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Experimental stress analysis of enhanced sliding contact spur gears using transmission photoelasticity and a numerical approach

Ahmed W Hussein[1,2] and Mohammad Q Abdullah[2]

Abstract

Free-Form-Gear (FFG) is a recently published title for a gear that has a curved path of contact and offers contact between a convex addendum and a concave dedendum during the meshing cycle. Based on this method of designing a gear pair, the path of contact can be altered to improve the way the gears mesh and slide against each other by only adjusting the maximum pressure angle and the involute curve parameter. The analytical investigations into this gear pair indicated that, when compared to the standard involute gear pair, the sliding velocity, meshing efficiency, contact, and fillet strengths are improved while the contact ratio is decreased. In this study, experimental stress analysis is conducted on various configurations of the tooth profile and tooth fillet shape for the proposed FFG and the standard involute gear to validate the analytical results. Since it is difficult to measure the contact stress for the gear specimens, the contact stresses at critical points are estimated using an effective computational technique based on photoelastic data and a numerical approach utilizing the nonlinear least squares method. At the fillet zone, isochromatic fringe patterns are used to directly measure the maximum fillet stress. Using addendum modification coefficients, the reduction in contact ratio for the proposed FFG is eliminated, and the results are then verified experimentally. Based on the experimental estimations, the finite element analyses are conducted using ABAQUS to simulate the examined gear specimens. Under the same loading conditions, the experimental, analytical, and numerical results have all been in good agreement.

Keywords

Free-form-gear, spur gear, contact stress, bending stress, FEM, photoelasticity

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Introduction

Involute gears, which utilize an involute curve as a tooth profile, are widely used in many applications due to their unique advantages. These benefits include less sensitivity to manufacturing and assembly errors, simplified manufacturing processes due to their simple rack cutter, and center distance adjustment via profile shifting. The low load-bearing capacity and meshing efficiency, on the other hand, are the main drawbacks of involute gears.[1] In authors' previous work,[2] a mathematical model has been derived based on the predefinition of the path of contact (POC) to mitigate the drawbacks of the involute gear by employing a composite tooth profile. The suggested tooth profile includes an involute curve segment through the pitch point and a general transition curve (GTC) for the rest of the profile. The newly suggested gear has been titled "Free-Form-Gear" (FFG). It was shown that a tooth with such a profile configuration would make contact between a convex addendum and a concave dedendum. Previous analytical investigations have shown that compared to the standard involute gear, the sliding velocity, meshing efficiency, contact stress, and fillet stress have all been improved, while the contact ratio has been reduced. In this study, the analytical results based on stress are verified experimentally using an effective stress analysis technique. In addition, a practical solution is proposed for the drawback in the contact ratio for such gears.

[1]Energy Engineering Department, College of Engineering Al-Musayab, University of Babylon, Babylon, Iraq
[2]Mechanical Engineering Department, College of Engineering, University of Baghdad, Baghdad, Iraq

Corresponding author:
Ahmed W Hussein, Energy Engineering Department, College of Engineering Al-Musayab, University of Babylon, 60th Street, Babylon 00964, Iraq.
Email: msb.ahmed.waleed@uobabylon.edu.iq