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On the Location of the Tooth Critical Section for the Determination of the AGMA J -Factor

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TECHNICAL PAPER

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

The bending strength geometry factor J depends on the location of the critical section and the tooth thickness at this section. The critical section is that in which the uncorrected bending stress, given by Navier's equation, is maximum and consequently it is defined by the point of tangency of the Lewis Parabola and the tooth profile. This point of tangency is usually placed over the root fillet, but in some cases the tangency may occur at the involute. For these cases the methods described in literature for determining the AGMA J -factor are not suitable. This paper presents the condition for tangency at the involute and a method to determine the J factor under this condition.

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ON THE LOCATION OF THE TOOTH CRITICAL SECTION FOR THE DETERMINATION OF THE AGMA J -FACTOR

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Introduction

To evaluate the maximum bending stress arising at any point of the tooth during the entire meshing interval, AGMA introduces the bending strength geometry factor, also known as AGMA J -factor [1]. According to Navier's equation, the point of maximum bending stress is located at the point of tangency of the tooth profile and the inscribed equal-stress parabola, or Lewis parabola [2], whose vertex is placed on the intersection of the line of action, at any contact point, and the tooth centerline. The most severe conditions correspond with the tooth loaded at the tip, for conventional helical gears, and at the highest point of single tooth contact, for spurs and low axial contact ratio helical gears. Consequently, the critical section of the tooth is defined by the point of tangency of the tooth profile and the Lewis parabola for load acting at the above points, and J factor can be expressed as a function of the height of the Lewis parabola (distance from the critical section to the vertex of the parabola) and the tooth thickness at the critical section.

Since the point of tangency is usually placed over the root fillet, existing methods to compute the AGMA J -factor [3,4] involve iterative procedures to find the point of tangency of the parabola and the root trochoid. However, tangency may occur at the involute, as seen in Fig. 1. Under these conditions, results provided by the above methods could be inappropriate. In this paper the tangency condition at the involute profile is established. Also a method for computing the AGMA J -factor under this condition is presented.

Location of the critical section

AGMA defines the bending strength geometry factor J as [3]

$$J = \frac{C_\psi}{K_r m_N} \frac{\cos \psi_r \cos \psi}{\frac{\cos \phi_{nL}}{\cos \phi_{nr}} \left[\frac{6 h_F}{s_F^2 C_h} - \frac{\tan \phi_{nL}}{s_F} \right]} \quad (1)$$

where C_ψ is the helical overlap factor, K_r the stress correction factor [5], m_N the load sharing ratio, ψ_r the operating helix angle, ψ the standard helix angle, ϕ_{nL} the load angle, ϕ_{nr} the operating normal pressure angle, h_F the height of the Lewis parabola, s_F the tooth thickness at the critical section and C_h the helical factor [6].

Figure 1 shows an example of tangency occurring at the involute. Involute profile and root trochoid are tangent at point E . This means there is neither undercutting nor tool protuberance (or grinding after generation by shaper cutter with protuberance), although for small undercutting and/or tool protuberance, it is possible that the tangency point still remains at the involute, as shown in Fig. 2. However, under this condition of tangency at the involute, the point of tangency shouldn't be considered neither for locating the critical section nor for determining the J factor. Though Navier's stress is maximum at this point, the stress concentration is very small at the involute, and corrected bending stress is greater at any point of the root fillet. Therefore, the J factor should be computed considering the section of the root in which Navier's stress is maximum, which