technische universität
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Dept. of Statistics

# Project 2
# BTA Deep Hole Drilling

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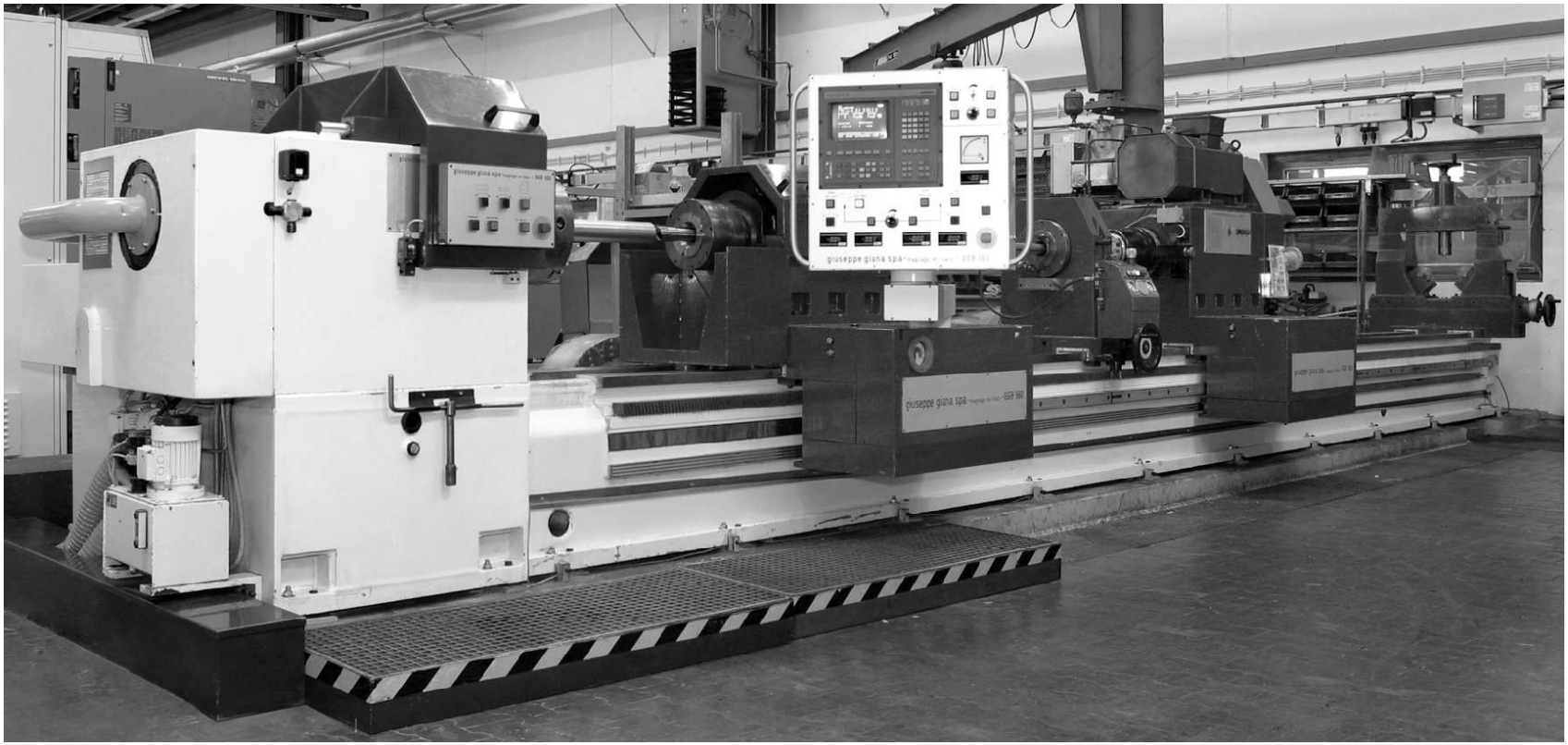
# BTA Deep Hole Drilling Process

- BTA: Boring and Trepanning Association
- drilling deep slim holes up to depth-to-diameter ratios of 400:1
- produces extremely precise and smooth holes, e.g., axial bores in turbines or compressor shafts
- drilling head mounted on a long drill bar: risk of dynamic process disturbances such as ‘chattering’ and ‘spiralling’.

