Together We Move The World

Monitoring of Spindle Bearings During Operation

Lecturer: Ehad Arifi, Schaeffler Technologies GmbH & Co. KG

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- ✓ Spindle bearing monitoring during operation
  - ✓ Targets and approaches
- ✓ Effects of bearing damages
- ✓ Possible monitoring parameters
  - ✓ Temperature, Vibration
- ✓ Vibration monitoring strategies
  - ✓ Basic principle of vibration monitoring
- ✓ Practical examples
  - ✓ Offline and Online vibration monitoring
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Condition Monitoring a tool of Condition Based Maintenance

Maintenance strategies:

- ✓ **Running until failure**
  - ✓ **Advantage:** Effort only in case of failure
  - ✓ **Disadvantage:** No maintenance planning possible
- ✓ **Planned maintenance / Preventive maintenance**
  - ✓ **Advantage:** Failures can be avoided
  - ✓ **Disadvantage:** In certain cases unnecessary effort
- ✓ **Condition based maintenance**
  - ✓ **Advangtage:** Optimum performance of components
  - ✓ **Disadvantage:** Information about components necessary

Condition Monitoring a tool of Condition Based Maintenance

Targets and approaches from point of view….

Maintenance:

- Avoid unplanned shut downs
- Ensure and increase machine availability
- Information about machine components
  - Support for maintenance schedule and maintenance capacity
  - Maintenance without disturbing normal machine operation
  - Reduce of maintenance costs
  - Reduce stock of components
- Online monitoring of beginning damages of components

Production:

- Avoid disruption of production
- Increase productivity
- Reduce production costs
- Ensure product quality

Condition Monitoring

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Cause of spindle bearing failure

- Operating life time is limited in most cases due to wear
  - Sealing: Ingress of foreign particles
  - Lubrication: contaminents
- Indentation in raceways
  - Plastic deformation as result of static overload
    e.g. crash
  - foreign particle cycling
- Material fatigue
  - pitting
  - crack

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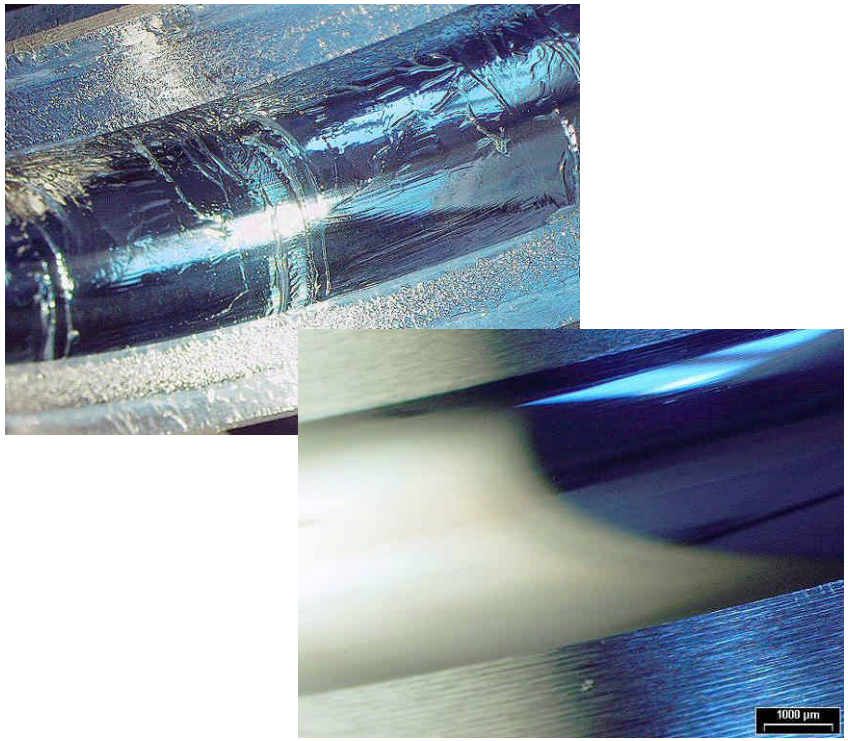
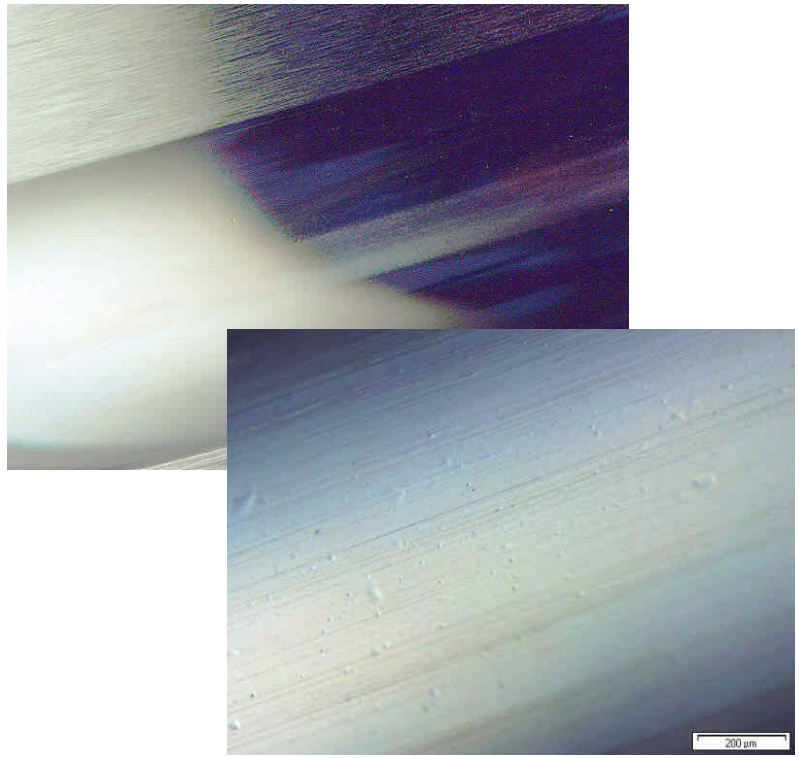
Normal raceway





