V. Investigation of the Influence of Waviness on the Excitation Behavior of Gears in the Tooth Contact Analysis –

Christian Westphal M.Sc. (WZL)

The aim of the report is to investigate the effects of waviness on the acoustics behavior of gear pairs. In this paper, an analytical model is used to explain the effects in theory. Afterwards the FE-based tooth contact analysis software ZAKO3D is used to calculate the behavior in detail. Key takeaways are, that a difference between Cb and Cw does not immediately lead to a reduction of the amplitude of the waviness order. The effect depends on the wavelength and the tooth width. Also, it is shown, that there are cross influences between width crowning and waviness.

Investigation of the Influence of Waviness on the Excitation Behavior of Gears in the Tooth Contact Analysis

Speaker: Christian Westphal M.Sc.
Author: Marius Willecke M.Sc.

WZL of RWTH Aachen
Prof. Dr.-Ing. Christian Brecher
MTI of RWTH Aachen
Prof. Dr.-Ing. Thomas Bergs
Dr.-Ing. Mareike Davidovic

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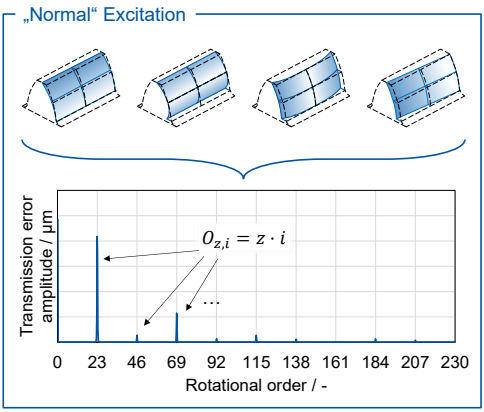
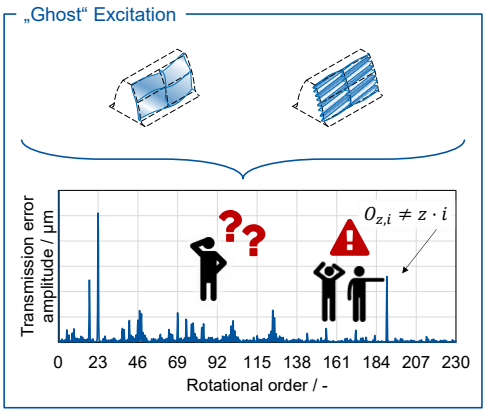
Agenda

Ghost Frequencies



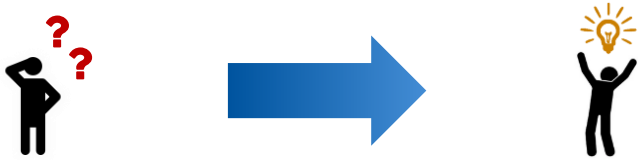


Agenda

Objective and Approach
Definition of Objective

Objective

Developing an understanding of the excitation behavior of waviness on tooth flanks



Objective and Approach
Questions to be Answered

Objective

Developing an understanding of the excitation behavior of waviness on tooth flanks

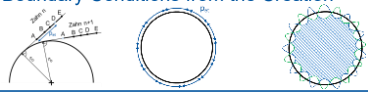
- What does a waviness look like and how can it be described?
- How does an excitation arise from a wavy tooth flank?
- What cross influence do other micro geometries and torque have on the excitation?

Objective and Approach
Questions to be Answered

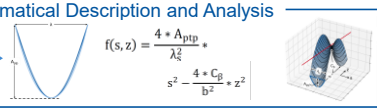
Objective

Developing an understanding of the excitation behavior of waviness on tooth flanks

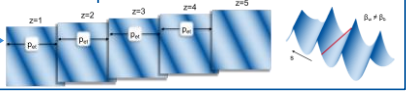
1 Finding Boundary Conditions from the Creation



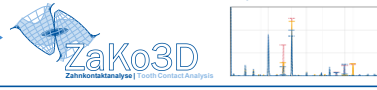
2 Mathematical Description and Analysis



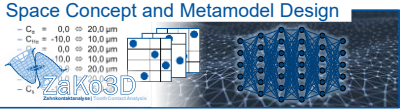
3 Analysis with Simplified Numerical Model