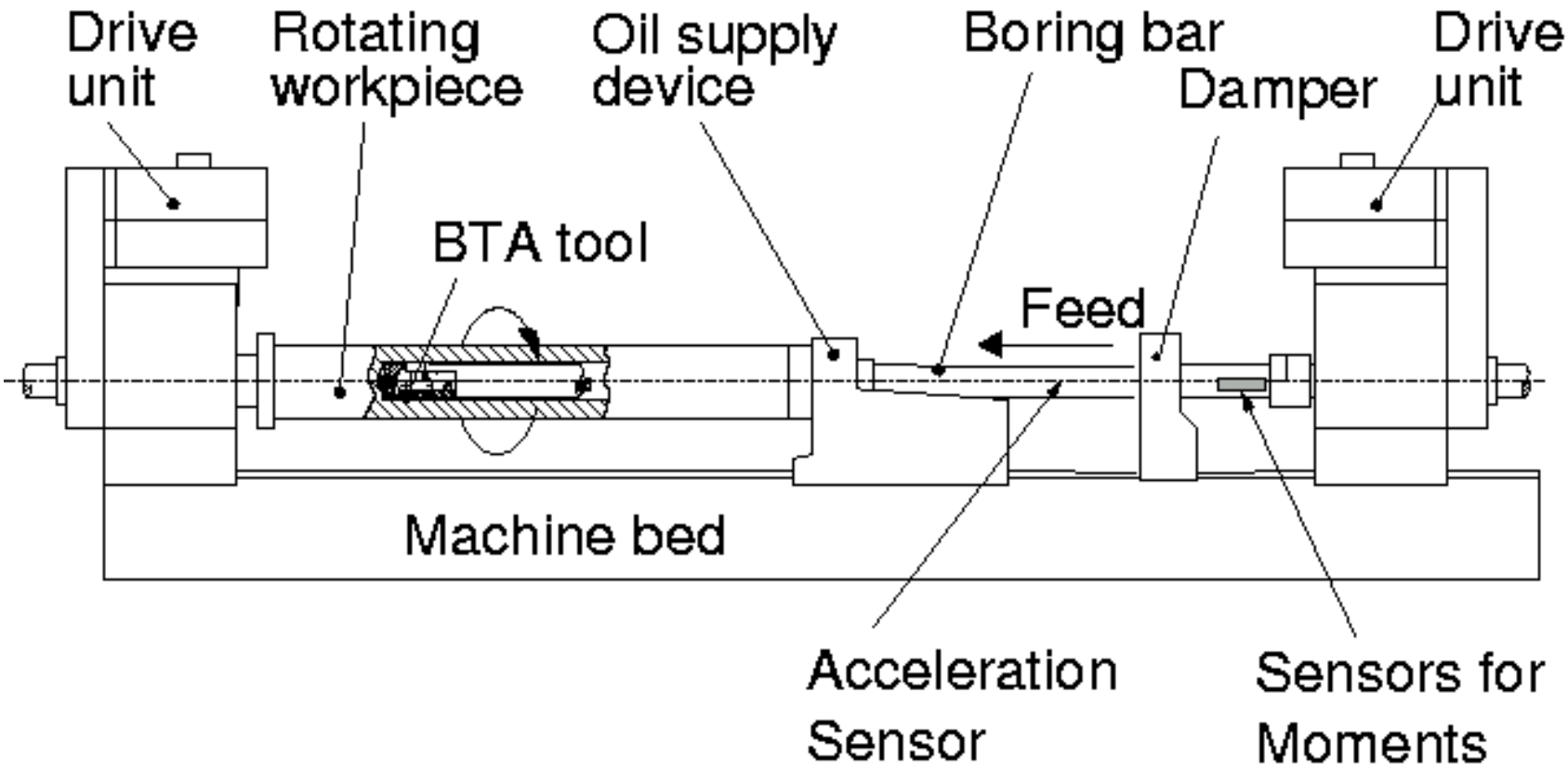
# References

- Parts of this introduction are taken from:
  Oliver Webber (2006): *Untersuchungen zur bohrtiefenabhängigen Prozessdynamik beim BTA-Tiefbohren*, Dissertation, FB Maschinenbau, Universität Dortmund
- Data from project C5, *Analyse und Modellbildung des Tiefbohrprozesses mit Methoden der Statistik und Neuronalen Netzen*, SFB 475 (Komplexitätsreduktion in Multivariaten Datenstrukturen), measured by the Institut für Spanende Fertigung, FB Maschinenbau, UniDo.

