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ANALYSIS OF AN PROFILE CORRECTED SINTERED SPUR GEAR TOOTH

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Abstract : *A gear is a rotating member having cut teeth ,which meshes with another toothed element to transmit torque.. In the involute system of gearing, interference is a serious defect which hampers conjugate action. This violates the fundamental law of gearing and further interference is an important aspect in kinematics of gearing. When the involute portion of the tooth mates with the non-involute portion of the other tooth an undercut is formed as in [3]. Due to this the mating gear will try to scoop out metal from the interfering portion. In order to avoid undercutting and interference, addendum modification of the gear tooth is carried out.*

The main objective of this paper is to model a standard spur gear tooth of sintered material composition, and compare the bending stress results with that of a addendum modified sintered gear tooth. Sintered spur gears are manufactured through powder metallurgy process by blending, briquetting, sintering, repressing, infiltrating and heat treating the suitable combinations of alloy metal powders.

In this project a design part is done with PRO-E for the modeling of the spur gear for both standard and profile corrected tooth. The finite element model of the gear tooth is imported to an analysis software ANSYS to study the bending effects for different modules. Results were obtained from the comparisons made for the bending stress variations for both the standard sintered spur gear tooth and the profile corrected sintered spur gear. The results of the study for the addendum modified tooth showed a decrease in bending stresses for the wider tooth for the same loading.

Keywords – *Modeling,sintered gears, profile correction,bending stress.*

I. INTRODUCTION

Due to globalization industries are facing an increasing competition nowadays. Therefore it becomes more and more necessary to consider new alternative technologies such as powder metallurgy.]Cost saving potentials are thus become exploited.The high-volume production industry such as the automobile industry has already recognized process powder metallurgy including little finishing operations, optimal utilization of raw materials, short cycle times and favorable energy consumption. Compared to conventional manufacturing technologies, the power metallurgy has experienced a worldwide growth in the last decades, due to innovations in the fields of namely the optimization of the compaction cycle, optimized sintering conditions, density increase and optimized heat treatment conditions. Most of the structural part applications are placed in passenger cars, e.g. ABS rings, oil pump pinions, camshafts, chain sprockets or synchronizer hubs. Nowadays, the typical US passenger car contains more than 25 kg of sintered parts, a figure that will increase within the next several years.

II. INFLUENCE OF THE DENSITY ON MECHANICAL PROPERTIES

The porosity of sintered parts causes an internal notch effect. Thus the properties of sintered parts depend on the density of the material. According to Beiss, most properties can be described by a parabolic function based on the relative density, see equation 1.

$$\frac{P}{P_o} = \left(\frac{\rho}{\rho_o}\right)^m = \rho_{rel}$$

P: property, P_o: property in full dense state
ρ: density, ρ_o: density of the pore – free state
m: property and pore morphology dependent constant

III. PROCESS CHAIN OF SURFACE DENSIFICATION

The process chain of PM parts starts with the powder production. For high density and high strength applications an iron molybdenum alloy is water atomized. Other alloying elements, usually copper and nickel, are diffusion bonded. The carbon is alloyed by powder mixing. A fill shoe fills the powder a cavity formed by the lower punches and the die.To obtain a homogenous density in complex and multilevel parts hydraulic presses are used. Surface densifed gears have to meet mainly three requirements.

- .A sufficient depth of the densified layer is required to reach the postulated strength.
- The gear has to meet the specified geometrical accuracy.
- The densification of the surface layer needs to be homogeneous.

IV. OBJECTIVES OF THE RESEARCH

The objective of this thesis is to study the stress state of a standard and profile corrected sintered spur gear by first developing a model of a gear tooth profile,using Pro-E modeling software and subsequent meshing of the model is done using hyper mesh software for better accuracy of mesh. Then the analysis is carried out ANSYS 10.0 .

V. GEAR BENDING STRESS

Among the several failure mechanisms for spur gears, failure due to bending stresses is very important. When the loads are too large, bending failure will occur. This bending stress equation was derived from the Lewis formula. The gear tooth is considered as a cantilever beam under load. The ability of the tooth to resist tooth breakage at the root is often referred to as the beam strength. The tooth load F_N is supposed to act at the tip corner. Load F_N acts along the line of action at pressure angle and when referred to Pitch point P. At the intersection of the line of action and the centre line of the tooth, this force F_N is resolved as.It is resolved into tangential component in the 'x' direction and tangential component in the 'y' direction.

