DETERMINATION OF TRUE BENDING STRESS IN SPUR GEARS

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Abstract - *This paper presents the work carried regarding the determination of true bending stresses in spur gears. Gearing is one of the most critical components in a mechanical power transmission system and the true bending stresses at the tooth root of spur gears are quite different from the nominal values. The three dimensional model of set of spur gear was prepared using 'KISSsoft' software. The step (.stp) files were imported to 'ANSYS workbench 14.5' software. Loads were applied in the form of torque on the spur gear. The results of bending stress obtained by 'ANSYS workbench 14.5' are in well agreement with those obtained by analytical method and KISSsoft results. Keeping the load of the gear constant the analysis is repeated for various tooth thicknesses of the gears. The analytical results, KISSsoft results and ansys results are compared and the effect of facewidth is on true stress determined.*

Keywords- True bending stress, Nominal value, Bending stress, KISSsoft, ANSYS workbench 14.5.

1. INTRODUCTION

Gears are utilized to carry power starting from driver shaft then onto the driven when they are separated by narrow distance. They keep up steady speed proportion overcoming slip. Helical, Spur, rack and pinion type, worm and worm wheel, bevel, etc. Gears having teeth lateral to axis are spur gears most accepted, because they made effortlessly also equipped for sustaining typical loading conditions and useful for small speeds.

Gears are important amongst wide basic segments in force transfer mechanism, also in maximum modern rotating apparatus. We can consider that gear will prevail as best method for transmitting power in future machines because of their high level quality of power transmission and smallness [1].

1.1 BENDING STREESES IN GEARS

There are a few types of fracture modes in spur gears, and one of the fundamental or important type of facture modes is 'Bending failure' of the teeth. The bending stresses are another interesting issue in a spur gear. When a load is maximum, bending failure will take place. In gears bending failure is anticipated by correlating the numerically determined to practically calculate permissible fatigue standards of assumed material. The equation for bending stress got using Lewis expression. In gear tooth catastrophic failure or yielding is due to extreme bending stress that's why it is one of essential gear design concept [2].

1.2 TRUE BENDING STRESS

The true bending stresses at root of tooth in a spur gears is not same as that of the supposed or theoretical values that are used for the determining the load capacity of spur gear, either by principals or common designing laws. No issues emerge in utilizing a weight holding strength while standards correlated along the outcomes of fatigue tests on bending for which cutoff points determined along similar simplified technics. In any case, at tooth root true stress has dissimilar pattern plus standards, plus the creator need to know this dissimilar pattern, particularly considering portable gears along small ribs plus rims [3].

2. PROBLEM DEFINITION

The stress will determined using a 3-D finite element solid model for spur gears. The study will determine bending stress with tooth thickness using given geometry condition also by changing tooth thickness.
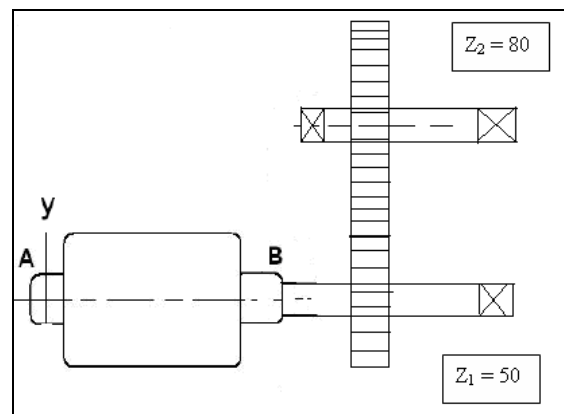

Figure 1 Gearing Arrangement of the problem considered
Table- 1: Specification of Gears

Gear	Speed	*Rpm*	Teeth	*Nos.*	P.C.D.	*mm*
Gear No.1	n_1	750	Z_1	50	d_1	150
Gear No.2	n_2	397	Z_2	80	d_2	240

As both the pinion & gear are made of same material, pinion is weaker. So the stress analysis of the pinion is carried out.

Parameters:
Motor Power (P) = 15 HP (8 Pole, Speed 750 Rpm)
Module (m) = 3 mm
Material: 18CrNiMo7-6, is used for both gears and the properties are as follow.

Table- 3: Material Properties

Density g/cm3	7.86 g/cm3
Young's Modulus (MPa)	210000 MPa
Tensile Strength (Yield) MPa	786 MPa
Poisson's Ratio	0.3

2.1 ANALYTICAL SOLUTION

The tangent force is main cause for bending stress, and that one is calculated as below.

The forces in Gear 1 and gear 2 are determined using following method.