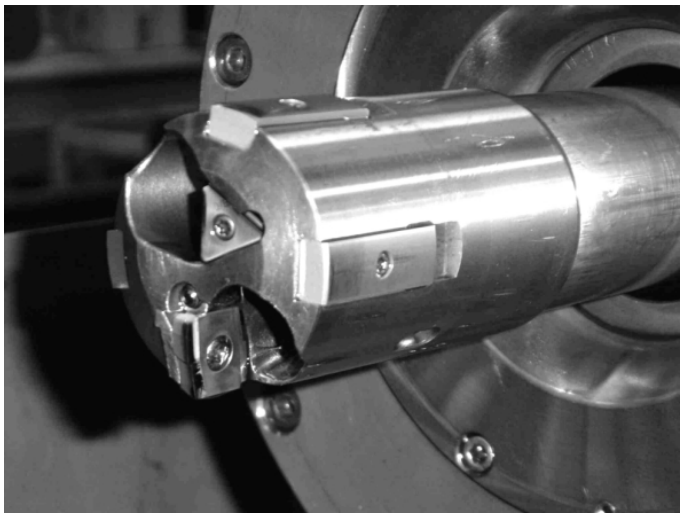
# BTA Deep Hole Drilling Machine I



# BTA Deep Hole Drilling Machine II

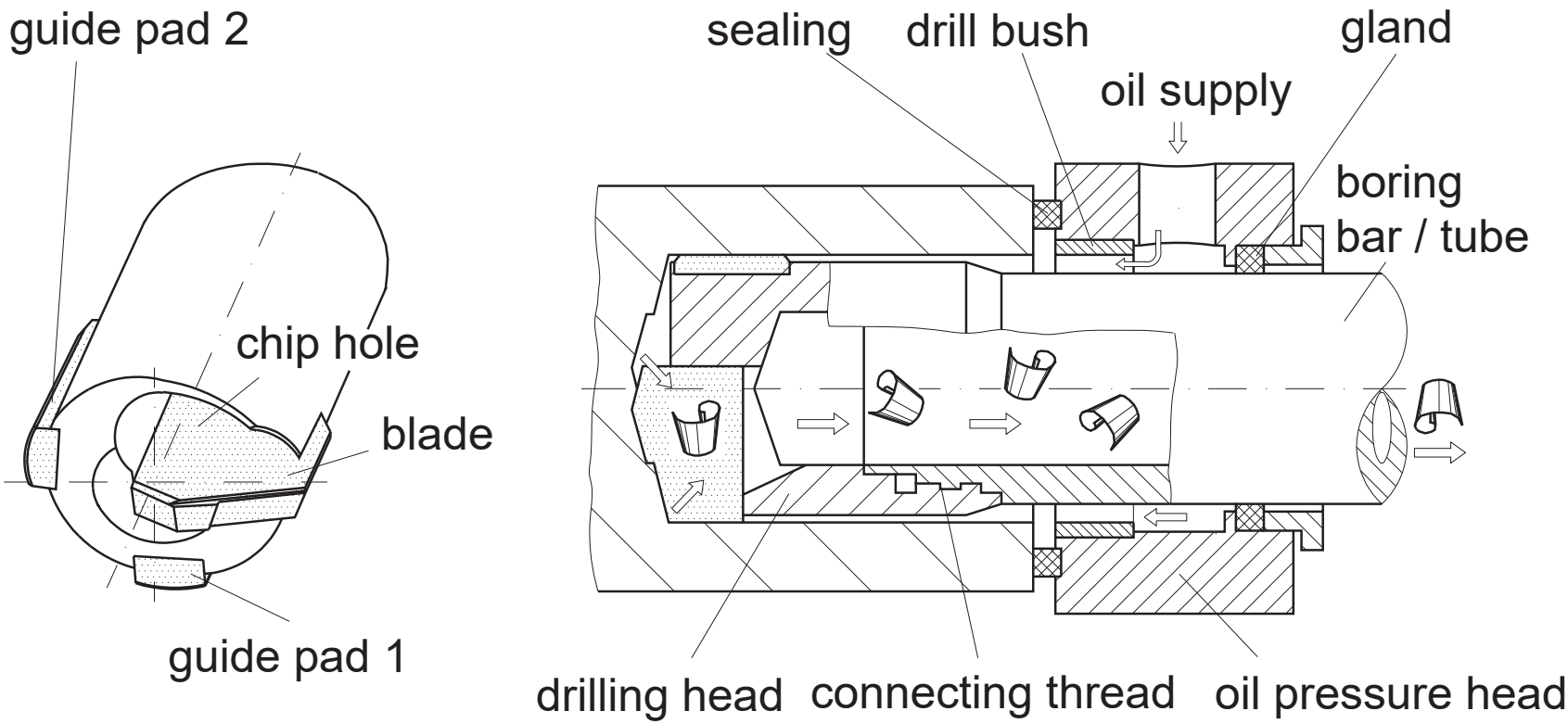


# BTA Deep Hole Drilling Machine III



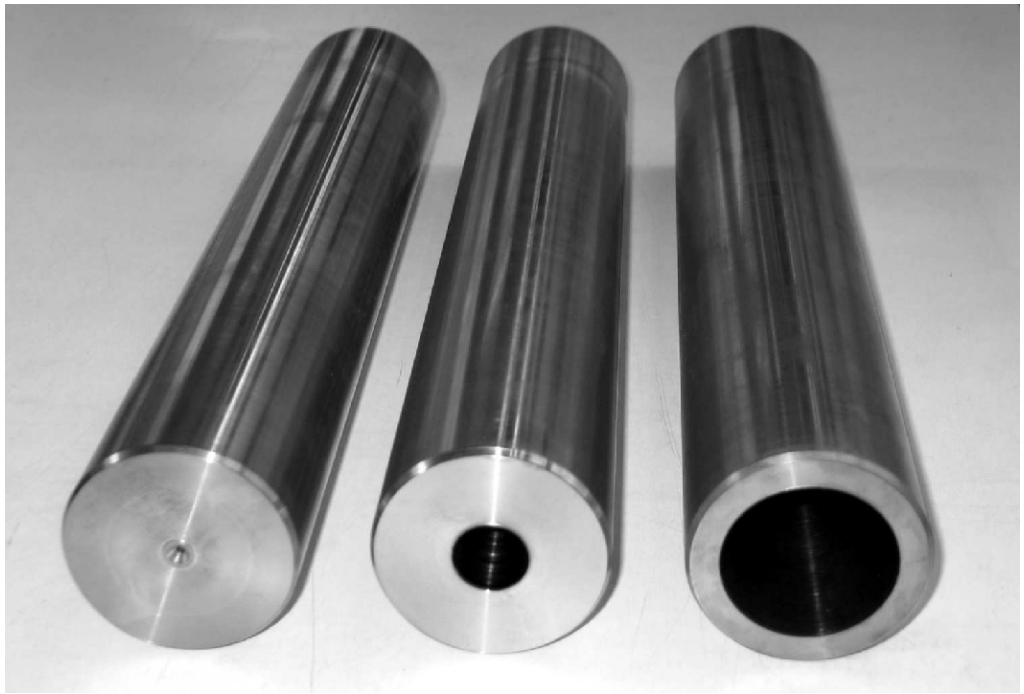

Drilling heads

# BTA Deep Hole Drilling Machine IV




Drilling head

# BTA Deep Hole Drilling Machine V



Workpiece (before / after)

# Problems

Typical problems are:

- **Chatter:** Self-excited rotational vibrations that lead to an increased tool-wear, loud noise, and reduced quality of the workpiece
- **Spiralling:** Spiralling is governed by bending vibrations and causes holes with several lobes that are a severe impairment of the bore hole.