Radial components= $F_N \sin \alpha$

Tangential component = $F_N \cos \alpha$

Tangential Tooth load,

$F_t = mb\,\sigma_b\,Y$ as in [1]

Where, m= module, b = face width,

σ_b = design stress and

Y = Lewis Form factor

$$\text{Stress, Fs} = \frac{F_t \text{ x Height (h)}}{\text{Section modulas(z)}}$$

The load is calculated for various numbers of teeth assuming a pressure angle of 20^0 and a full - depth involute. The Lewis form factor is dimensionless and is also independent of tooth size and only a function of shape. This analysis considers only the component of the tangential force acting on the tooth, and does not consider the effects of the radial force, which will cause a compressive stress over the cross section on the root of the tooth. When the load is at top of the tooth, usually there are at least two tooth pairs in contact. In fact, the maximum stress at the root of tooth occurs when the contact point moves near the pitch circle because there is only on tooth pair in contact and this teeth pair carries the entire torque. When the load is moving at the top of the tooth, two teeth pairs share the whole load. If one tooth pair was considered to carry the whole load and it acts on the top of the tooth this is adequate for gear bending stress fatigue.

A.Gear Parameters used

Gear Type: Standard Involute, Full - Depth Teeth

Material :Sintered Iron – Copper – Carbon

Modulus of Elasticity: 1.37 X 10^5 N / mm^2

Module : 7, 8, 9 10

Pressure Angle : 20^0

VI. PROFILE CORRECTION OF GEARS

In gear technology, the profile correction is also termed as addendum modification (or) profile displacement (or) profile shift. We generally use the terms correction and correction factors respectively.

B. Advantages of profile correction

1. To avoid interference
2. Tooth strength will increase
3. Load capacity will increase
4. Betterment of sliding and contact relations
5. We can attain a predefined centre distance
6. To shift the beginning of the effective profile away from the base circle

VII. MODELING AND ANALYSIS

In this section, the profile of the involute spur gear tooth was generated using PRO-E. First, the four different circles representing the Addendum, pitch circle, base circle and the dedendum are drawn using the sketch tool. Using the extrude tool and the pattern tool the full gear model is developed. Then by using the sketch tool and extrude tool the bore diameter is created. The single tooth profile is then selected meshed using hyper mesh and imported through IGES file conversion to the ANSYS file.

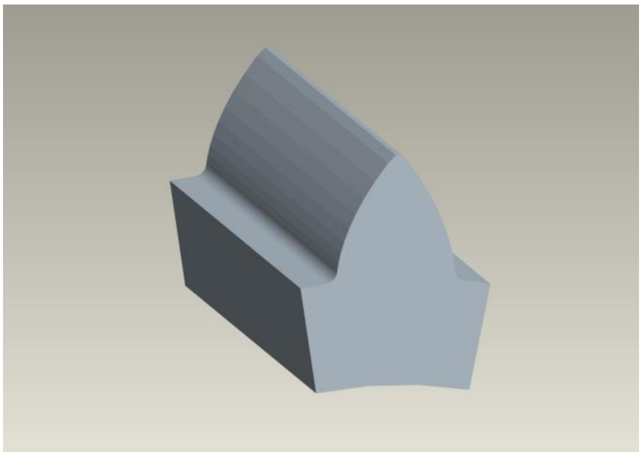

Fig-1.Profile corrected spur gear, m=9, ϕ = 20^0, Correction factor = +0.62

The analysis consists of discretization of the given domain into a collection of pre-selected elements, derivation of the element equations for all typical elements in mesh, boundary conditions, solving, solution & post processing of the results. The gear tooth at the fillet region is discretized into many numbers of small elements. Here the element type is considered as 8 node 82 plane element.

Large von-mises stresses are at the root of the tooth. They are equal to the tensile stresses. The tensile stresses are the main cause of the crack failure, if they are large enough. That is why cracks usually start from tensile side.

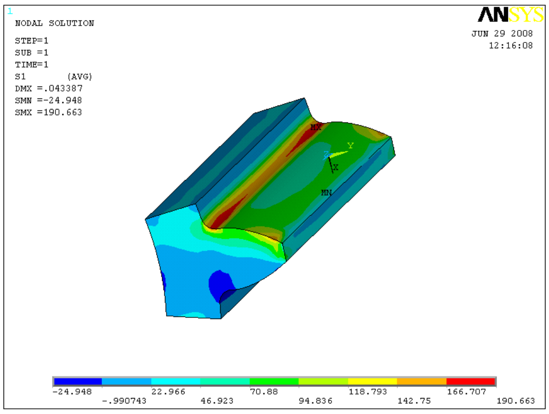

Fig-2. Stress Contour – Von – Mises Stres m=9, Correction Factor = 0

TABLE I Von-Mises Stress for Standard Sintered Spur gear

Module (mm)	Von-Mises Stress (MPa)
7	194
8	191
9	187
10	184

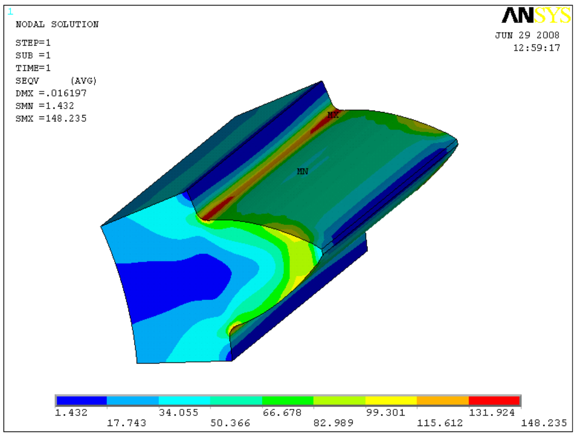

Fig-3.Stress Contour – Von – Mises Stress of Profile Corrected Spur Gear for m = 9, Correction Factor = +0.62