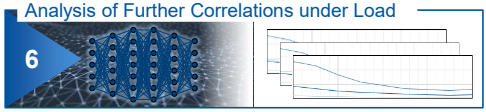
4 Verification with Tooth Contact Analysis under Load



5 Variant Space Concept and Metamodel Design



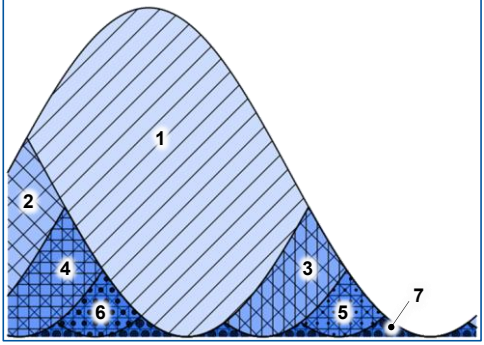
6 Analysis of Further Correlations under Load

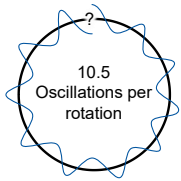


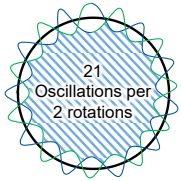
Agenda

Description of Waviness
Formation

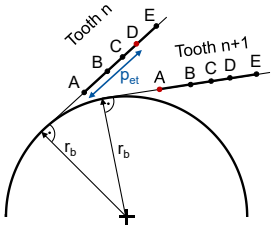
Material Removal over Several Workpiece Rotations

