



AGMA Technical Paper

A Different Way to Look at Profile and Helix Inspection Results

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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

The traditional inspection of involute gear profile and helix deviations results in plots of deviations from a perfect involute and from a perfect helix. While this is appropriate for gears with an unmodified profile or helix, it is not ideal for gears that have intentional modifications. This paper explores the advantages of looking directly at deviations from the design shape. This type of analysis is implied but not explicitly stated nor is it pictured in ISO 1328-1:2013. Also presented is a modification to zone based tolerance evaluation as presented in ISO 1328-1:2013, with limits on the total deviation from design given graphically.

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Introduction

Elemental inspection of gears is commonly carried out with computer numerically controlled (CNC) machines. While these range from special purpose gear measuring machines with a precision rotary table to 3-axis co-ordinate measuring machines (CMM) with software adapted for gear measurement, what these inspection machines have in common is they produce graphical output that shows deviations of the profile from a perfect involute and deviations of the helix from a perfect helix. For gears designed without any profile or helix modifications, this is appropriate and sufficient. However, it has become very common for gears to be designed with a design profile that deviates from a perfect involute shape and a design helix that deviates from a perfect helix [1]. For these gears, a graphical output showing deviations of the profile from the design shape can be very helpful.

Background and proposal

The proper specification of design shape is very important for the proper performance of the gear. Design shape modifications may be used to improve the noise, vibration and harshness (NVH) of a gear set, prevent tooth collisions in heavily loaded gears, compensate for changes in tooth shape due to shaft bending and thermal deformation that occur during normal operation, or for other reasons. In many gears, proper tooth shape modifications are essential for both smooth operation and long life [2]. The designer specifies what the tooth shape should be, but it is then up to the machine operator or inspector to verify that the design intent has been met. Unfortunately, for gears with modified profiles, typical gear charts require a high level of expertise to properly evaluate how the gear deviates from the design shape. What is proposed here is that since the design profile is the ideal shape, the deviations from the design profile should be displayed in addition to the deviations from a perfect involute. No additional data collection will be required, it is simply an alternate method to display the data gathered by an inspection machine. Graphical displays of deviations from the design shape are much easier to evaluate, and can be a very useful addition to the inspection processes. These deviations should of course be zero, so the plot of deviations from design profile should be a straight line coinciding with the axis. These new charts are not intended to be a replacement for traditional charts, but rather an additional chart that in combination with traditional gear charts will make understanding of the deviations much easier. Each method of display has its own advantages; used together they can quickly lead to a full understanding of the deviations.

Examples

Figure 1 shows a typical output of gear profile and helix (sometimes called lead) charts. These charts show the measured traces for both left and right flanks of 3 teeth spaced approximately 120° apart.

Figure 2 is a schematic based on ISO 1328-1:2013 [figure 8] showing how a single profile trace is analyzed for a gear with a design profile that has both root and tip relief. Note that the orientation of the chart is not critical as long as it is properly labeled, many charts present the traces vertically as in figure 1 while in ISO 1328-1:2013 the traces are presented horizontally.

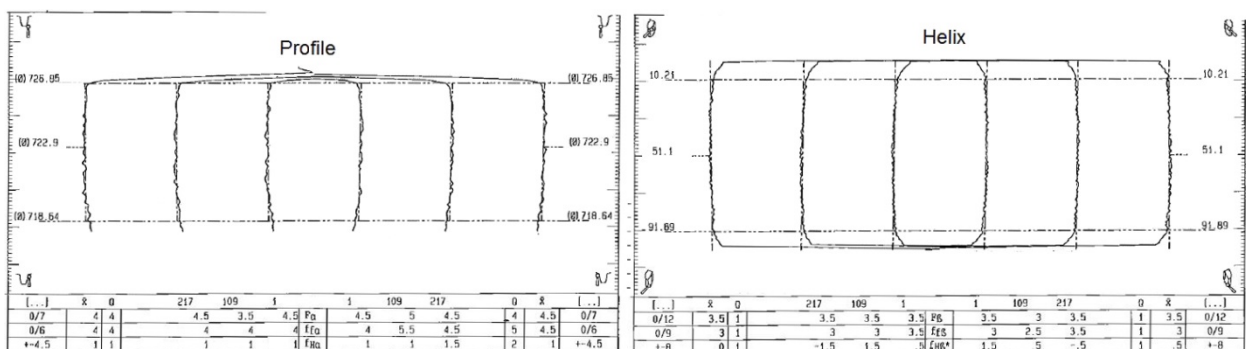


Figure 1. Typical profile and helix charts