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Surface Roughness Measurements of Cylindrical Gears and Bevel Gears on Gear Inspection Machines

By G. Mikoleizig, Klingelnberg
GmbH

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Günter Mikoleizig, Klingelnberg GmbH

[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

Alongside the macro test parameters on tooth flanks for profile and tooth traces, surface properties (roughness) play a decisive role in ensuring proper toothed gear function. The generally increased load stresses on gear teeth can only be implemented by maintaining precisely defined roughness parameters. Roughness measurements are therefore conducted on the gearing flanks in all highly developed drives, in the automotive industry, aircraft industry, or the area of wind energy drives, for example.

This article addresses roughness measurement systems on tooth flanks. In addition to universal test equipment, modified test equipment based on the profile method for use on gears is addressed in particular. The equipment application here refers to cylindrical gear flanks and bevel gear flanks. The most important roughness parameters, as well as the implementation of the precise measurement procedure will also be described under consideration of the applicable DIN EN ISO standards as well as the current VDI/VDE Directive 2612 Sheet 5.

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American Gear Manufacturers Association
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Günter Mikoleizig, Klingelnberg GmbH

Introduction

Alongside the macro test parameters on tooth flanks for profile and tooth traces, surface properties (roughness) play a decisive role in ensuring proper toothed gear function. The generally increased load stresses on gear teeth can only be implemented by maintaining precisely defined roughness parameters. Roughness measurements are therefore conducted on the gearing flanks in all highly developed drives, in the automotive industry, aircraft industry, or the area of wind energy drives, for example.

This article addresses roughness measurement systems on tooth flanks. In addition to universal test equipment, modified test equipment based on the profile method for use on gears is addressed in particular. The equipment application here refers to cylindrical gear flanks and bevel gear flanks. The most important roughness parameters, as well as the implementation of the precise measurement procedure will also be described under consideration of the applicable DIN EN ISO standards as well as the current VDI/VDE Directive 2612 Sheet 5.

The purpose of roughness measurement on toothed gear flanks

Alongside the macro test parameters on tooth flanks for profile and flank lines, surface properties (roughness) play a decisive role in ensuring proper toothed gear function. Unlike general functional surfaces, the particular shape (curvature) and the slide-roll effect during meshing come into play with tooth flanks. Thus the surface roughness affects the following properties:

- Flank load capacity
- Tooth root load capacity
- Wear load capacity
- Load capacity involving heavy scoring
- Lubrication conditions
- Noise behavior
- Approach behavior

When determining the gearing quality according to DIN/AGMA/ISO standards via profile and tooth trace, an impression of the existing roughness is also obtained, but this is in no way comparable to roughness measurement performed according to the standard. The correlation is clear when the various probe elements for the measurement are taken into account, for example (Figure 1). A standard gear measurement is performed with a 1.5 mm probe (radius 750 μm); for a roughness measurement, however, a diamond tip with a radius of 2 μm or 5 μm is used. A roughness measurement therefore measures significantly finer structures on the surfaces. Along with the macro test parameters on tooth flanks according to the gear standards for cylindrical gears, surface properties (roughness) plays an important role in ensuring a proper toothed gear function.

Overview of roughness parameters

The general roughness parameters are defined in the DIN EN ISO 4287 standard. An application of this standard for tooth flank measurements is described in the current VDI/VDE 2612 Sheet 5. In a general roughness measurement, the unfiltered P profile [2] is obtained initially. Filtering then produces the long-wave deviation (W profile) or the short-wave deviation (R profile). The short-wave deviations form the basis for the general roughness parameters used (Figure 2).

During filtering of the recorded profiles, DIN ISO 16610-21 specifications apply, including measuring paths and cut-off wavelength (Figure 3).