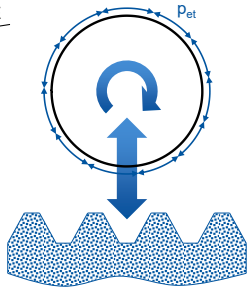


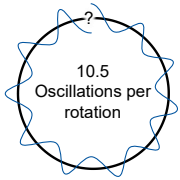


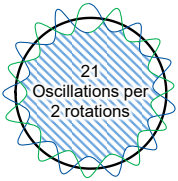


Description of Waviness
Formation



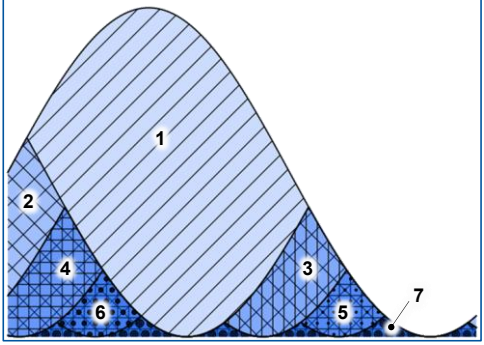




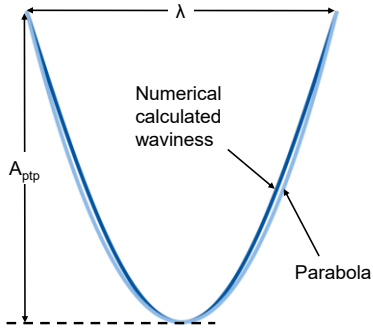


Description of Waviness
Formation

Material Removal over Several Workpiece Rotations

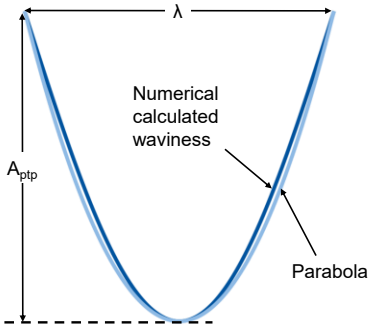


Approximation of the Waviness Form

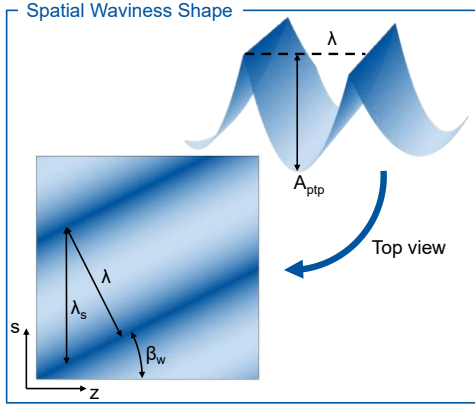


Description of Waviness
Parameterization

Approximation of the Waviness Form



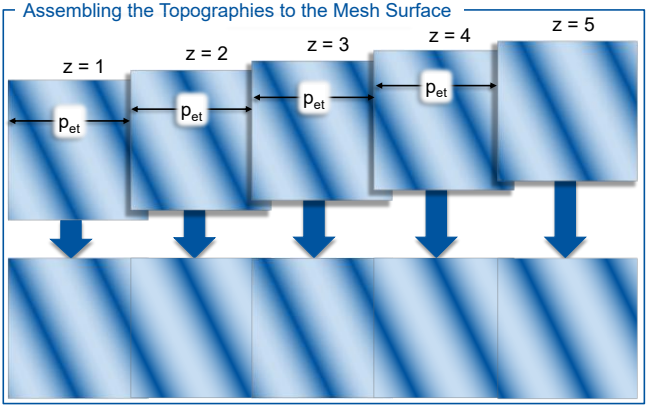
Spatial Waviness Shape



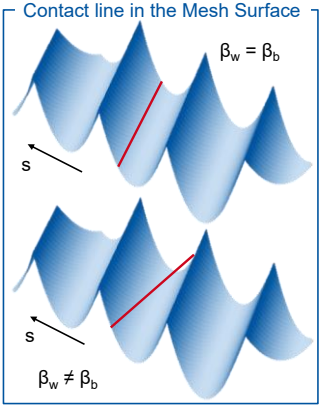
Agenda

Arising of Excitations from Waviness
Contact line in the Mesh Surface

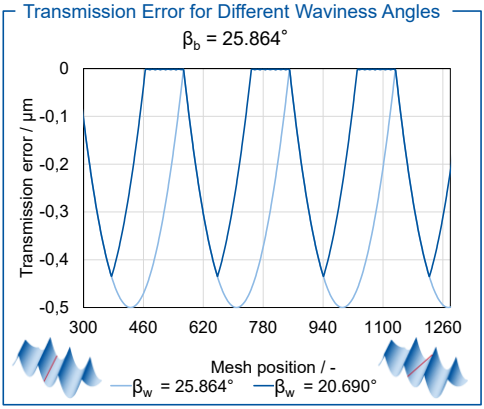
Assembling the Topographies to the Mesh Surface

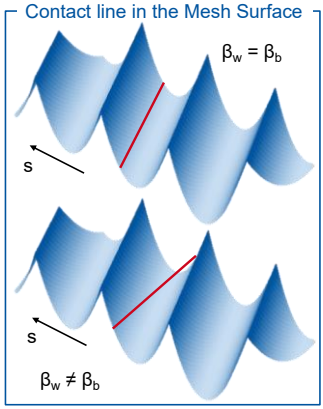


Contact line in the Mesh Surface

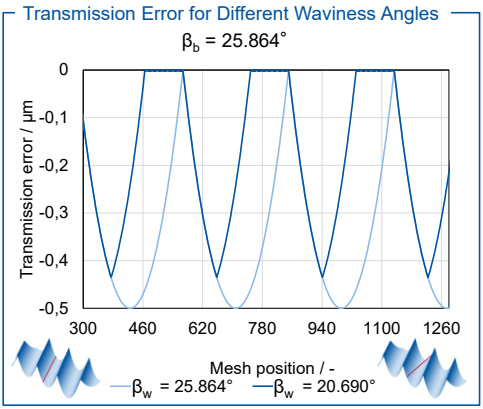


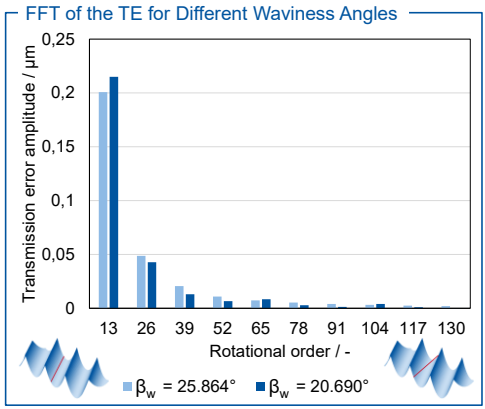
Arising of Excitations from Waviness
Influence of the Angle of the Waviness on the Transmission Error in the Time Domain