$F_t = P/V$ where,
F_t is tangent force (N)
P is power (W)
M_t Toque in (N/m)
V is velocity (m/s)
Power = 15 x 746 = 11190 W
$V = (\pi d_1 n_1)/60$
V = 5.89 m/s
F_t = 11190/5.89
F_t = 1899.83 N
$M_t = F_t \times r_1$
    = 1899.83 x 0.075
M_t = 142.417 N/m
The Actual Bending Stress is found from AGMA equation [4]:

$\sigma = F_t/ (b*m*j) K_v K_0 K_m$ Where,
σ = 1900/ (20 x 3 x 0.45778) x 1.4x1x1.3
  = 125.8862 MPa

Table- 2: Bending stress for different Face width

Face width of Gear in mm	Bending Stress MPa
20	125.8862
25	100.7089
30	83.92412
35	71.93496
40	62.94309

2.2 BENDING STRESS CALCULATIONS USING KISSsoft

KISSsoft is outline programming for engineers and creators utilized as a part of a wide assortment of fields: like assembling link auto frameworks, gears for development hardware, Formula 1 race auto transmissions or the minor gears utilized as a part of Mars rovers, more organizations everywhere throughout the world have come to depend on KISSsoft plan programming.

Naturally all important geometry calculations are also executed, reference dimensions are provided for manufacturing, and tooth form is determined in two and three dimensions [5].

Table- 3: Bending stress for different Face width using KISSsoft

Face width of Gear in mm	Bending Stress MPa
20	133.71
25	106.96
30	89.14
35	76.40
40	61.28

2.3 BENDING STRESS CALCULATIONS USING FEA

Numbers of issues in engineering and applied science are connected by differential or integral equations. The answer for these conditions would give an exact and close solution to these conditions to the specific issue being studied. In any case, complexities in geometry and in boundary conditions that are seen in most genuine world problems that means an exact solution cannot be calculated or calculated in real amount of time. However, current product design process durations infer that engineers must acquire design solutions in a short measure of time. They are satisfied to acquire approximate solutions that can be promptly gotten in a sensible time period, and with sensible effort. The Finite Element Method is one such approximate solution technique. "The Finite Element Method is a

numerical technique getting estimated answers for some issues experienced in designing analysis".

The Workbench 14.5 software is the foundation on which the all organizations wide spacious and most profound software that has latest simulation technique. A creative project perspective holds complete simulation flowchart, directing designer in difficult multiphasic analyses by only copy-import technique. Using two-directional CAD connection, with auto project update system, the ANSYS Workbench Platform conveys exceptional profitability, empowering reproduction driven item improvement [6].

METHODOLOGY

Procedure:

First of all, we have prepared gear pair in KISSsoft for spur gear and save as this part as step file (.stp) for Exporting into ANSYS workbench. Import step file in ANSYS workbench simulation module. Apply material for spur gear (18CrNiMo7-6). Then we applied frictional support for both and torque of 142.417 N-m for driver.
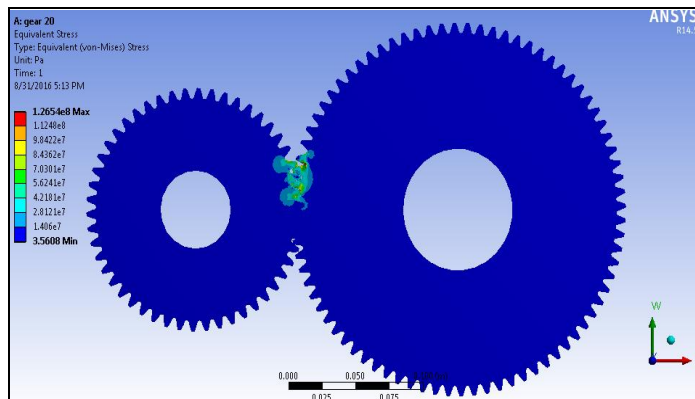
FEA RESULTS FOR SPUR GEARS:

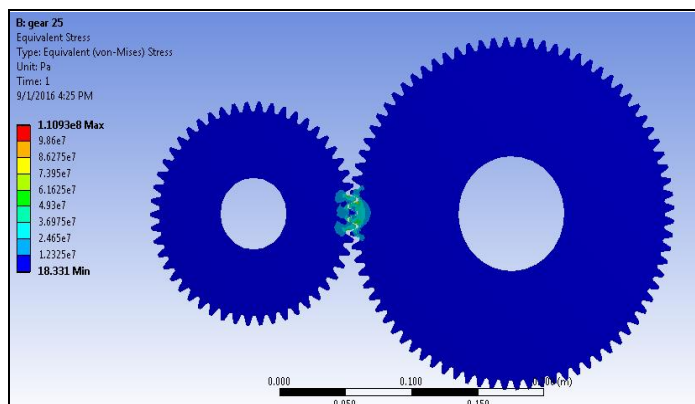Figure 2 Equivalent Von Misses Stress for face width 20 mm