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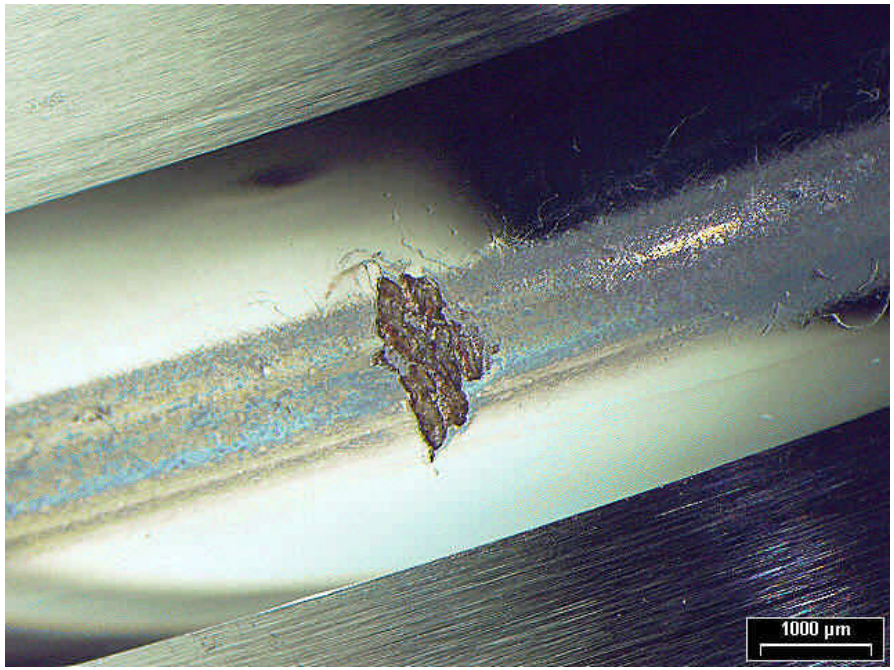
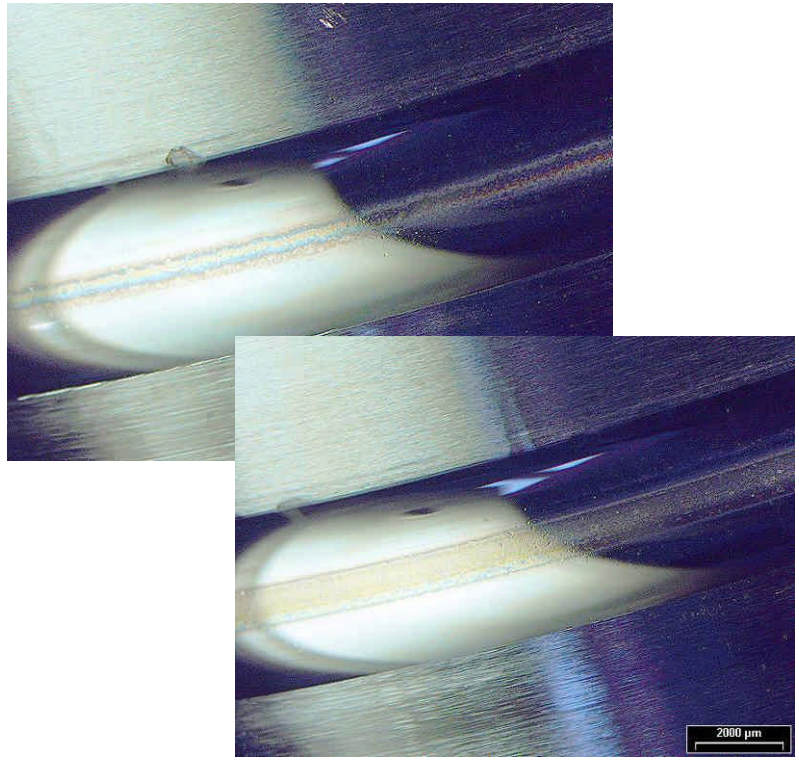
Fatigue, pitting





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Indication of bearing damage

- Reduction of workpiece quality
- Temperature profile
- Noise, Vibration
  - Due to fatigue and raceway damages

