„Optical Inspection of Cutting Tools by means of 2D- and 3D-Image Processing“

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Structure

1. Introduction

2. 2D- and 3D-Optical Inspection of Wear Features of Cutting Tools

3. 3D-Optical Inspection of Surface Features of Grinding Tools

4. Summary
Introduction – Hard-whirling process

Hard-whirling process is used for the production of threads and thread-like profiles

Whirling Tool

Cutting insert

Ball screw
Initial situation  
(comparing new/ wearied cutting insert)

New cutting insert  
Wearied cutting insert

(Source: GFE)  
(Source: GFE)
Tasks

Determination of

- Profile wear
- Face wear
- Depth of wear on cutting edge
- Difference between CAD-data and real tool data
- Calculation of regrinding-parameters for a grinding process

(All Sources: GFE)
Solution

Face wear

Profile wear

(All Sources: GFE)
Developed illumination unit with two light sources
(integrate in a coordinate measuring device)

PC-controlled incident light sources
(Source: MahrOKM)
Stitching of single images

Composed image by 5 single images

Single image

(All sources: GFE)
Process of image acquisition
Technical implementation

Steps of wear calculation

Detailed screen

Calculation of wear

Stitched image

(All sources: GFE)
Determination of depth of wear

(All sources: Mahr OKM)
Determination of depth of wear

(Source: Mahr OKM)
Achieved Results

Measuring station
- Accuracy for profile measurement: +/- 1 µm
- Accuracy for wear measurement: +/- 2 µm
- Accuracy for measurement of depth of wear: +/- 1 µm

Profiling process
- Achieved tolerance of profile quality is +/- 2 µm
- Regrinding of tips can be reduced from 0.5 mm to 0.2 mm

Whirling process
- Increasing of life time of ball screws from 40 km to 320 km
Characterisation of metal bonded grinding tools

(Source: GFE)
Initial situation

Determination of *average grain protrusion* and *average deviation of grain peaks*

**Main size and parameters:**
- Grain size: D46 to D501
- Grain shape: 0,5 to 1,0
- Surface curvature: 0,45 mm up to infinite

**Regarding the following influencing variables:**
- Grain size scatter
- Grain distribution
- Grain reflection
- Grain type
- Type of nickel bond (weak or bright)
Definition: average grain protrusion $K_B$

$$K_B = \frac{1}{N} \sum_{n=1}^{N} Z_{Bn}$$

(Source: GFE)
Definition: average deviation of grain peaks $K_S$

$$K_S = \frac{1}{N} \sum_{n=1}^{N} Z_{Sn}$$

(Source: GFE)
Surfaces of grinding tools

Scanning Electron Microscope Images (grain size D 357)

Synthetic diamonds

Natural diamonds

(All sources: GFE)
Specific of galvanic bonded grinding tools

- Single layer of diamonds on metal body
- Grain protrusion 30 ... 60 % of diameter, depending on thickness of galvanic bond
- Large chip rooms caused by grain protrusion
- High flexibility concerning tool geometry
- No dressing of tools necessary
Optical measurement methods

- White Light Interferometry
  using short coherence of white light

- Confocal microscope
  using small depth of focus
Michelson-Interferometer

(Source: Eric W. Weisstein)
White Light Interferometry (correlogram)

Alteration of pixel fixed light intensity caused by interferences by vertical adjustment

(Source: GFE)
Results by using White Light Interferometry

Galvanic bonded tool (3D-diagram)
Confocal measuring principle

Grabbing of Equidistant Layer Images

Calculation of Contrast Every Pixel for Evaluation Local Sharpness

Calculating the Maximum of the Focal Function Determination Surface Points

3D-point cloud (discrete 3D-description of surface)
Example of a focal series of images

(Permission: GFE)
**Determination of intensity of a single point on a surface**

![Graph showing intensity vs. z in µm](image)

Intensitätsverlauf

Maximale Schärfe des Pixels

Intensität

z in µm

(Source: GFE)
3D-Presentation of a grinding tool surface

Developed 3D-Viewer

(Source: GFE)
Results by using the confocal measuring principle

Integration of a false colour rendering 3D-data and showing a histogram of measured average grain protrusion on a desktop

Ergebnisse der letzten Messung:

- Mittlerer Korrespondenzüberstand: 94 μm
- Kornspitzenverteilung: ±2 μm
- Anzahl der erkannten Körner: 116

(All sources: GFE)
Technical data of the developed microscope

- Grain size: 46µm → 501µm
- Min. curvature radius: D 46 - 91 : 1,4mm
  D126 - D301 : 2,8mm
  D356 - D501 : 5,6mm
- Samples with good structured and bright underground testable
- Measuring time: ca. 15 s/ field of view
- Measuring accuracy: ± 2 µm (field of view 740x740µm²)
Summary

Wear measurement on cutting tools

- 2D-Determination of profile and face wear in transmitted and incident light
- 3D-Determination of depth of face wear in incident light

3D-Characterisation of grinding tools

- both White Light Interferometry and Confocal Microscopy may be used for the measurement
Thank you for your attention...

Historical City Center Schmalkalden

Castle Wilhelmsburg / Schmalkalden

Further information: www.gfe-net.de