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RESEARCH ARTICLE

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ANALYSIS OF SPUR GEAR FOR INVOLUTE PROFILE WITH VARIATION IN DIFFERENT GEOMETRICAL PARAMETERS USING FEM

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ABSTRACT

Gear is one of the most critical component in a mechanical power transmission system. In the present Static Analysis of Spur Gear using FEA a standard spur gear (whose 3-D involute tooth profile model is generated on CREO-2.0) is geometrically iterated (in its gear thickness, bore and pressure angle) for a constant load acting at one of its tooth faces. The geometrical variation is made to identify the geometrical entity of gear which has the most profound effect on von-Mises stress acting on the gear, when subjected to constant load. The resulting stresses (von- Mises stress), displacements (in X, Y, Z directions) and the displacement vector sum which comes into action on the gear are analysed by structural analysis using ANSYS- 14.0 APDL (with solid 185 element). The final results of the analysis showed that the pressure angle is the most important geometrical parameter of a gear geometry, as the analysis explicitly showed that a change in pressure angle resulted in greatest change of von-Mises stress acting on the gear (with respect to the maximum von-Mises stress coming into action when gear thickness and bore are changed). The knowledge of this analysis on geometrical variations in gear (especially the pressure angle) will help the design engineer to generate a more safe gear design.

Keywords— Spur Gear, Involute Tooth Profile, CREO2.0, ANSYS- 14.0 APDL, Von-Mises Stress, Pressure Angle

I. INTRODUCTION

The paper being presented is a static analysis of spur gear using FEM to develop a hypothesis illustrating pressure angle to be the most profound entity affecting the gear's von-Mises stress distribution in the loading process. The past analysis approaches were based on static and dynamic loadings using Hertz equation whereas the work being presented is based on the static load distribution over the various geometric parameters of an involute spur gear using von-Mises stress analysis. Through the rigorous testing carried out during the project duration it was observed that pressure angle is the most sensitive parameter over which the von-Mises stress varies the most.

II. RELATED WORKS

The previous analysis on spur gears were based on static and dynamic loading conditions focussing on fatigue failure, bending stresses etc. and analyzing the results using ANSYS.

The other form of research included changing the gear material and then analysing it for various loading conditions using various SOM equations such as Hertz equation (for calculating contact stresses) and other being the Lewis formula (for calculating bending stresses).

III. PROPOSED WORK

In the research work being proposed, the analysis is performed for involute profile standard spur gear under static loading conditions for variations in different geometrical parameters (pressure angle, the bore & the gear thickness) using FEM. The work focuses on determining the geometrical parameter which has the most profound effect over the von- Mises stress distribution of the gear.

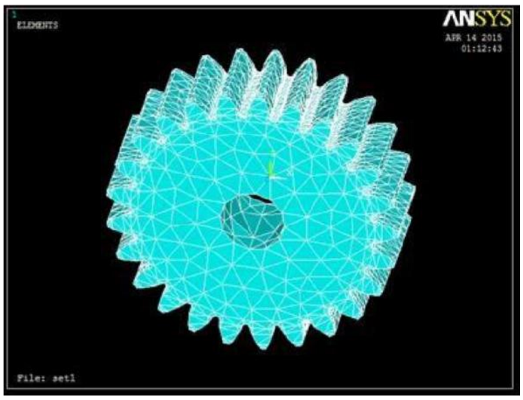

Figure 1 Spur Gear 3-D Model

The steps involved for the completion of the proposed work includes development of involute profile on CREO-2.0. Following mathematical equations were used to make the involute curve:-

r = 2.819 ang = t * 90 s = (Π * r * t) / 2 xc = 0.75 * cos (ang) yc = 0.75* sin (ang) x = xc + (s * sin (ang)) y = yc - (s * cos (ang)) z = 0

' r ' radius of circle

' t ' lies between 0 to 1 over the length of involute curve

Other important steps include sketching of gear tooth on appropriate planes, drawing gear tooth profile, extruding the sketch up to desired gear thickness and patterning the tooth profile by applying requisite fillet.

The working platform of the current research work can be broadly classified under the following domains:-

a) Designing of pinion (since the material for gear and the pinion is same)
b) Development of involute profile of spur gear (3-D model) on CREO-2.0
c) Analysis of gears on ANSYS-14.0 APDL

IV. TESTING

For the testing purpose in the proposed project work three sample gear sets with following specifications were used :-