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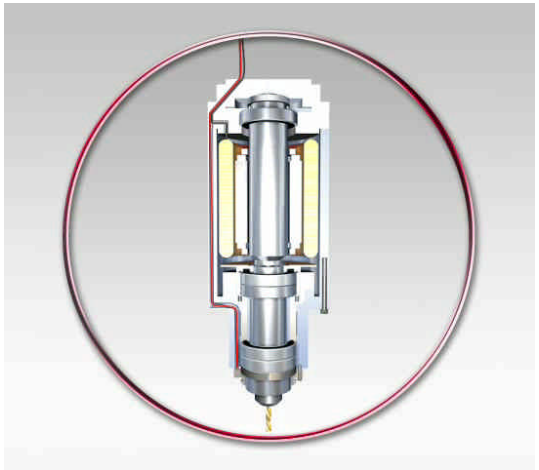
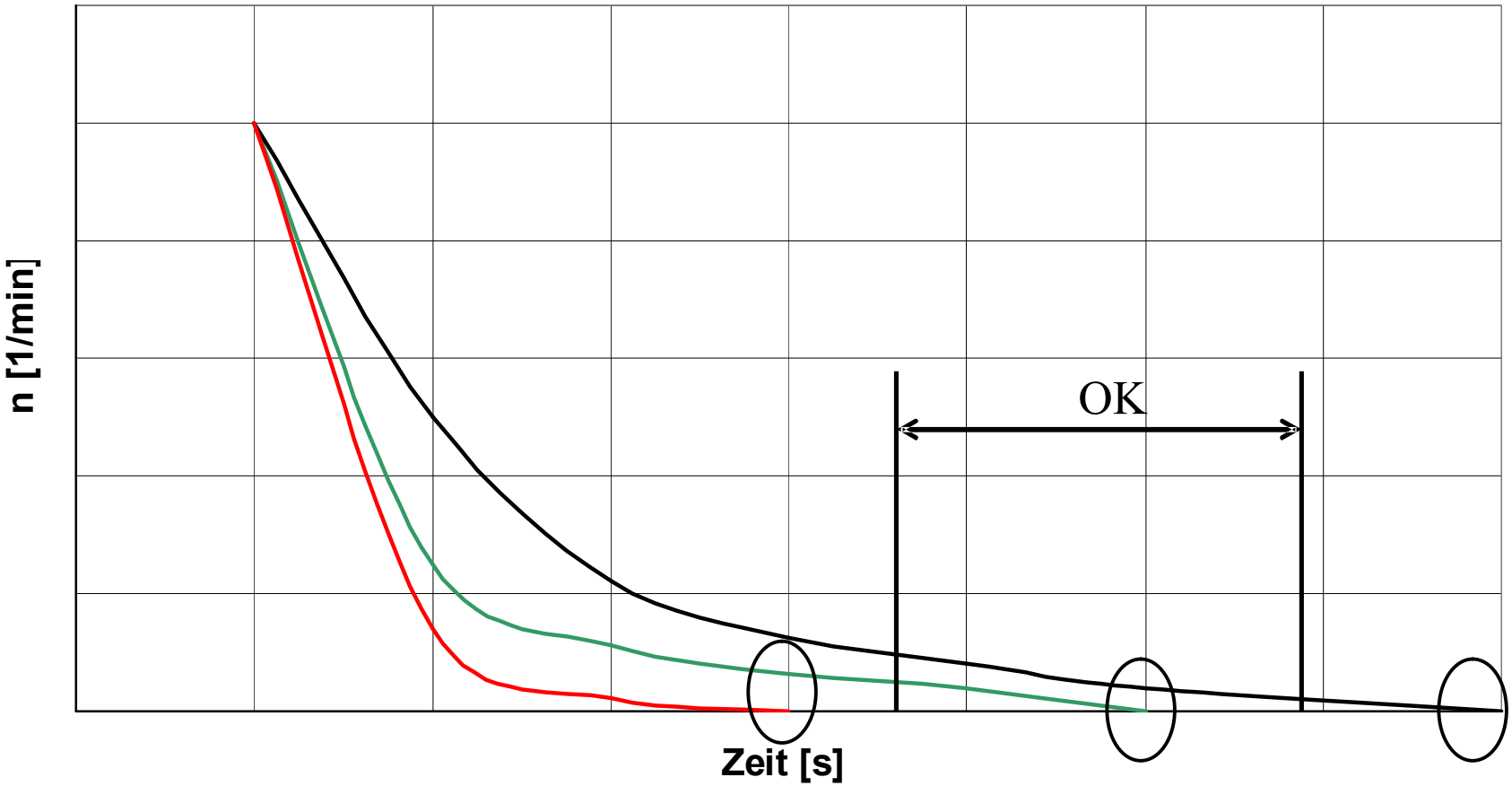
Possible monitoring parameters



- Friction Torque
- Bearing temperature monitoring
  - Change of preload and malfunction of floating bearing generates typical temperature profiles
- Vibration monitoring / noise
  - Continuous monitoring
  - Periodic monitoring
  - Characteristic value monitoring
  - Frequency analysis

Bearing Friction Torque (coast down)