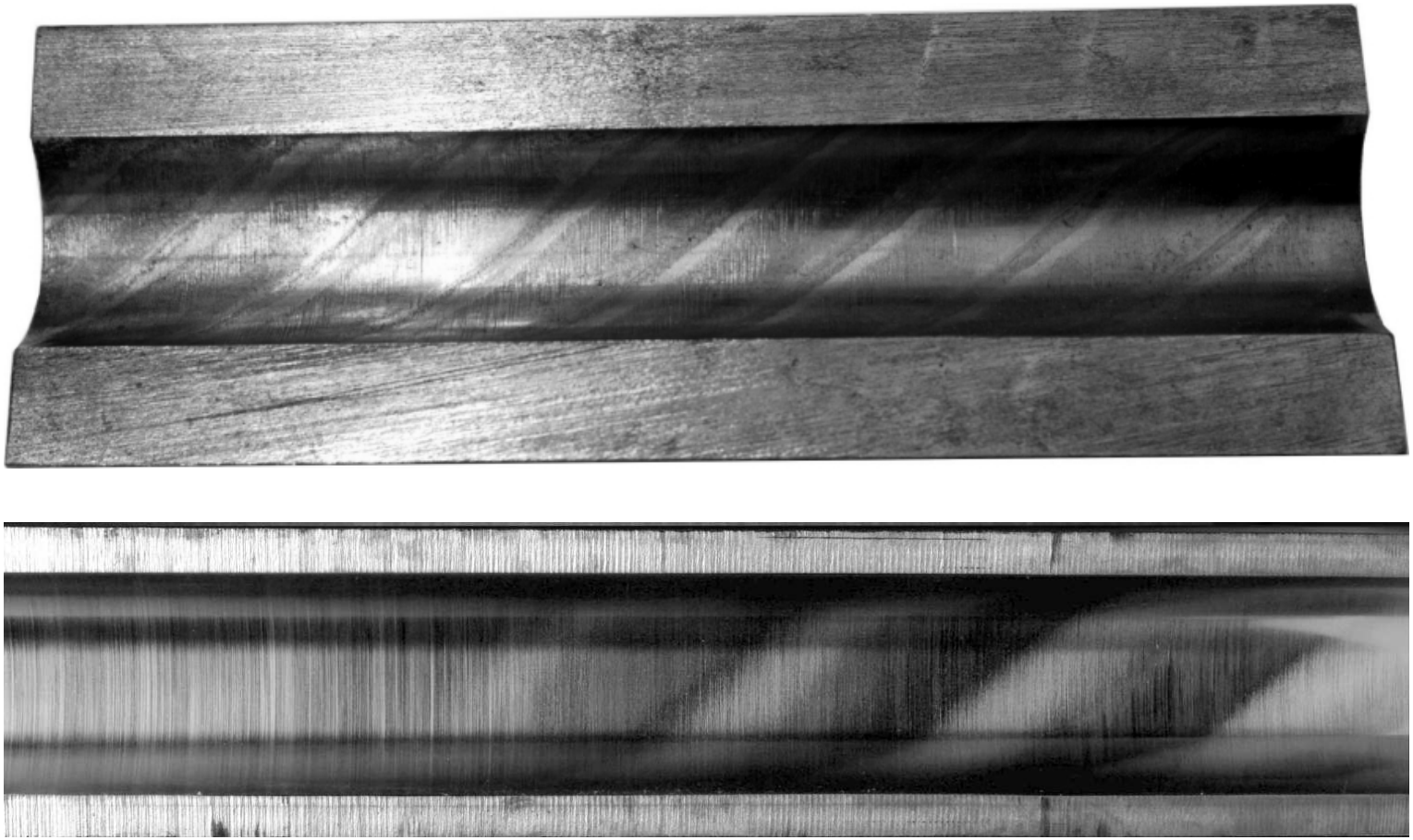
# Some Former Ideas

(translated from: *Oliver Webber (2006): Untersuchungen zur bohrtiefenabhängigen Prozessdynamik beim BTA-Tiefbohren, Dissertation, FB Maschinenbau, Universität Dortmund*)

Concerning chatter we know that during the drilling process undisturbed process phases and disturbed process phases are alternating. The disturbed phases show self excited torsional frequencies close to natural torsional frequencies. Chattering depends on the frequencies and typically starts at specific drilling depths.

