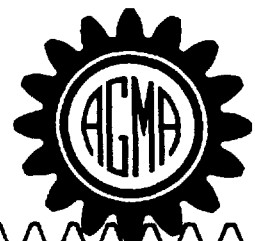


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The New Way of Manufacturing Bevel and Hypoid Gears in a Continuous Process

by: Dr. Hermann J. Stadtfeld, The Gleason Works



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

Much attention has been paid to face hobbing in the last decade. The CNC technology made a quantum step in this period which was beneficial especially for the continuous bevel gear cutting process. Parallel to the CNC technology a new method of face hobbing was subsequently developed and is introduced today as the different and new way of face hobbing. The basis is a new gear theoretical approach to design the blank geometry, the ease off and the tooth contact. The tools are different in design than regular cutting blades and enable a high economical procedure of roughing and finishing in one chucking. The process kinematic was completely redesigned, benefitting from the free form concept of today's cutting machines. All the aspects of precision, flexibility and economy made the new face hobbing also popular for the gearbox manufacturer and jobber. The paper explains the theoretical background and the important tool and process details.

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1. Introduction

In 1920 James E. Gleason and Arthur L. Steward received a patent on a method and the machine to cut face hobbed gears using face cutter heads. Today's machining processes for face hobbing are still based on this 80 year old idea.

Until 20 years ago only face milling (single indexing method) was used for the tens of thousands of gears produced daily in the automotive industry. Face hobbing (continuous indexing) was only used by a few gearbox manufacturers. Even the advanced continuous methods were always 10 years behind the single indexing process in their innovative steps like controlled flank crowning or non-generating of the ring gears.

More attention has been paid to face hobbing in the last decade. The CNC technology made a quantum step especially for the continuous method. Parallel to the CNC technology a new method of face hobbing was subsequently developed and today is introduced as the different and new way of face hobbing.

The basis is a new gear theoretical approach to design the blanks, the ease off and contact. The tools are

different in design than regular cutter heads and enable a highly economical procedure of roughing and finishing by chucking. The process kinematic was completely redesigned, benefiting from the free form concept of today's cutting machines.

If lapping is not sufficient or desired as a finishing process, a skiving operation with carbide tools can be applied. The skiving uses identical machines and cutter heads, the only difference being that the blade sticks are from special ultra fine grain carbide. The new method is even supported by the fast, numerically controlled building of cutter heads to a high accuracy.

All the aspects of precision, flexibility and economy make the new face hobbing also popular for the gearbox manufacturer and jobber. This paper explains the theoretical background and the important tool and process details.

2. Face Hobbing, a Continuous Bevel Gear Cutting Method

The continuous indexing method requires a second rotational coupling (electronic gear box) between the cutter head rotation and the workpiece rotation. For this reason the method is also called three axis process. **Figure 1** shows the orientation of the blade groups on a cutter head (right side of figure). On the left side of Figure 1, the single indexing method for comparison is shown [1].

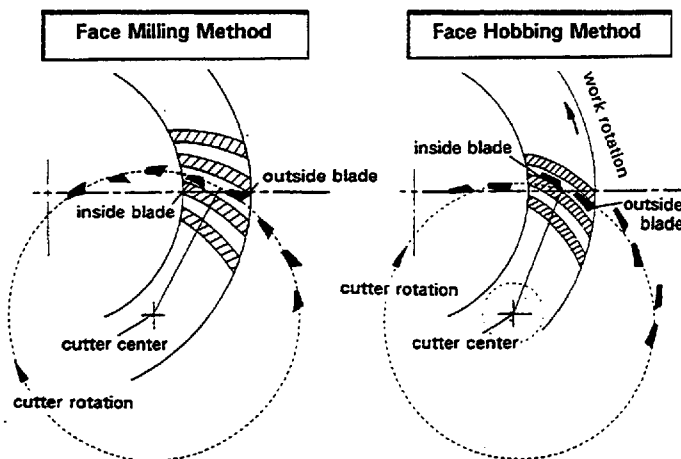


Figure 1: Configuration and motions of single indexing versus continuous indexing

Each blade group of a TRIAC® cutter head has only two blades, one outer blade and one inner blade. While one blade group passes through a slot, the work gear rotates in the counter direction of the cutter. This relative motion produces an epicyclic function along the face width of the work gear. After the blade group leaves the slot, the next blade group enters the next slot. The ratio between the cutter head and the gear must be the number of teeth of the work divided by the number of starts (blade groups) of the cutter head. In the generation process, the roll motion is used as cutting feed. This roll is very slow compared with the face milling process. Since face hobbing takes chips on tooth after tooth in about the same roll position, the roll motion can be slower (by the number of teeth of the work gear), and still have about the same cutting time as face milling.

3. Advantages of Face Hobbing

The epicyclic shape of the flank in the face-width direction makes a face hobbed gearset less sensitive to bending of the pinion shaft and deflection of the gear housing. Those deflections in most cases cause a misalignment of the spiral angles between pinion and gear where the reaction of the contact is a length movement toward the heel. For an epicyclic function, the spiral angle increases more between toe and heel compared to a circular function. The curvature radius is smaller at the heel than at the toe. The relative movement between pinion and gear flank provides the higher radius of curvature of the pinion flank to contact the lower radius of curvature of the gear flank (drive side), which counteracts the movement of the contact from center to heel. The profile movement of the contact under deflections or misalignment caused by tolerances follows about the same rules as for face milled gears.

Wrong adjustment of the backlash was detected to have a sensitive impact to the rolling sound and the contact. This has to do with the relatively long bias in contact pattern which is commonly applied to face hobbed gears (**Figure 2**, lower graphic). Using the same amount of length crowning and some amount of profile crowning delivers a "natural" kind of bias in for face hobbed gears with the appearance of a longer contact. This has to be compared with the short high bias bearing of a face milled gear (**Figure 2**, upper graphic). However, the adjustment of the backlash gets simplified by the fact that face hobbing is a completing operation with proper tooth thickness' without stock division trials.

Face hobbed gearsets deliver generating flats which are optimally suited for an efficient lapping process with a quality result. The contact lines and the generating flats of face hobbed flanks have a significantly different angular position. Lapping compound is pumped through the contact area of face hobbed gears. In addition to a reduction in lapping time on face hobbed gears versus face milled gears, also a non-wavy surface finish is developed; although the generation marks are higher in peak to peak magnitude than the comparable marks of a face milled gear. **Figure 3** shows the contact lines between pinion and gear as thin single lines. The generation flat for face milling is shown as double line which matches the contact lines from shape and angle.