EFFECT OF NEGATIVE CORRECTION FACTOR IN SPUR GEAR TOOTH PROFILE USING FEA

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ABSTRACT

This paper investigates the effects of negative correction factor on tooth contact stress and bending stress. 3D model of gear tooth has been modeled with different correction factors and the face contact modal of the teeth was used for finite element method (FEM) to conduct loaded tooth contact analysis. Deformation and stress calculation of spur gear with different correction factors was done and the effects are discussed after making the comparison with a standard gear pair. The gear ratio assumed was 2.5. The correction factor assumed was based on industrial applications.

KEYWORDS: Gear Design, Spur Gears, Mesh Generation, Bending & Contact Stress Analysis

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INTRODUCTION

Driven by globalization the industry is facing an increasing competition. Therefore it becomes more and more necessary to consider the alternative technology of manufacturing materials used for gears. The correction factor is the radial displacement of the tooth generating profile. When + (toward exterior) the tooth becomes more resistant to bending and the curvature decreases so that also the contact stress is less. A correction affects the center distance between the shafts as well. This paper investigates the effect of correction factor on tooth contact strength, bending strength and basic performance parameters of spur gears. 3D model of gear tooth has been modeled with different correction factors and face contact model of teeth method was used for Finite Element Method (FEM). Both are used together to conduct loaded tooth contact analyses. Deformation and stress calculations of spur gears with a different correction factor and contact ratios are done. Effects of correction factor and contact ratio on gear strength and basic performance parameters are also discussed. Gear correction is done where a chosen number of teeth and module, for gear and pinion, results in a center distance which is slightly the desired center distance between the two shafts.

REASON FOR THE GEAR TOOTH FAILURE

The different modes of failure of gear teeth are bending failure, pitting and scoring, corrosive wear. In bending failure – every gear tooth acts as the cantilever. If total repetitive dynamic load acting on the gear tooth is greater than the beam strength of the gear tooth, then the gear tooth will fail in bending.

In pitting failure, Scoring, Corrosive wear – the corrosion of the tooth surfaces is namely caused due to the presence of corrosive elements such as additives present in the lubricating oils. To avoid these proper

anticorrosive additives should be used.

OBJECTIVE OF RESEARCH

The objective of this thesis is to study the various stress state of a standard and corrected spur gear. We calculated the torque distribution on the various point that basis we can generate a corrected profile. To generate the gear tooth profile of the standard spur gear, profile corrected gear and to predict the effect of gear bending stress, contact stress.

INTERFERENCE AND UNDERCUTTING OF GEAR TOOTH

The involute curves begin at the base circle and extend outwards to form the gear tooth profiles. Obviously, there is no involute inside the base circle. We know that the line of action of two inter-meshing gears is tangent to the two base circles. The tow point of tangency represents the two extreme limiting point of the length of action. These two points called the “interference point”

Figure 1: Interference and Under Cutting

Static Tooth Load and Bending Stress

Tooth loads and bending stress, contact stresses are calculated by the following relation at different profile correction, $x=0$, $x=0.02$, $x=0.04$

$$F_t = \sigma_b \times b \times \pi \times m \times y$$

σ_b = bending stress

$$\text{Bending stress } \sigma_b = \frac{i+1}{amby} [M_t]$$

Where, i = Gear ratio, a = Centre distance b = Face width y = Form factor = 0.3

GEAR PARAMETER USED

Gear Type: Standard involute teeth

Material: Alloy steel, 15 Ni2Cr1 Mo15 case hardens 50-63 RC

Modulus of Elasticity: 2.1×10^5 N/mm²

Module: 5

Pressure angle = 20°, Gear ratios = 2.5

Table 1: Standard Gear Dimensions

Standard	Pinion	Gear
Module	5 mm	5mm
Dedendum	6.25mm	6.25mm
Addendum	5mm	5mm
No. of Teeth	10	25
Pitch Dia.	50mm	125mm
Root Dia.	37.5mm	112.5mm
Tip Dia.	60mm	135mm
Center distance	87.5 mm	

Pressure angle = 20.38° , Gear ratios = 2.5

Table 2: Corrected Gear Dimension for 0.02 Correction

Parameter	Pinion	Wheel
Module	5mm	5mm
Dedendum	6.15mm	6.15mm
Addendum	5.11mm	5.11mm
No. of Teeth	10	25
Pitch Dia	50.117mm	125.305mm
Root Dia	37.7mm	112.7mm
Tip Dia	60.22mm	135.22mm
Centre distance	87.711mm	

MODELING

As per the design calculations, the spur gear pair was modeled using PRO-E software

Figure 2: 2-D Model, $m=5$, $Z_1=25$, $Z_2=10$ **Figure 3: 3-D Model, $m=5$, $Z_1=25$, $Z_2=10$** **Figure 4: Corrected Gear $x=0.02$, $m = 5$, $Z_1=25$, $Z_2=10$** **Figure 5: Corrected Gear $x=0.02$, $m = 5$, $Z_1=25$, $Z_2=10$**

Figure 6: Bending Stress for Standard Pinion
 $m=5$, $\phi=20.38^\circ$, $Z=10$

Figure 7: Bending Stress for Corrected Pinion
 $X=0.02$, $m=5$, $\phi=20^\circ$, $Z=10$

Figure 8: Bending Stress for Corrected Pinion
 $X=0.04$, $m=5$, $\phi=20.78^\circ$, $Z=10$

Figure 9: Contact Stress for Standard Pinion
 $m=5$, $\phi=20^\circ$, $Z=10$

Figure 10: Contact Stress for Corrected Pinion
 $X=0.02$, $m=5$, $\phi=20.38^\circ$, $Z=10$

Figure 11: Contact Stress for Corrected Pinion
 $X=0.04$, $m=5$, $\phi=20.78^\circ$, $Z=10$

Similarly the results obtained were tabulated.

RESULT

Table 3: Stress Results

Stress N/mm ²	Standard Gear	Profile Corrected Gear X = 0.02	Profile Corrected Gear X = 0.04
Bending stress on pinion (theoretical)	36	-----	-----
Bending stress on gear (theoretical)	36	-----	-----
Contact stress on pinion (theoretical)	589.72	-----	-----
Contact stress on gear (theoretical)	589.72	-----	-----
Bending stress on pinion (Ansys)	33.82	29.091	20.635
Bending stress on gear (Ansys)	33.824	10.72	9.888
Contact stress on pinion (Ansys)	589.004	545.91	538.218
Contact stress on gear (Ansys)	589.004	545.91	538.218

CONCLUSIONS

From the above table 3, it was observed that for a standard spur gear the variation of stress results for bending was varying from 6% and for contact, stress is varying to 0.12%. The profile corrected gear with a correction factor of 0.02 was less compared to a standard gear pair with a variation of 44.70 % in bending stress and 7.42% in contact stress. For 0.04 it was observed with a variation of 57.5% in bending stress and 8.73% in contact stress. So we concluded that by profile correction the stresses at the root can be minimized greatly

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