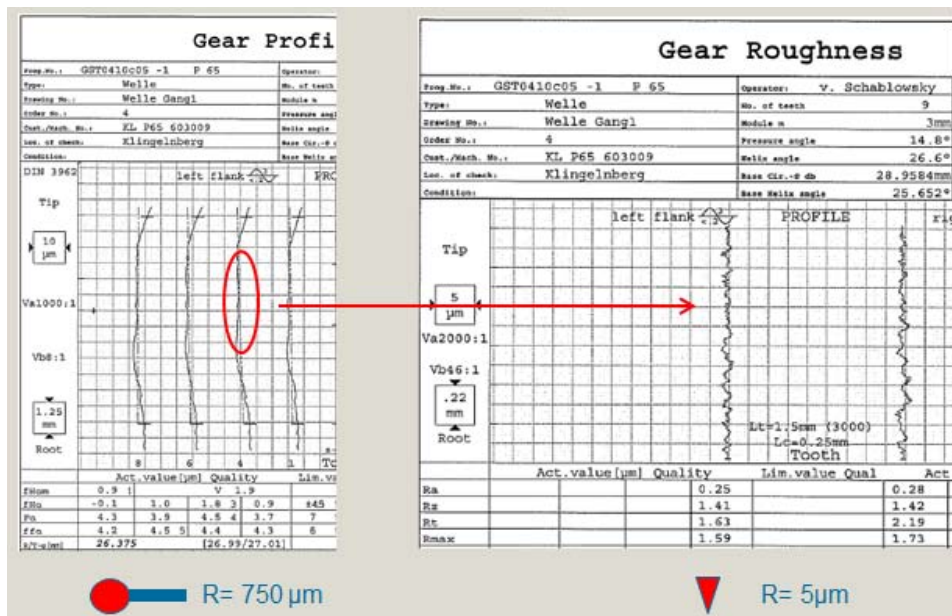
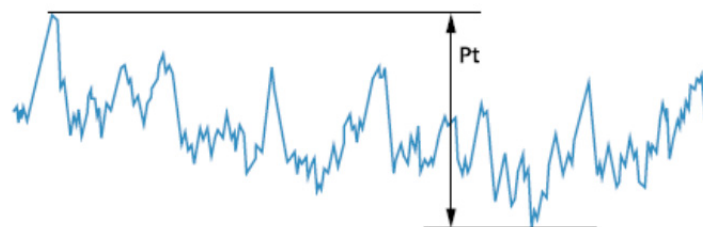
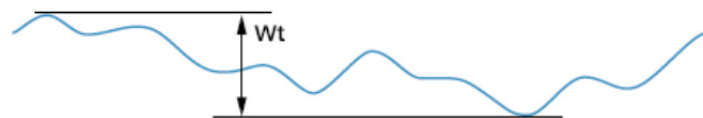


Figure 1. Comparison of measuring results

Unfiltered P-profile



Filtered W-profile



Filtered R-profile

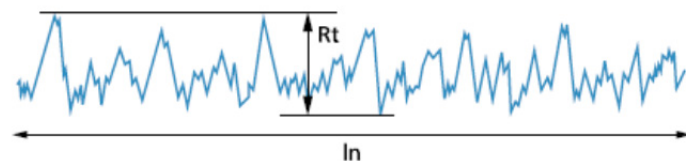


Figure 2. Division of a surface

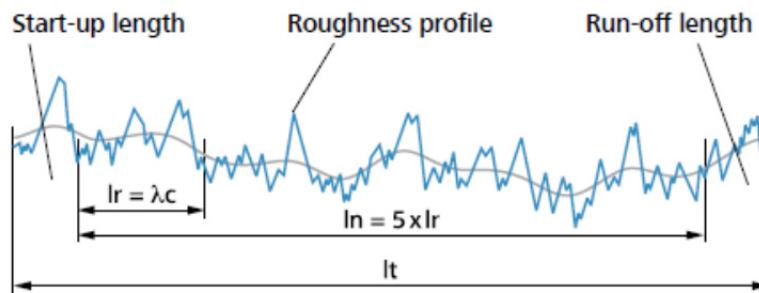


Figure 3. Evaluation lengths-cut off