

Stock Distribution Optimization in Fixed Setting Hypoid Pinions

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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

In the spiral bevel and hypoid gear manufacturing industry, master pinions and gears are usually developed from initial machine settings obtained from computer software such as The Gleason Works' TCA, which are then modified until a satisfactory bearing pattern is obtained.

Once a satisfactory combination of master pinion and gear is obtained, the Stock distribution between the rough and finish cuts of fixed setting, face milled pinions is usually altered to the point where left-overs may appear at the finish cut. The operator must then modify the roughing machine settings until left-over disappears, which does not guarantee that Stock will be evenly distributed over the tooth flank. Even Stock distribution allows increases in cutting speeds and feed, and produces gears with better tooth flanks while increasing tool life.

This paper presents an algorithm to optimize the Stock distribution in two and three cut face milling processes for spiral bevel and hypoid gears. The algorithm minimizes the differences in terms of spiral angle, pressure angle, and tooth taper between the roughed and finished tooth flanks. An application example is presented to illustrate the usefulness of the method.

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STOCK DISTRIBUTION OPTIMIZATION IN FIXED SETTING HYPOID PINIONS

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1. Introduction

Face milled hypoid pinions produced by the three cut, non completing, fixed setting system where roughing is done on one machine and finishing for the concave-OB and convex-IB tooth flanks is done on separate machines with different setups, are still in widespread use today.

The undeveloped machine settings, for the finish and rough cuts, are normally obtained from a TCA program, such as those produced by Gleason and Klingelnberg [1]. During the development process, where the finishing machine settings on the pinion are modified until the desired bearing pattern is obtained, the stock distribution between the roughing and finishing operations may be altered to the point where the finishing cut hardly touches the tooth flank in some areas of the tooth. The machine operators then either decrease the depth of the roughing operation, in which case an undesired lip or step may be left at the root of the tooth, or decrease the thickness of the finished tooth at the expense of increased backlash.

This paper presents an algorithm used to optimize the stock distribution between the roughing and finishing cuts for spiral bevel and hypoid members cut by the fixed setting method. The optimization is based on the Surface Match algorithm [2], where the differences between the roughing and finishing spiral angle, pressure angle and tooth taper are minimized in order to obtain rough and finished tooth flanks that are parallel.

Application results of the optimization are shown. Better stock distribution usually results in :

- both roughing and finishing tool life can be increased, at Finishing by more uniform and

reduced stock for the finishing cutters and, at Roughing, by being able to increase the point width of the roughing cutter;

- reduced development times; otherwise, both the rough and finish setups must be developed;
- improved productivity: it may be possible to increase the feeds and speeds with reduced chip loads;
- improved tooth fatigue performance due to more uniform fillet radii in the roots.

2. Main Nomenclature

$\bar{N}$	tooth flank normal unit vector
$\bar{V}_r$	relative speed vector
S	position of a point on the blade edge
α_c	cutter angular position
α_3	work roll angle
Φ	pressure angle error
Ψ	spiral angle error
ζ	tooth taper error

3. Tooth Cutting Process

The generating process of gear teeth are based on the basic concept of meshing elements between a cutter blade whose rotation represents the shape of one tooth of a theoretical generating gear, and the work itself. The fundamental equation of meshing is:

$$\bar{N} \bullet \bar{V}_r = 0 \quad (1)$$

which states that the relative speed vector $\bar{V}_r$ between contacting surfaces must be in a plane