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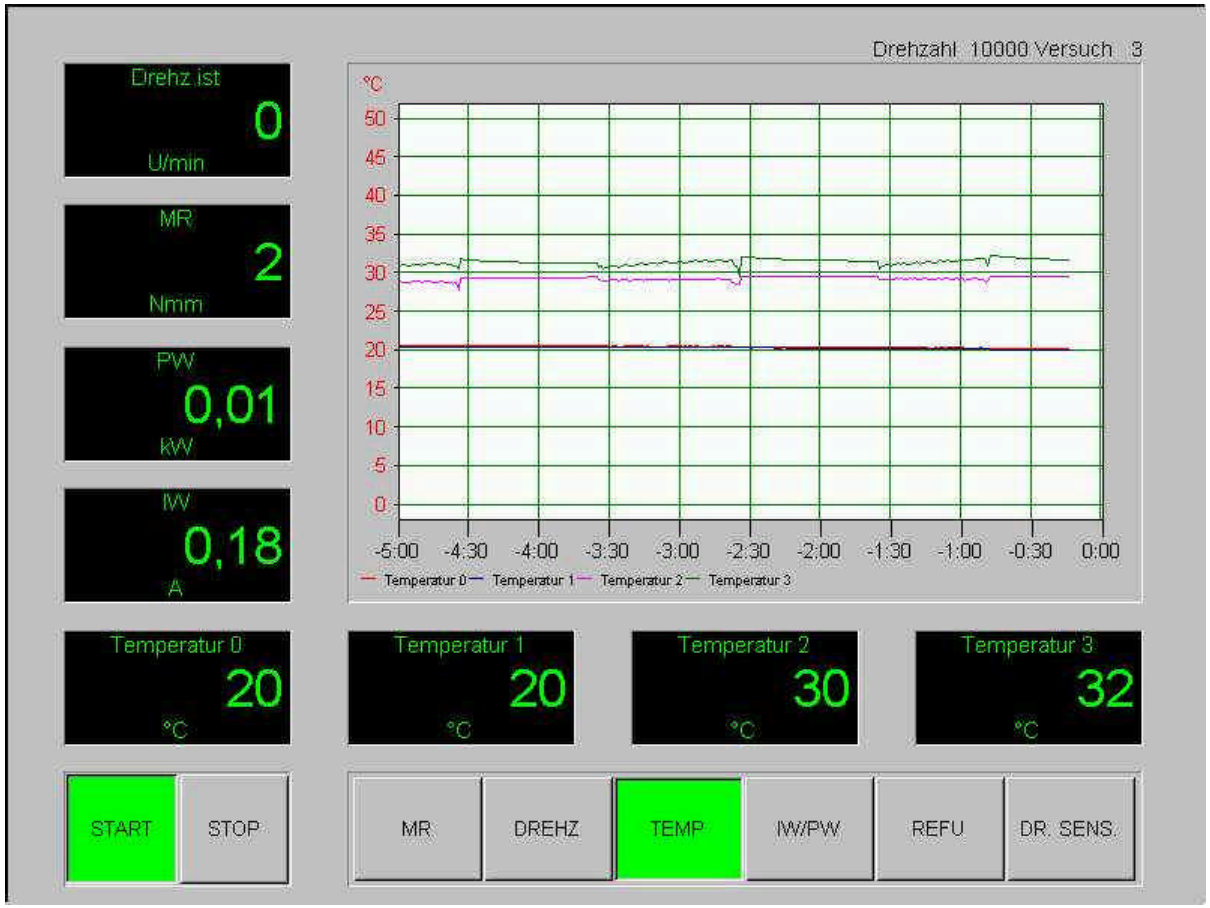
Temperature Monitoring



- **Reference Temperature**
- **Contact to the measuring Object**
- **Temperature Developing**

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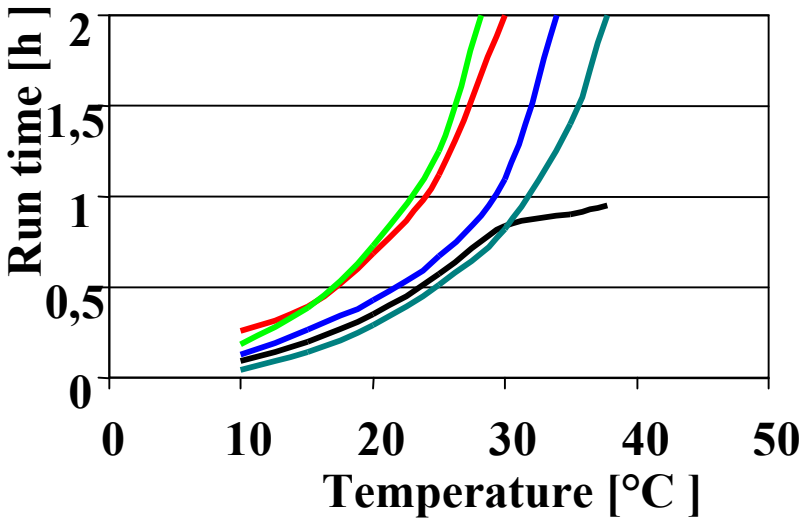
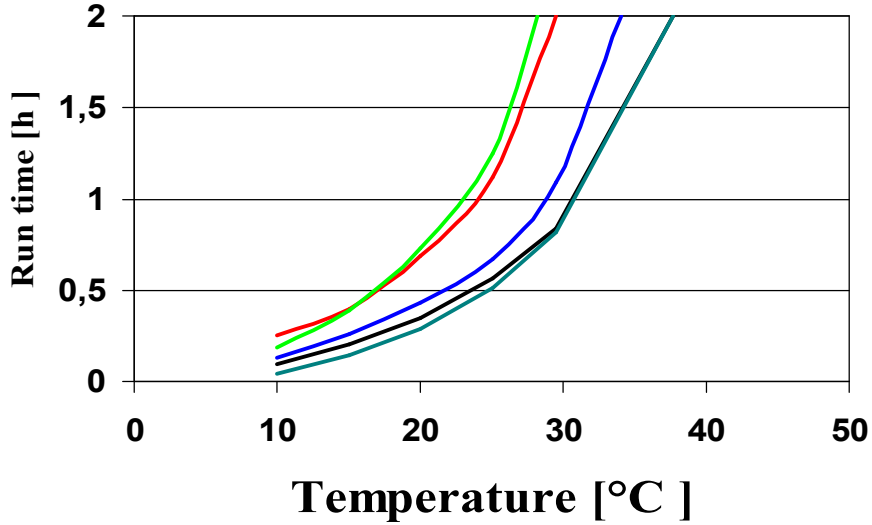
Temperature Monitoring





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Targets - Vibration monitoring strategies

	One-Time	Periodical	Continuous
Quality Assurance	X		X
Storing of Operating Conditions			X
Damage Limitation		X	X
Condition based maintanance		X	X

