Results in Engineering 16 (2022) 100523

Contents lists available at ScienceDirect

Results in Engineering

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

A Novel Fillet Form for Non-Generation Cutting Gear Teeth

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
Bending stress
Circular fillet
Involute gear
Noninvolute gear
FEM

ABSTRACT

Tooth fillets are commonly made of circular profiles because they are easy to define analytically and have been shown to be superior from a bending perspective to the trochoid fillet. For gears that are cast, forged, or 3D printed, the tooth fillet can be any curve as long as it is capable of providing a smooth mesh without interference. For such design flexibility, the circular fillet may not necessarily be the best fillet profile from a bending stress point of view. Therefore, the first aim of this study is to develop a general mathematical model for defining the tooth fillet profile analytically for gears manufactured by non-generation cutting processes. The mathematical model employed a general fillet transition curve (GFTC) to ensure smooth transition surfaces in the fillet zone and an improved radius of curvature as well as tooth form factor compared to the circular fillet profile. The second aim of this work is to examine if increasing the order of the proposed GFTC can enhance the fillet strength of the gear tooth further. The design method is conducted for involute gear and, for the first time, non-involute gears. Various fillet design parameters and tooth numbers are examined. The results showed that by using the proposed fillet shape, the tooth fillet strength can be enhanced by 18–23% for involute gears and by 30–32% for non-involute gears. Also, the results showed that increasing the order of the fillet curves might not always improve the fillet strength of the gear teeth.

1. Introduction

1.1. Background

Gears are commonly used in power transmission devices for transferring motion at a constant velocity ratio. Recent engineering advances have boosted the demand for reliable gear teeth. Because failing systems are costly, both in terms of replacement or repair and outage.

Gear failures are of two kinds. The first is pitting and scoring across gear surfaces. The second failure type is tooth-breaking, caused by excessive fillet stress. In this case, gear technology such as case-hardening, shot peening, or carburizing can be used to improve the tooth fillet strength rather than a revision of the gear geometry. However, some designers have found alternative geometrical ways to strengthen the tooth fillet, such as increasing gear size (module). Even though this reduces the gear's durability, it's better than broken teeth [1].

Heavy-duty and high-speed gearboxes need to be more reliable, so researchers tried to modify the tooth profile to increase the fillet strength. These researchers aimed to increase root width. The first trial was to design an alternative tooth shape with a wider tooth root thickness, either by using gears with different pressure angles on the loaded and unloaded sides (asymmetric gear) or by using non-involute tooth shapes. Under the same load conditions, the fillet stress in both design scenarios was shown to be lower than that of standard involute gear [2–10]. The shape of the gear tooth fillet is usually defined by the trochoid cutting tool trace. In the second trial, the researchers tried to optimize the fillet profile itself to improve the tooth fillet strength.

R.L. Chang et al. [11] used the finite element method (FEM) to analyze spur gear stress under different loads, support, fillet size, and rim thicknesses. The results showed that the maximum fillet stress decreases as the fillet radius increases. S. Senthilvelan and R. Gnanamoorthy [12] used the FEM and experiments to study the effect of the tooth fillet radius on the molded polymer gear performance. The results showed that the gear tooth fillet radius affects polymer gear performance significantly. C. Spitas and V. Spitas [13] investigated the benefits of using a circular fillet in generation cutting gears. The results demonstrated that the standard trochoid fillet is far from optimal for

Abbreviations: GFTC, General fillet transition curve; FFG, Free-form-gear; POC, Path of contact; CF, Circular fillet.

* Corresponding author. Energy Eng. Dept., College of Engineering Al-Musayab, University of Babylon, Babylon, Iraq.
E-mail address: msb.ahmed.waleed@uobabylon.edu.iq (A.W. Hussein).

https://doi.org/10.1016/j.rineng.2022.100523
Received 10 June 2022; Received in revised form 27 June 2022; Accepted 29 June 2022
Available online 12 July 2022