Results in Engineering 14 (2022) 100412

Contents lists available at ScienceDirect

Results in Engineering

journal homepage: www.sciencedirect.com/journal/results-in-engineering

High-contact ratio spur gears with conformal contact and reduced sliding

Ahmed W. Hussein [a,b,*], Mohammad Q. Abdullah [b]

[a] *Energy Eng. Dept., College of Engineering Al-Musayab, University of Babylon, Babylon, Iraq*
[b] *Mechanical Eng. Dept., College of Engineering, University of Baghdad, Baghdad, Iraq*

ARTICLE INFO

Keywords:
Spur gear
Non-involute gear
High contact ratio
Contact stress
Sliding velocity
EHL

ABSTRACT

The high-contact ratio (HCR) spur gear is a possible choice for a quiet and smooth gearing system. However, HCR spur gear of the involute type has several constraints, such as high sliding contact under large loads and interference problems in high speed reduction systems, so its benefits may not be fully offered. As a result, the primary goal of this research is to design a non-involute HCR spur gear with reduced sliding contact, enhanced fillet strength, better lubrication conditions, and no interference issues compared to the traditional HCR involute pair. A generalized mathematical model for defining the gear tooth profile and its geometrical aspects is built based on the path of contact shape. The involute curve length parameter and maximum pressure angle during the meshing cycle are only introduced to characterize this model. This model is utilized to create a new non-involute HCR gear pair that provides a free-form tooth profile to meet the design requirements. To demonstrate this method, certain case studies are provided, and the analytical results are validated using the finite element method. The new gear's performance is compared to the traditional involute gear that is currently in use. The results showed that by employing the proposed method, the HCR spur gear can achieve better surface durability and fillet strength.

1. Introduction

1.1. Background

In typical industrial gearing systems, low-noise performance becomes a fundamental requirement for determining the quality of the gears for consumers. High contact ratio (HCR) spur gears can give smooth meshing in operation while being smaller and lighter. The HCR gear has a contact ratio of at least 2 or more, which means that it has at least two or more tooth pairs in contact during the meshing cycle to share the load. Gears with an involute curve as the tooth profile are widely used in the industry. Using this gear type necessitates teeth with a lower pressure angle, finer pitch, or extended addendum. All of these factors affect tooth stress per unit load, interference issues, and high sliding velocity, resulting in increased wear rates, scoring, and pitting [1–3]. As a consequence of such constraints, in addition to surface destruction, the installation of a larger and specialized cooling system to reduce heat generation is required. Therefore, the advantages of the HCR spur gear may not be fully realized.

Many researchers have studied HCR gears over the last few decades. Staph H. E. [1] proposed a computer program for designing involute gears with low contact ratios (LCR) and high contact ratios (HCR). The effects of gear proportions on various performance variables were investigated. It was determined that the HCR gear generated by raising the addendum of an LCR gear has reduced bending and contact stresses while having higher heat generation and flash temperature. Anderson N. E. and Loewenthal S. H. [3] proposed a method for computing the efficiency of the HCR involute gear. In their study, the effects of the applied load, gear speed, and tooth proportions were investigated. The findings indicated that, despite the high sliding velocities of HCR gears, they may be built to have efficiency levels that are comparable to those of standard gears while still preserving their advantages through correct gear geometry selection. Elkohly A. H. [4] proposed a solution for estimating the load share factor (LSF) between the HCR involute gear pair in the mesh. The sum of tooth deflection, spacing error, and profile modification was considered to be identical for all pairs in contact. After calculating individual loads, tooth fillet stress and contact stress were estimated. The results showed good agreement with the photoelastic

Abbreviations: FFG, Free-form-gear; POC, Path of contact.; SLS, Straight-line segment.; TLF, Top land factor; HCR, High contact ratio; LCR, Low contact ratio; LSF, Load share factor; UTC, Universal transition curve.

* Corresponding author.
E-mail address: msb.ahmed.waleed@uobabylon.edu.iq (A.W. Hussein).

https://doi.org/10.1016/j.rineng.2022.100412
Received 8 February 2022; Received in revised form 6 April 2022; Accepted 8 April 2022
Available online 14 April 2022