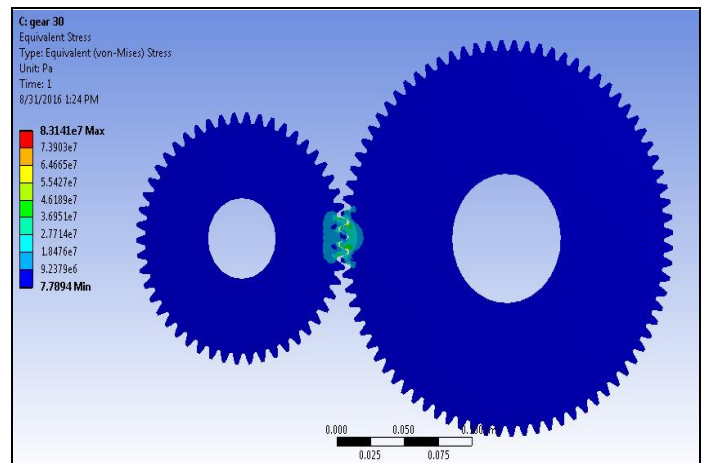Figure 3 Equivalent Von Misses Stress for face width 25 mm

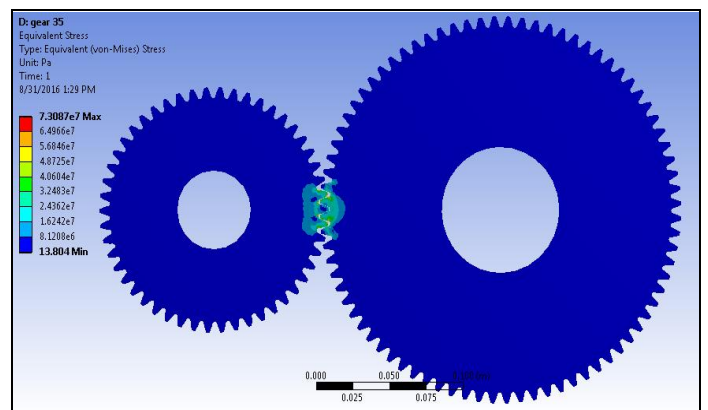Figure 4 Equivalent Von Misses Stress for face width 30 mm

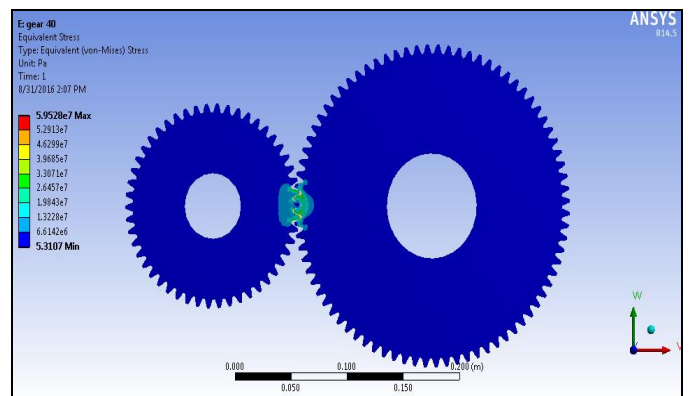Figure 5 Equivalent Von Misses Stress for face width 35 mm

Figure 6 Equivalent Von Misses Stress for face width 40 mm
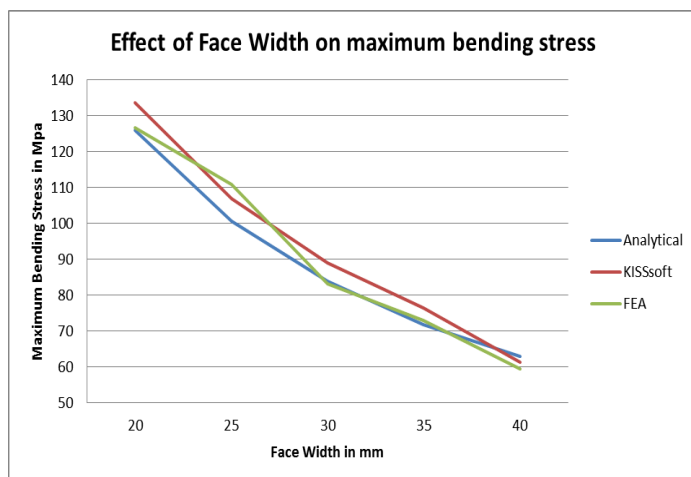
3. EFFECT OF FACE WIDTH:

The results of Maximum Stress obtained for various thicknesses are tabulate below. As load per unit thickness is kept constant, the maximum stress is almost same for all gears.

Table- 3: Effect of Face Width on Max. Bending Stress

Face width of Gear in mm	Maximum Stress (MPa)		
	Analytical	KISSsoft	Analytical
20	125.8862	20	125.8862
25	100.7089	25	100.7089
30	83.92412	30	83.92412
35	71.93496	35	71.93496
40	62.94309	40	62.94309

Chart -1: Variation in Maximum Stress with reference to Thickness of gear

4. CONCLUSIONS

The bending stress in a spur gear is decreases linearly with increase in Face width of the gear. The maximum stress is in the middle zone of the thickness whereas on the sides the stresses are lesser. The variation in the Bending stress is considerable. Maximum Bending stress is at the tooth root. Bending stress obtained by Analytical, KISSsoft and FEA method is nearly same.

ACKNOWLEDGEMENT

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