Bearing arrangement of machine tool

Spindle bearing arrangement in machine tool

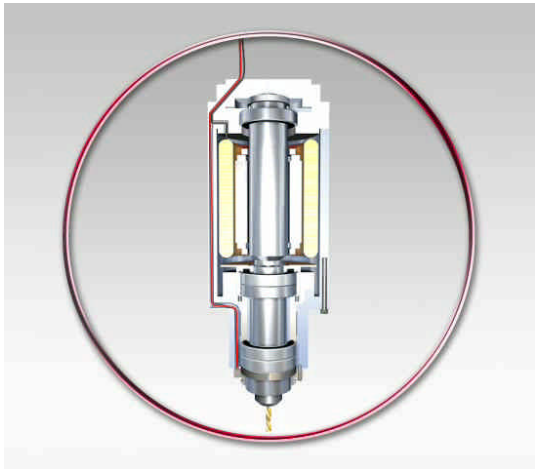
- Lathe machine
- Milling machine
- Drilling machine
- Grinding machine

Characteristic of spindle arrangement

- High running accuracy
- High stiffness
- Low running noise
  - at high turning speed

➔ **Consequential:**
Definition of monitoring parameters and strategies

Source of noise in bearings



- Elastic deformation
- Friction, lubrication noise
- Surface effects
  (change of contact surface, local damage, wear)
  - Surface of rolling element
  - Outer and Inner ring raceway

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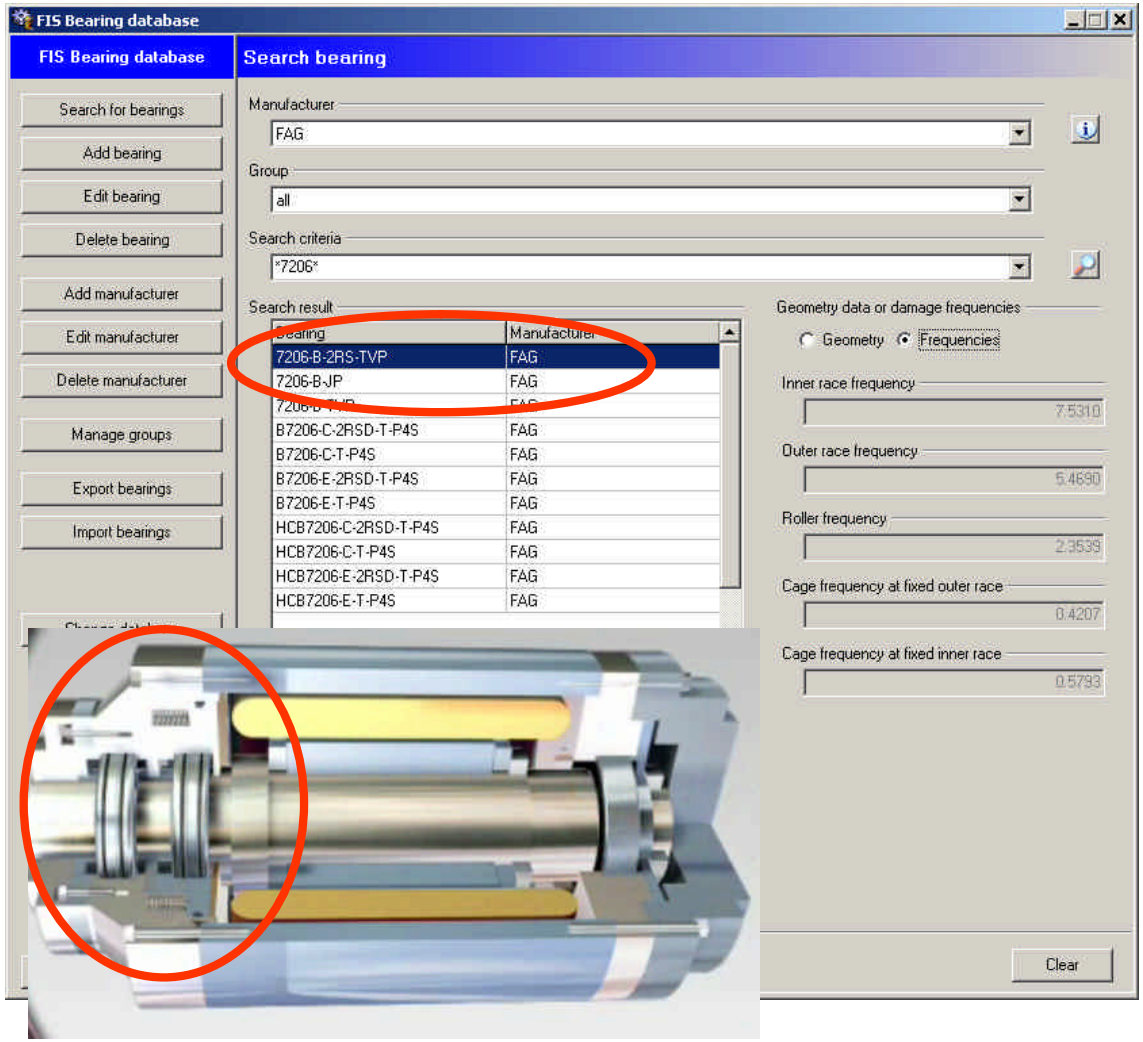
Cycling of surface effects

- *Damage on outer ring*
- *Damage on inner ring*
- *Damage on rolling element*

- **Cycling of damages on surfaces generates impacts**
- **Impacts leads to looses of quality and higher running noice**
- **Even little damages may lead to strong quality problems**
- **Specified monitoring of bearing defect frequencies**
- **Attention !**
  Progress of damage very fast on high speed applications