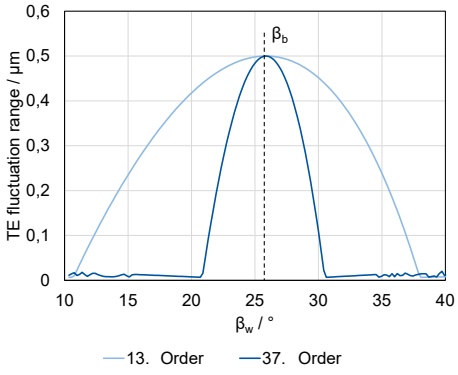
Arising of Excitations from Waviness
Influence of the Angle of the Waviness on the Transmission Error in the Frequency Range



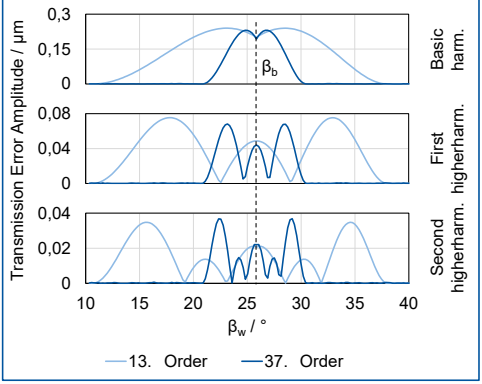


Arising of Excitations from Waviness
Wavelength Dependency of the Angular Influence of the Waviness on the Transmission Error

Fluctuation Range of the Transmission Error

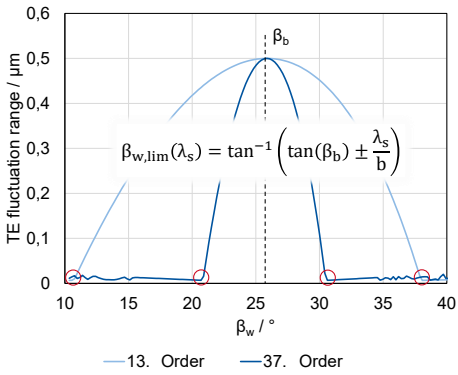


Harmonics of the Transmission Error

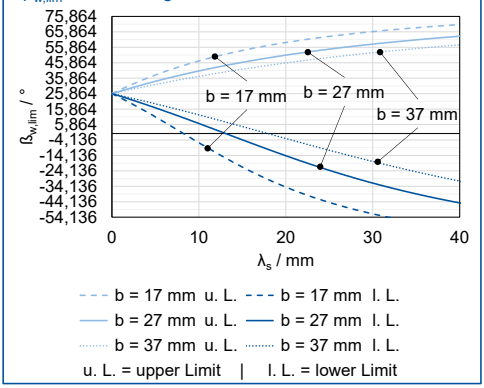


Arising of Excitations from Waviness
Calculation of the Limiting Wavelength / Influence of the Tooth Width

