

Single Flank Testing and Structure–Born Noise Analysis

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ABSTRACT:

Testing the running behavior of a gearset that is ready for installation must take place on a bevel and hypoid gear tester. This paper describes single flank generation testing and structure–borne noise analysis of gear pairs based on a highly modern real-time analysis device for which software was specially developed for the transmission testing of gearsets. The single flank generation test which has been known for decades has experienced a virtual breakthrough into mass production through the application of the fast measurement method. The new possibilities and a trouble shooting example are explained in the paper.

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1 Introduction

The method of measuring the "quasi-static" transmission behavior of any given hypoid gearset which has been well known for many years is now experiencing a renaissance. In addition to the measurement of coordinates for purposes of comparing nominal and actual tooth surfaces, the single flank test should enable direct conclusions to be drawn concerning noise development under critical operating conditions.

An appropriate testing arrangement is adapted to perform these single flank tests by fitting high resolution angle increment encoder heads to the pinion and gear spindles (e.g., with 18,000 tick marks on circumference).

The time constant T is determined from sinusoidal signals by data measurement and evaluation electronics.

With the pinion driving and the gear braked, the motion differential (separate for drive and coast) is formulated from the difference between the signals from the pinion and the gears.

The derivation of the velocities of the pinion and gear spindles with the resulting differential development is as important as the relative acceleration induced by tooth meshing and is a measure of the ensuing disruptive forces. A Fourier Transformation with the representation of referenced amplitudes shows acceleration levels over octave bands, respectively, a lineally depicted frequency spectrum.

A series of gearsets must be tested in vehicles in order to determine the relationship between noise behavior in the vehicle and the results of single flank testing. Using reference gearsets with known characteristics, i.e.,

"good", "acceptable" and "no longer acceptable", an interpretation can be achieved which, however, will most certainly vary from one design to another.

The recording of vibration noise, respectively, acceleration is an important supplement to rotary transmission measurements. It best establishes the relationship between real noise in the vehicle and the analysis on the test machine. The relationship between structure-borne noise, or vibration pattern, and transmission error graphs can only be established using the Fourier analysis and frequency spectrums.

Finally, in order to demonstrate a corrective influence on gear geometry, the results of a mathematical contact analysis should be available since theoretical graphs for rotary variations, path of contact, and Ease-Off topography are usually key elements in the noise optimization process.

2 Test machine and test configuration

The single flank test is a quasi static testing method. The pinion, therefore, drives at a low speed of between 30 and 60 rpm. The gear is braked just sufficiently to assure constant tooth surface contact on the coast and drive sides.

The test machine used might be a high precision bevel and hypoid gear tester, or a special single flank testing machine. The test machine should have a repeating accuracy of 0.004 mm. by fitting Heidenhain encoders (18,000 tick

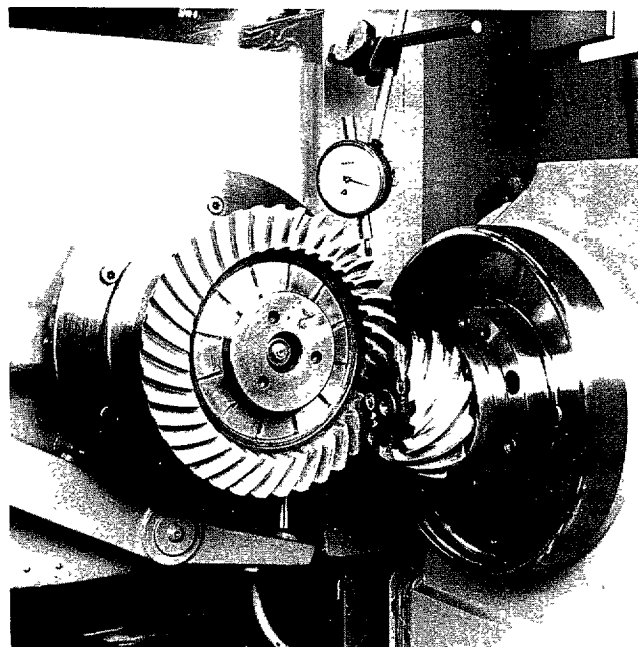


Figure 1: Test machine as basic for structure born noise analysis and single flank testing (Source, The Gleason Works)

marks) the exact angle of rotation can be recorded in the immediate vicinity of the pinion and gear spindle (**Figure 1**).

Recording and processing of measurement values is performed by compact electronics from the firm, CMS, Ettlingen. Both the electronics and the software for measurement signal processing were developed especially for operation within the characteristic environment of all kinds of gears. This so-called "MessTop" package includes a display for graphic output of the diagrams generated during the analysis. With a laser printer connected, all graphics can be printed out on paper for archiving purposes.

Using newly developed ring-shaped angle increment encoders (**Figure 3**), the angle measurement takes place at the leading end of the work spindles. The