TABLE-2 .Von-Mises Stress for Profile Corrected Sintered Spur gear

Module (mm)	Von-Mises Stress (MPa)
7	164
8	155
9	148
10	140

TABLE-3 Von-Mises Stress Values for different correction factors **Module = 9 Φ=20°**

Correction Factors (x)	Von-mises stress (MPa)
+0.62	148
+0.43	161
0	190
-0.43	202
-0.62	212

VIII. RESULT OF STRESS ANALYSIS

The results of stress analysis are as given below:

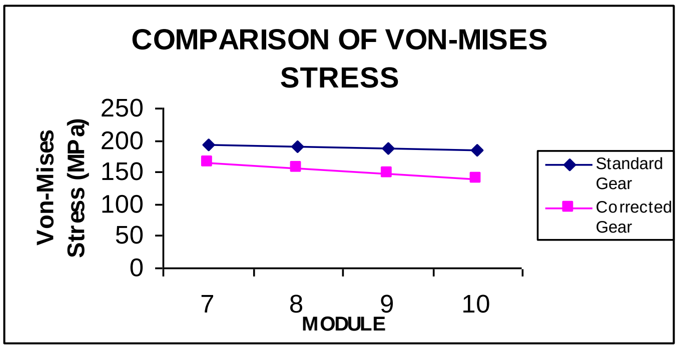

Fig -4 Comparison of Standard Tooth and profile corrected tooth Results

IX. CONCLUSION

. By using ANSYS the von mises stress is calculated for the standard and corrected spur gear tooth. From the above discussion about the stress analysis, it is finalized that the maximum stress concentration occurs at the root of the gear tooth. With the increase in correction factors the stress value decreases.

By increasing the density by different processing means such as warm compaction or high velocity compaction tensile strength, impact energy and hardness of Fe-Cu-C are increased significantly. By increasing the carbon content in the material tensile strength and hardness are increased due to changes in the microstructure. At 0.3% carbon the microstructure consists of ferrite and upper bainite changing to a microstructure consisting of upper bainite without any ferrite.

Vacuum carburization of Fe-Cu-C with 0.3% carbon significantly increases hardness and tensile strength compared to the sintered material. By increase in the density of the gear material the load carrying capacity can be considerably enhanced.

REFERENCES

[1] T.J.Prabhu, "*Design of transmission elements*" 2003, 5th, Edition, PP 2.1-2.15.
[2] Chang et al., "*A Finite element stress analysis of spur gear fillets radii and rim thickness effect", ASME* Journal of Mechanisms, Transmission and Automation in Design**,** PP 327-30, 1983.
[3] Giti M Maitra,"Handbook of gear design", 2nd Edition Tata Mc-Grawhill Book Company Ltd., PP 2.1-3.37, 1994.
[4] Shigley Joseph Edward "*Theory of machines*", 2nd Edition, Tata Mc-Grawhill Book Company Inc. (1995), PP.250 - 294.
[5] Earle Buckingham, **"***Manual of gear design***",** 3rd Vol., Industrial Press, New York, 1935.
[6] Chironis, N.P.(Editor): "*Gear design and application*", Mcgraw-Hill Book Co., Iuc. New york, NY., 1967.
[7] D.W.Dudley, "*Gear handbook*", Mc Graw-Hill, Newyork, 1962
[8] Knut O.Kverneland (Editor), "*World metric standards for engineering*", Industrial Press, New York, NY.1978.
[9] G.W.Michalec, "*Precision gearing: Theory and practice*", John Wiley & Sons, New York, 1966.
[10] Ali Raad Hassan,"*Contact Stress Analysis of Spur Gear Teeth Pair*, World Academy of Science, Engineering and Technology 58 2009
[11] Dr Ir H G H Van Melick,"Tooth bending effects in plastic spur gears", www.gear technology.com, Sep/oct 2007.
[12] Buljanović, K. & Obsieger, B," Influence of tip relief profile Modification of spur involute gear on stresses",Advanced Engineering 3(2009)2, ISSN 1846-5900.
[13] A. Mekhalfa, A. Bouaricha, A. Kallouche, E.Hadjadj,"*Teeth's Gear Correction***"** Vol. 3. n. 3.,pp. 271-274