Set 1

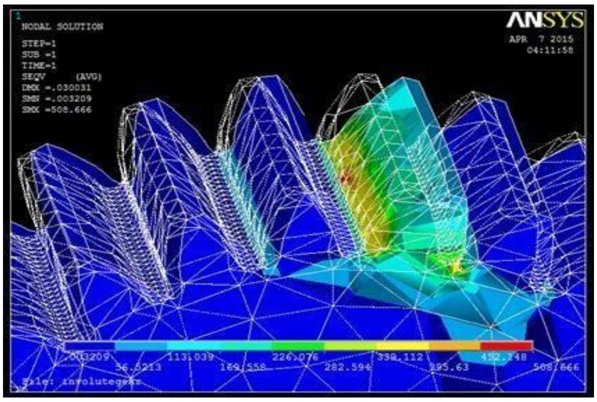

Figure 2 Set 1 von-MisesStress Module (m) = 2 mm

Pressure Angle (Φ) = 20° full depth

No. of teeth (z) = 25

Outside Diameter (D_o) = 54 mm

Pitch Diameter (D_p) = 50 mm

Addendum (A) = m = 2 mm

Dedendum (D) = 1.25m = 2.5 mm

Base Diameter (D_b) = D_o – 2 (A+D) = 45 mm

Gear Thickness = 16 mm

Bore = 12 mm

Set 2

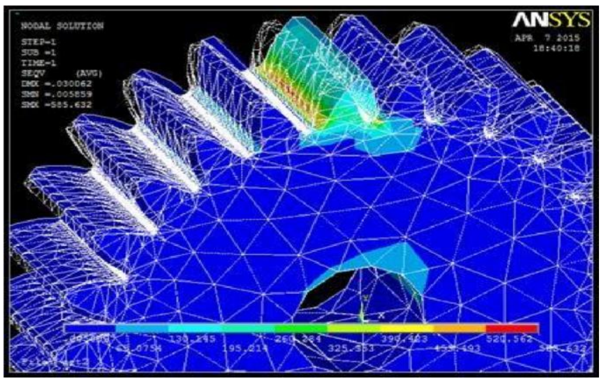

Figure 3 Set 2 von-Mises Stress

Module (m) = 2 mm Pressure Angle (Φ) = 14.5° full depth No. of teeth (z) = 25

Outside Diameter (D_o) = 54 mm

Pitch Diameter (D_p) = 50 mm

Addendum (A) = m = 2 mm

Dedendum (D) = 1.157m = 2.314 mm

Base Diameter (D_b) = D_o −2(A+D) =45.372 mm

Gear Thickness = 16 mm

Bore = 12 mm

Set 3

Module (m) = 2 mm Pressure Angle (Φ) = 20° stub No. of teeth (z) = 25

Outside Diameter (D_o) = 54 mm

Pitch Diameter (D_p) = 50 mm

Addendum (A) = 0.8m = 1.6 mm

Dedendum (D) = m = 2 mm

D_b D_o

Bore = 12 mm

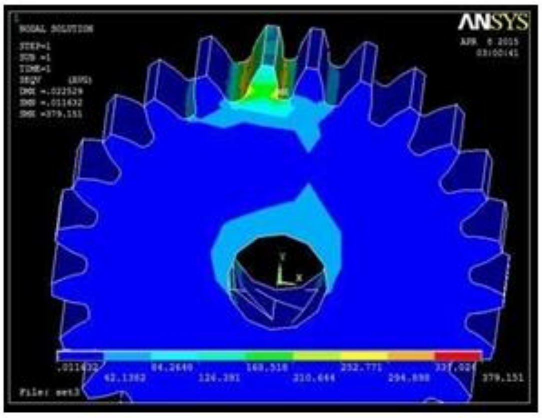

Figure 4 Set 3 von-Mises Stress

In the present work three testing methods were used depending upon the parameters to which variations were made. The
different tests proposed are defined as:-

a) Pressure Angle Variation

This test uses fixed values for the gear thickness as 16 mm and bore as 12 mm whereas the pressure angle is varied through 20° fd, 20° st and 14.5° fd.

b) Bore Variation

This test uses fixed values for the other two parameters i.e. gear thickness and pressure angle to 16 mm and 20° fd respectively, whereas the bore value is varied through 10 mm, 12 mm and 14 mm.

c) Gear Thickness Variation

This test uses fixed values for the other two parameters i.e. pressure angle and bore diameter to 20° fd and 12 mm respectively, whereas the gear thickness was varied through 14mm, 16mm and 18mm.