Fluctuation Range of the Transmission Error



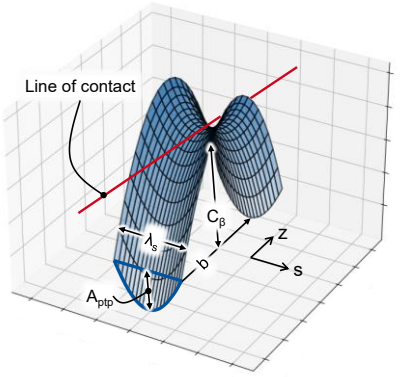
βw,lim of Wavelength and Gear Width



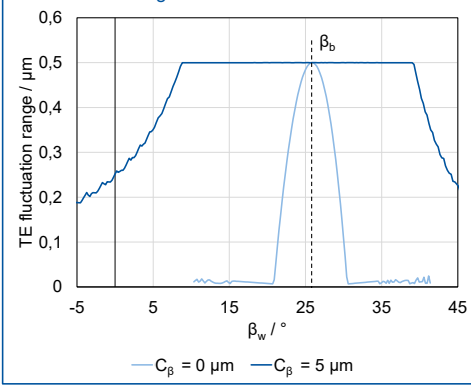
Agenda

Influence of Micro Geometries and Load
Influence of Width Crowning Load-Free

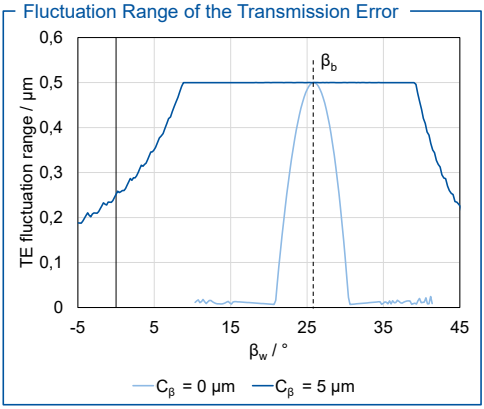
Double Parabola: Waviness + Crowning

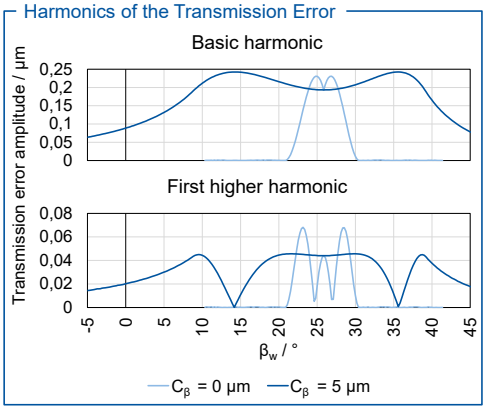


Fluctuation Range of the Transmission Error

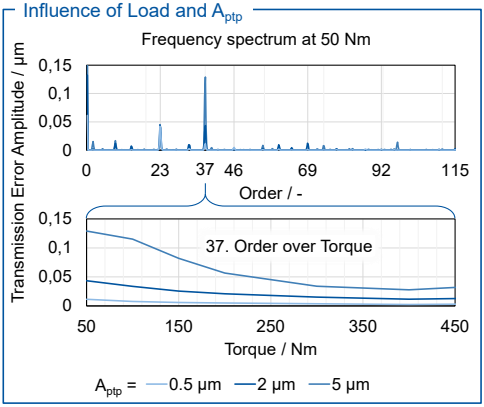


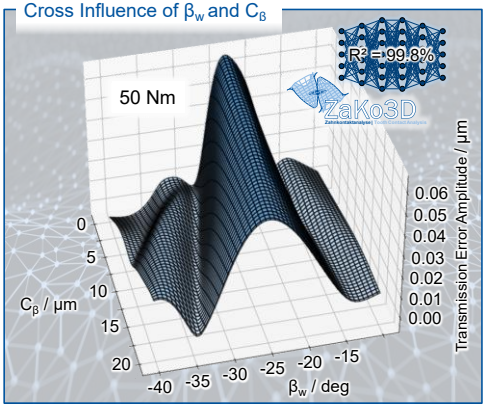
Influence of Micro Geometries and Load
Influence of Width Crowning Load-Free in the Frequency Domain





Influence of Micro Geometries and Load
Behavior of the Waviness Amplitude under Load



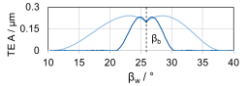


Agenda

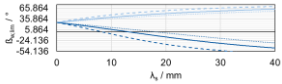
Summary and Outlook

Summary

- A difference between β_b and β_w doesn't immediately lead to a reduction of the amplitude of the waviness order



- The effect depends on the wavelength and the tooth width



- There are cross influences between width crowning and waviness

Outlook

- Investigation of the cross influences of other micro geometries with waviness under load