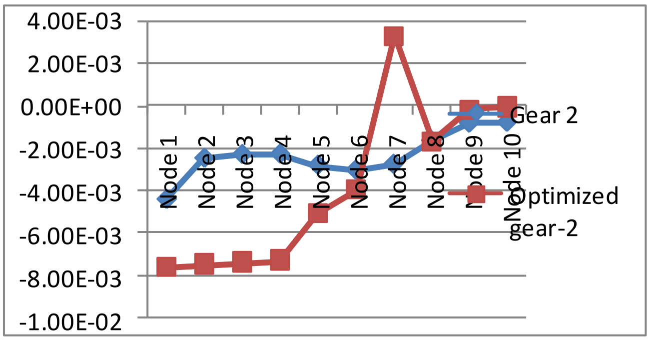

Figure 23 : Graph of Displacement at various nodes

XI. CONCLUSION

The design, modeling and analysis of spur gear & optimized spur gear are done. It is observed that the same required out put the dimensions of spur gear are various with respect to the material. And optimization of gear is also done on the same gears and computed the results and drawn the graphs for the results. The conclusion is that for the cast iron material the stress intensity and displaced shape results are better for actual spur gear compared to optimized spur gear as well as for the steel material the stress intensity and displaced shape results are nearly same for actual spur gear compared to optimized spur gear so by this i came to know that the optimization of spur gear may depends on change of materials.

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REFERENCES

[1]. Machine design by S.Md.Jalaludeen, Anuradha agencies.
[2]. Machine design by R.K. Jain
[3]. Machine design by ‘R.S. Kurmi’
[4]. Design of machine elements by ‘Bandri’
[5]. Machine design by R.K. Rajput
[6]. Design data book by Md.jalaludeen
[7]. Design data book by P.S.G. College
[8]. . www.cs.cmu.edu/People/rapidproto/mechanisms/references.html
[9]. Mechanical Engg design – Joseph E. Shigley.
[10]. Design data book – P.S.G. College of technology.
[11]. Design data book – K.Mahadevan & K.Balaveera Reddy.
[12]. Analysis and approximation of contact problem By Mircea Sofonia and Weimin Hann
[13]. Elastic contact analysis by boundary elements By Susumu Takahashi
[14]. “A comprehensive analysis of fillet and contact stresses in straight spur gears” By M.A. Alfares