Specified damage bearing frequencies



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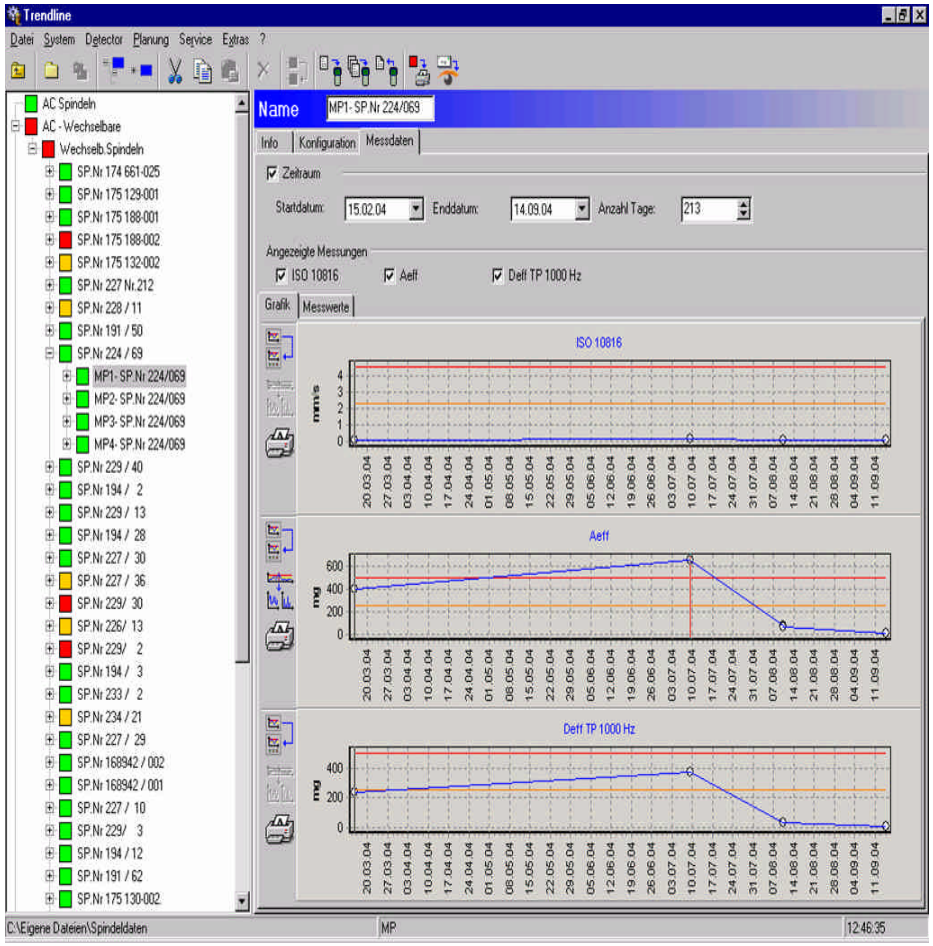
Offline monitoring of spindles

- Offline measuring with Data collector
- Measurements on test rig
- Create database
  machine information, spindle number, bearing type and documentation spindle condition
- Combination of parameter monitoring and deep frequency analysis

Offline monitoring of spindles

- Measurements at same turning speed and same sensor position
- Trending of parameters and amplitudes of specified frequencies
- Right setting of monitoring configuration

Offline monitoring of spindles



- Periodic measurements with documentation
- Trending data and deviation
- As a result of frequency analysis bearing damages are detected on time

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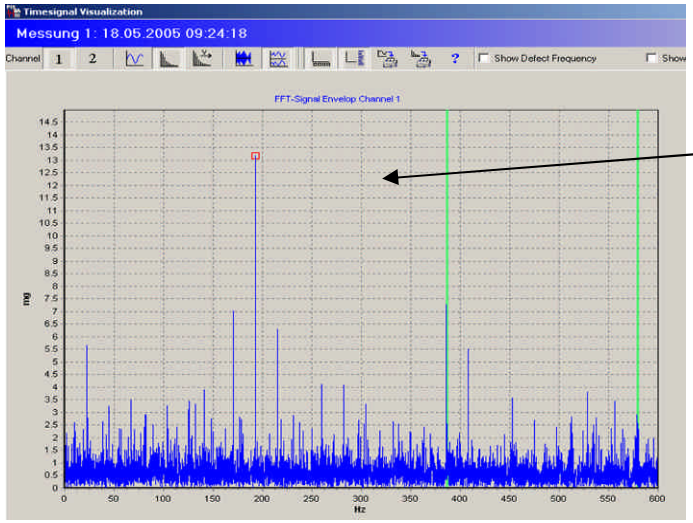
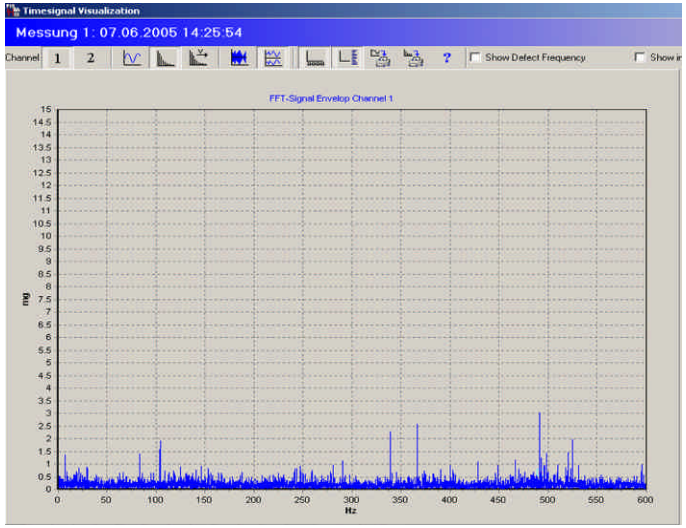
Damage on bearing raceway