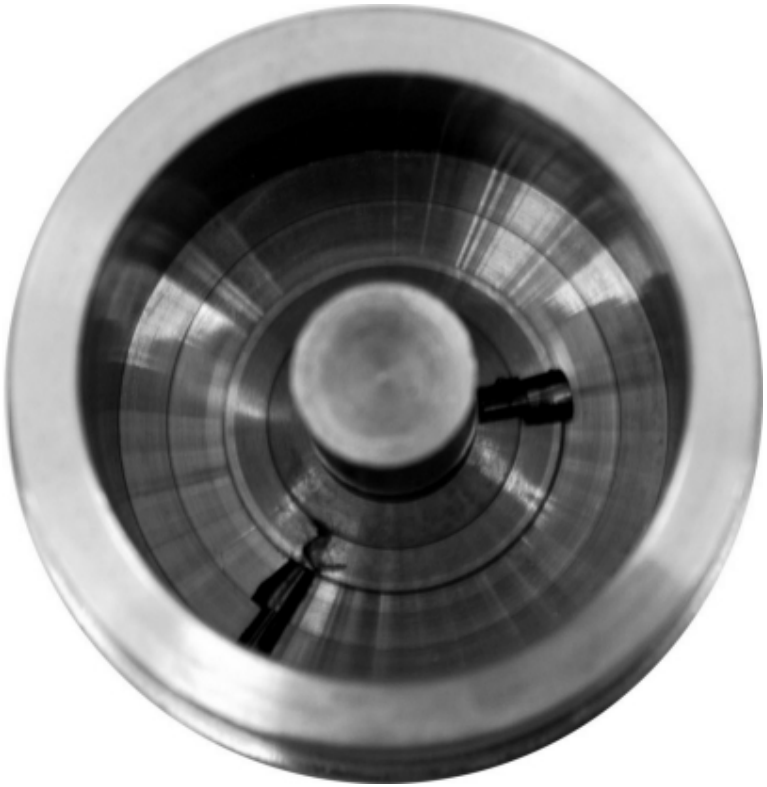
Spiralling is more probable if a multiple of the rotation frequency is identical with the natural bending frequency (Biegeeigenfrequenz) of the drilling tool. These natural frequencies cannot [easily] be forecasted in practice.

