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Bending and Wear Analysis of Spur Gear

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Abstract - *Gear are the fundamental components in power transmission to obtain high mechanical advantage. Bending and Wear failure are the main contributors for the primary failure of the gear. Failure by bending will occur when the significant tooth stress equals or exceeds either the yield strength or the bending endurance strength. A surface failure occurs when the significant contact stress equals or exceeds the surface endurance strength. In this paper bending and wear stress have been calculated using AGMA standards and finite element method. The Lewis Bending Equation has been used for calculating the Analytical bending stress. The Analytical factor of safety and the factor of safety from ANSYS have been compared.*

Key Words: AGMA, Lewis equation, Spur gear, Ansys.

1. INTRODUCTION

Gears are used to transmit motion from one shaft to another or between a shaft and a slide. This is accomplished by successively engaging teeth. Gears use no intermediate link or connector and transmit the motion by direct contact. Variety of gears are available for transmission of power. Spur gear has been selected as it is economical to manufacture compared to other gears. AGMA standards are used for analytical calculations of bending and wear stress when the torque on the pinion is 80 Nm and speed is 480 rpm so as to obtain a gear ratio of 2.

1.1 Material Properties:

In this paper material for both the gears is Alloy Steel. Case hardened 15Ni4Cr1 is used for manufacturing of gear. 15Ni4Cr1 provides a good wearing resistance.

Table-1 Material Properties

Parameters	Value	Unit
Density	7850	Kg/m^3
Poisson's Ratio	0.3	
Ultimate Tensile Strength	1500	MPa
Young's Modulus	203000	MPa
Hardness number	650	

2.DESIGN CALCULATION:

Nomenclature

σ =Bending Stress

W_t=Transmitted load
K_o=Overload factor
K_v=Dynamic factor
K_m=Load distribution factor
P_d=Diametral pitch of pinion
F=Net face width
J=Geometry factor
S_f=Safety factor-Bending
S_t=AGMA bending strength
Y_N=Stress cycle factor
K_T=Temperature factor
K_R=Reliability factor
σ_c=Contact stress
C_p=Elastic coefficient
K_s=Size factor
C_f=Surface condition factor
d_p=Pitch diameter of Pinion
I= Geometry factor for pitting resistance
S_c=Surface endurance strength

Z_n=Stress cycle factor
C_H=Hardness ratio factor
S_H=Safety factor-Pitting
K_B=Rim thickness factor

Table-2 Design Parameters

Parameters	Value	Unit
Pinion teeth	18	Nos
Gear teeth	36	Nos
module	3	mm
Pressure angle	20	Degree
Input Torque	80	Nm
Input rpm	480	rpm
Face width	35	mm

Gear bending equation:-

$$\sigma = W_t K_o K_v K_s \frac{P_d}{F} \frac{K_m K_B}{J}$$

Bending Factor of safety:-

$$S_F = \frac{S_t Y_N / K_T K_R}{\sigma}$$

Gear contact stress equation:-

$$\sigma_c = C_p \left(W_t K_o K_v K_s \frac{K_m}{d_p F} \frac{C_f}{I} \right)^{\frac{1}{2}}$$

Bending Factor of safety:-

$$S_F = \frac{S_t Y_N / K_T K_R}{\sigma}$$

Gear contact stress equation:-

$$\sigma_c = C_p \left(W_t K_o K_v K_s \frac{K_m}{d_p F} \frac{C_f}{I} \right)^{\frac{1}{2}}$$

Wear factor of safety :-

$$S_H = \frac{S_c Z_N C_H / (K_T K_R)}{\sigma_c}$$

Using the above AGMA equations and substituting the values of material properties and design parameters we get Bending Factor of safety(S_F) and Wear factor of safety(S_H) as 3.054 and 1.768 respectively.

3. FEA RESULT:

By importing the Solidworks CAD file in Ansys workbench and defining the boundary constraints as well as the tangential load of 2962.5 N to the face of the tooth we get bending factor of safety as 3.0725.

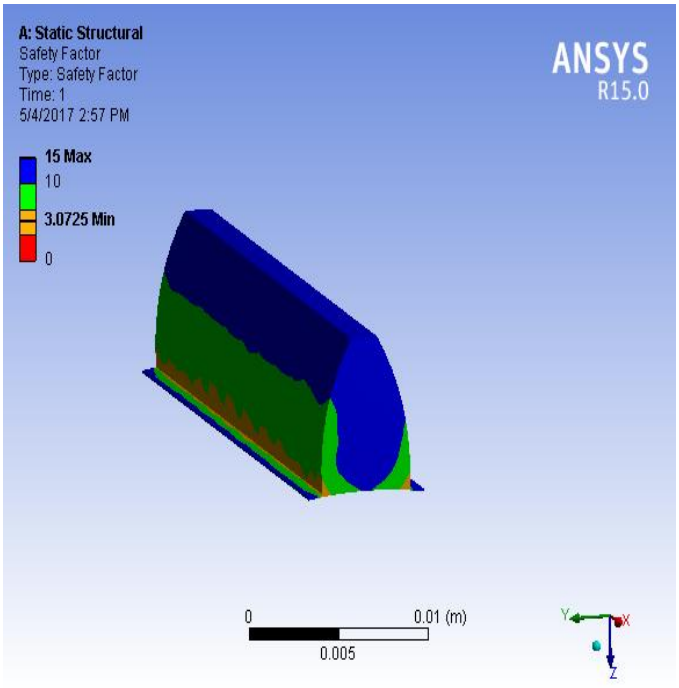

Fig 1- Bending factor of safety

Similarly, importing gear and pinion in ansys workbench and applying contact constraint between the mating faces of the gear tooth. A torque of 80 Nm is applied on pinion and thus wear factor of safety is obtained as 1.8332.

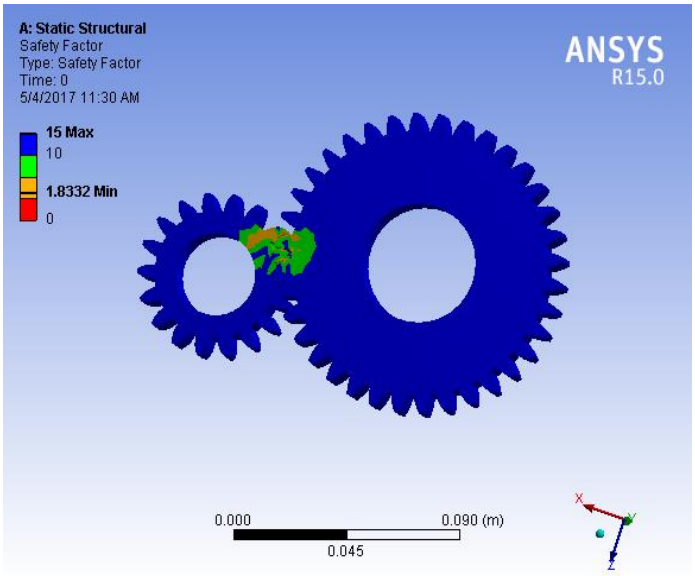

Fig 2- Wear factor of safety

4.RESULTS:

Bending factor of safety by analytical and Finite element method are 3.054 and 3.0725 respectively. Wear factor of safety by analytical and Finite element method are 1.768 and 1.8332 respectively.

5.CONCLUSION:

Thus the bending factor of safety and wear factor of safety obtained by analytical and finite element method are approximately nearby.

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