Table 1 Spur Gear Geometry Variation

SET	GEAR THICKNESS	BORE	PRESSURE ANGLE
1	16	12	20° full depth
2	16	12	14.5° full depth
3	16	12	20° stub
21	16	10	20° full depth
31	16	14	20° full depth
22	14	12	20° full depth
32	18	12	20° full depth

Table 2 Variation in Pressure Angle

S. NO.	GEAR THICKNESS (mm)	BORE (mm)	PRESSURE ANGLE (degree)	STRESS (N/mm^2)		X-DISPLACEMENT (mm)		Y-DISPLACEMENT (mm)		Z-DISPLACEMENT (mm)		VECTOR SUM (mm)
				MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	(DMX)
SET 1	16	12	20 fd	0.003209	508.666	-0.005907	0.029547	-0.007581	0.008882	-0.001762	0.001544	0.030031
SET 2	16	12	14.5 fd	0.005859	585.632	-0.005821	0.029558	-0.007446	0.008943	-0.001813	0.001762	0.030062
SET 3	16	12	20 st	0.011632	379.151	-0.004896	0.022076	-0.006181	0.006943	-0.001155	0.001237	0.022529

Table 3 Variation in Bore Diameter

S. NO.	GEAR THICKNESS (mm)	BORE (mm)	PRESSURE ANGLE (degree)	STRESS (N/mm^2)		X-DISPLACEMENT (mm)		Y-DISPLACEMENT (mm)		Z-DISPLACEMENT (mm)		VECTOR SUM (mm)
				MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	(DMX)
SET 1	16	12	20 fd	0.003209	508.666	-0.005907	0.029547	-0.007581	0.008882	-0.001762	0.001544	0.030031
SET 21	16	10	20 fd	0.003128	506.031	-0.009885	0.034264	-0.011787	0.012617	-0.001637	0.001756	0.034883
SET 31	16	14	20 fd	0.009412	556.049	-0.003798	0.027618	-0.005965	0.005688	-0.001643	0.00164	0.027623

Table 4 Variation in Gear Thickness

S. NO.	GEAR THICKNESS (mm)	BORE (mm)	PRESSURE ANGLE (degree)	STRESS (N/mm^2)		X-DISPLACEMENT (mm)		Y-DISPLACEMENT (mm)		Z-DISPLACEMENT (mm)		VECTOR SUM (mm)
				MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	(DMX)
SET 1	16	12	20 fd	0.003209	508.666	-0.005907	0.029547	-0.007581	0.008882	-0.001762	0.001544	0.030031
SET 22	14	12	20 fd	0.012139	476.409	-0.005896	0.029218	-0.00755	0.008713	-0.001547	0.001549	0.029777
SET 32	18	12	20 fd	0.003148	469.66	-0.005903	0.029473	-0.007556	0.008845	-0.001609	0.001692	0.029973

VI. CONCLUSION

The present paper has attempted to establish a relationship between the various geometrical parameters of the gear and the static loads acting on it in order to illustrate the effect of change in von-Mises stress with the changes in such geometrical entities.

With various values of pressure angle, bore and the gear thickness on the application of a constant static load on the gear it was observed that the change in pressure angle brought about the maximum change in the vonMises stress w.r.t. other two geometrical parameters.

This analysis amply reveals that the pressure angle of a gear has the most significant effect on the von-Mises stress distribution.

This study provides a solid foundation for future studies on variation in geometrical parameters of gear.

VII.REFERENCES

[1]. Mrs. Shinde S.P., Mr. Nikam A.A., Mr. Mulla T.S., "Static Analysis of Spur Gear Using Finite Element Analysis", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684, PP: 26-31.

[2]. Suresh Babu V., TsegawAssefaAsmarc, January 2009, "Involute Spur Gear Template Development by Parametric Technique", African Research Review, ISSN 1994-9057.

[3]. Kohara Gear Industry Co. LTD., "Practical Information on Gears".

[4]. BOSTON GEAR, "Information on Spur Gear".

[5]. Reliance Gear Tech Data, "Technical Information on Standard Gear Range".

[6]. W. Dudley Darle, 1954, "Practical Gear Design", Mc. Graw Hill Book Company.

[7]. Mrs. Meenakshi C.M., Kumar Akash, PriyadarshiApporva, Kumar Dash Digant, 2012, "Analysis of Spur Gear Using Finite Element Analysis", Middle East Journal of Scientific Research 12(12):1672-1674.

[8]. KaraveerVivek, MogrekarAshish and Reynold Joseph T. Preman, 2013, "Modeling and Finite Element Analysis of Spur Gear", International Journal of Current Engineering and Technology ISSN 2277-4016.

[9]. Khurmi Gupta R.S., 2000, "Machine Design", Khanna Publications

[10]. Khurmi, R.S., 1997, Khanna Publications "Theory of Machines",

[11]. Rattan, S.S., 1998, DhanpatRai Publications "Theory of Machines",

[12]. Bhandari V.B., 2010, "Design of Machine Elements", Tata Mc. Graw Hill.

[13]. Pro/Engineer Wildfire 3.0.

[14]. Fagan M.J., 1992, "Finite Element Analysis Theory and Practices", Longman Group UK Ltd. 15)

[15]. Rao S.S., "The Finite Element Method in Engineering".

[16]. Penfro Mike, 2010, "Modelling Gear Teeth in Pro/ENGINEER Wildfire 4.0", Macmillan, National Kaohsiung University of Applied Sciences, Taiwan.