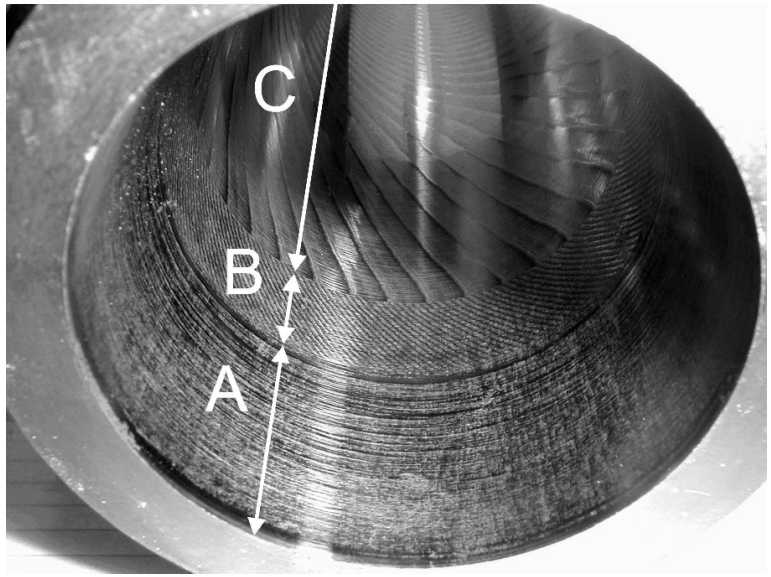
# Problems with the Workpiece I



View inside workpieces

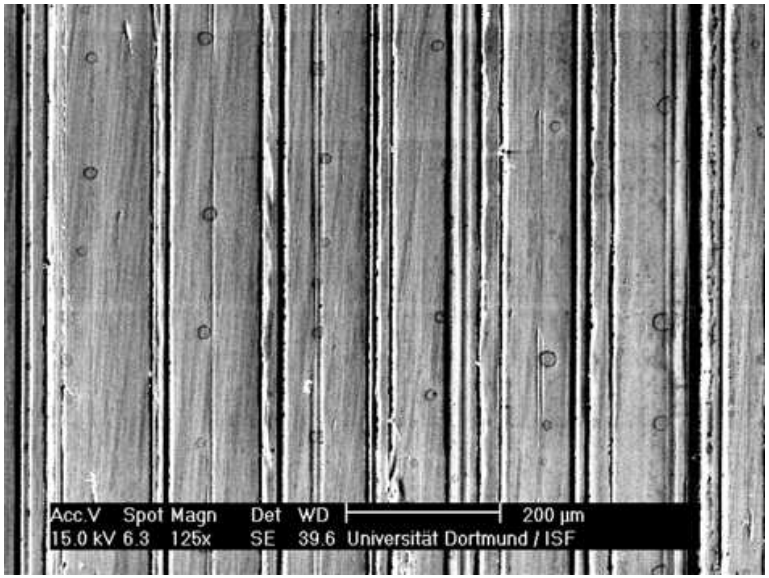
# Problems with the Workpiece II

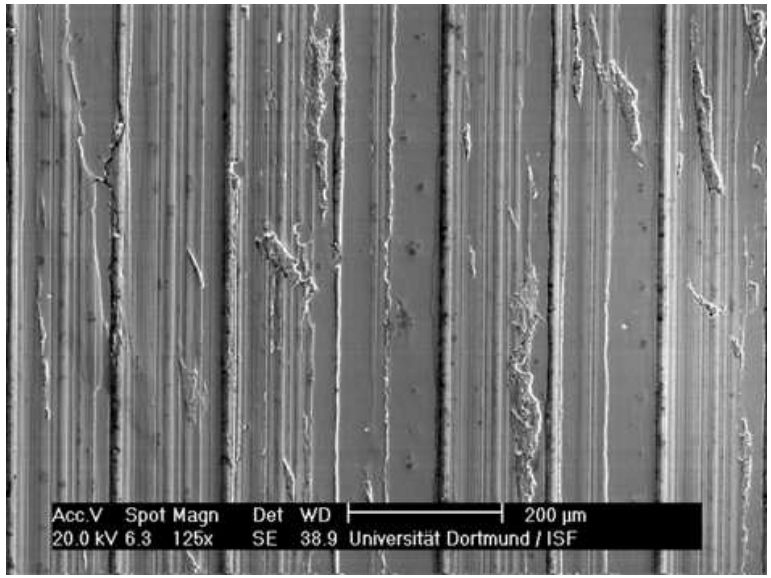





View inside workpieces

# Problems with the Workpiece III




Views produced by a microscope

# Aims

- **Produce high quality workpieces**
  - Concentricity: deviation from the form of a circle
  - Roughness: roughness of the surface
- high speed
- low costs (toolwear vs. time)

- possible steps:
  - dependency between sensors, select suitable sensors
  - give early alarm before chatter/spiralling starts
  - automatical process control in case of an alarm?
  - predict suitable process parameters for a non disturbed process without need for automatical process control?
  - drilling depth dependent process control
  - ...

# Parameters of the Machine

- cutting speed workpiece (in m/min)
- cutting speed drilling bar (in m/min; here: fixed, 0 m/min)
- feed speed (in mm/sec)
- oil pressure (in bar) or oil flow rate (in l/min)
- position of damper before clamping (in mm; here: no damper installed)

# Data I

To learn about the data and generate first ideas, the engineer shows us example observations:

- V2_00001
- V2_00001-1 (only the first sensor measured from V2_00001)
- V10_0001

# Data II

These data contain several series of measurements:

- Torque (Moment): drilling torque (Bohrmoment) or torsional moment, in Nm
  - at the drilling bar above the bore hole of the drilling tool
  - excited by forces of chipping (Zerspanung),
  - and also by friction (Reibung) and deformation at the guide rails (Führungsleisten).
- Force: Force in feed direction, in N
- SyncSig: ???, in V

# Data III

- akustik: Sound/noise of the machine, in Pa
- WSAS: Acceleration of the drilling head in lateral direction, in $m/s^2$
- WSAF: Acceleration of the drilling head in frontal direction, in $m/s^2$
- BOZA: Acceleration of the drilling oil supply apparatus, in $m/s^2$

Some measurements may be added or removed in later experiments.