Measurement taken on work piece spindle

- **Impacts as a result of damaged bearing are visible in the frequency spectra**



Measurement taken after replacement of spindle bearing arrangement

- **The vibration signal doesn‘t consist bearing defect frequencies**

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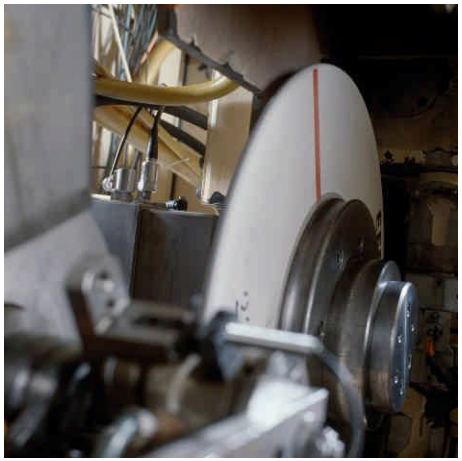
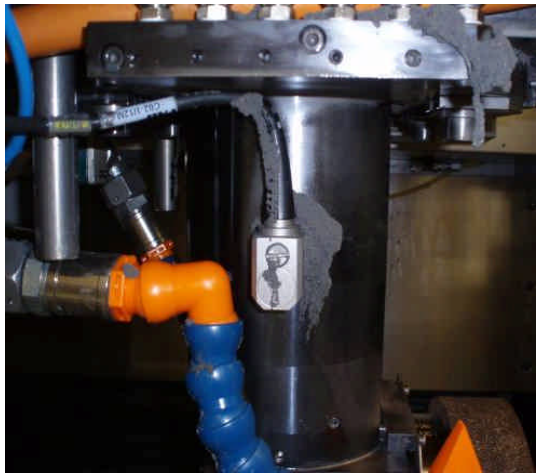
Online monitoring of tool spindles

- Online monitoring of stationary tool spindles with permanent installed sensors
- Monitoring of spindle bearings
  - Monitoring of overall vibration level
  - Frequency analysis
- Monitoring of unbalance (1x turning speed)
- Data communication via TCP/IP (Network)
  - Alarm information
  - Data transfer

Online monitoring of tool spindles





Measuring only during idle position at same speed:

- **Measuring on idle position:**
  - **No additional vibration sources**
  - **Increased visibility of damage frequencies**
  - **Detection of incipient damages on bearings is possible**
  - **Spindle bearing frequencies can be separated**

- **Measuring on same speed:**
  - **Reliable data trending and alarm settings**

Start button for measurement

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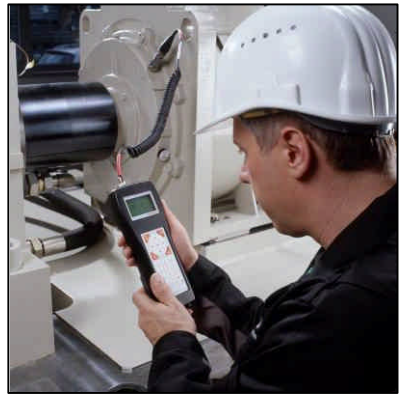
FAG Detector III – Monitoring and balancing with a single device

FAG Detector III – Functions

Vibration diagnosis

- Route planning
- Integrated bearing database
- Automatic alarm threshold adjustment
- Automatic selection of measuring points (RFID technology)
- Presentation of vibration data trends
- In-depth diagnosis
- Customer-specific measurement reports



FAG Detector III – Scope of delivery

FAG Detector III Kit*

- Base device with rechargeable battery
- Acceleration sensor with magnetic foot
- Contact-free (infra red) temperature sensor
- Power pack
- PC data cable (serial/USB)
- User manual
- Protective bag with holder for temperature sensor
- PC software Trendline
- RFID tags
- Case

Complete diagnosis system

•Available with and without RFID technology- Please note: The RFID functionality is not available worldwide.

FAG Detector III Balancing Kit

- Acceleration sensor with magnetic foot
- Trigger sensor (optical and inductive)
- Weighing balance
- Magnetic holder for trigger sensor
- Extension for magnetic holder
- Cable for trigger sensor (length 10 m)
- Reflex mark for trigger sensor
- Dongle for activation of balancing function
- Case

FAG DTECT X1 s

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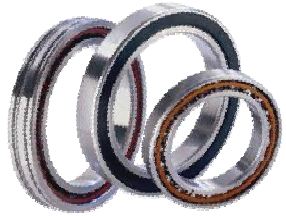
FAG DTECT X1 s - Advantages

New

All necessary functions in one device:

- Monitoring from up to eight channels plus two additonal channels
- Integrated rotary frequency input
- Improved overvoltage protection for power, additional signals and communication, sensor defect identification
- TCP/IP and serial communication (WiFi option)
- Extended operating temperature from -20 °C up to +70 °C for device environment
- Analog interfaces to process systems with optional galvanic isolation to protect control systems
- Protection class IP 67



FAG DTECT X1 s - Advantages

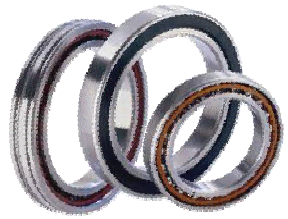
New

Small design:

- W: 260 mm x H: 150 mm x D: 90 mm

Standardized connection technology:

- Flexible and easy installation in the field through M12 connection sockets
- Isolation amplifier as separate modules upgradable in the field (adjustable: 0 – 10 V, 0 – 20 mA, 4 – 20 mA)

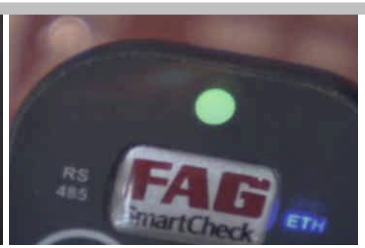


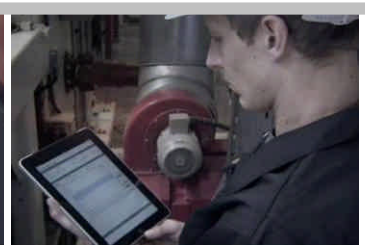
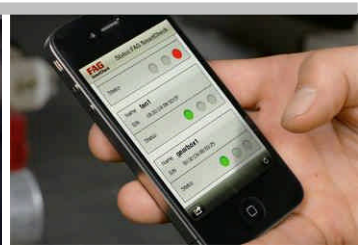
Compatibility to existing installations:

- Firmware and software

Safety through vigilance!
The time is ripe: vibration sensors on every machine

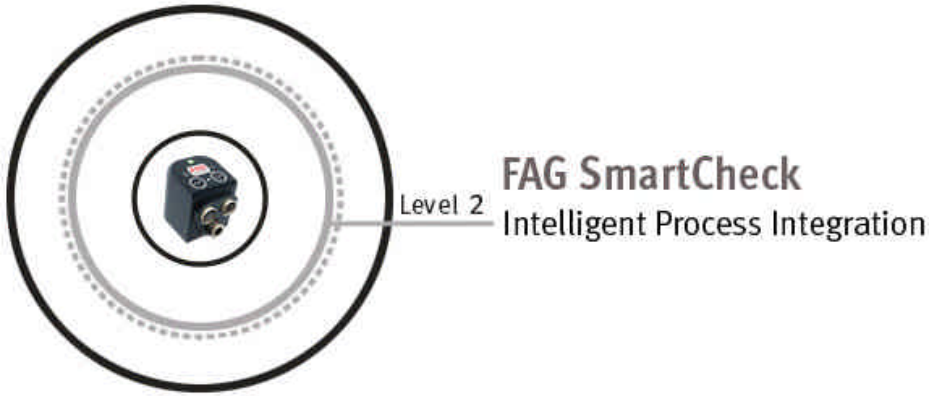
FAG SmartCheck – Products and services

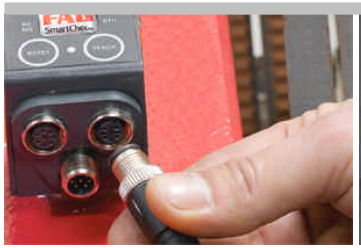


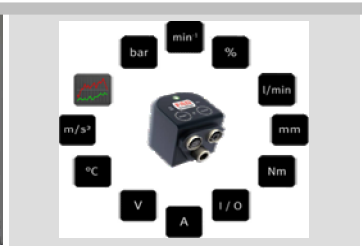



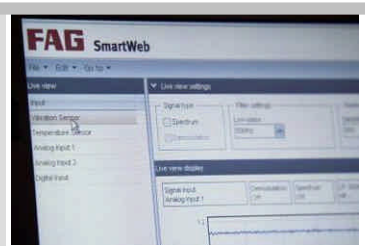
QUICK installation	IMMEDIATELY ready for use	INTUITIVE operation	EASY retrieval of measured data	FAG SmartCheck App
through easy mounting and little wiring	thanks to monitoring configuration template	thanks to status LEDs	e.g. via standard web browser	permits access to data via smartphones

FAG SmartCheck – Products and services





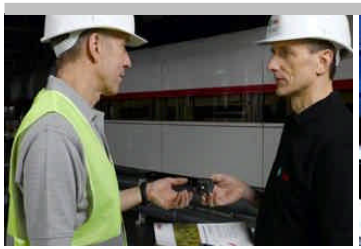


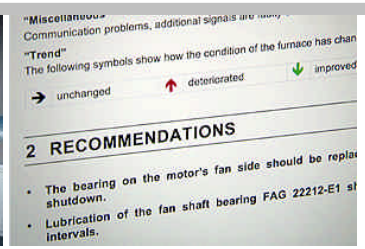


Network capable and Power over Ethernet (PoE)	Integration into PLC / OPC	Gain information from data	Webinterface: FAG SmartWeb	Integration into control station
Communication and power supply via a single line	Data exchange OPC UA client server*	Various machine and process parameters are recorded and correlated with vibration signals	Analysis and diagnosis software permits remote access to FAG SmartCheck	Derivation of process control measures

* At the planning stage

FAG SmartCheck – Products and services





On SITE service	Remote monitoring	Condition report	Services Reconditioning	Training courses
• Definition of measuring points • Commissioning • Reference measurements • Measuring rounds • System integration • Investigation of the cause(s) of problems	• Remote servicing (analysis and reporting) • System maintenance (adjustment of alarm thresholds etc.)	• Preparation of condition reports • Written recommendations for action	• System integration and adaptation • Integration related consultation • Maintenance service	Standard and tailored to our customers‘ needs

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Thank you

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