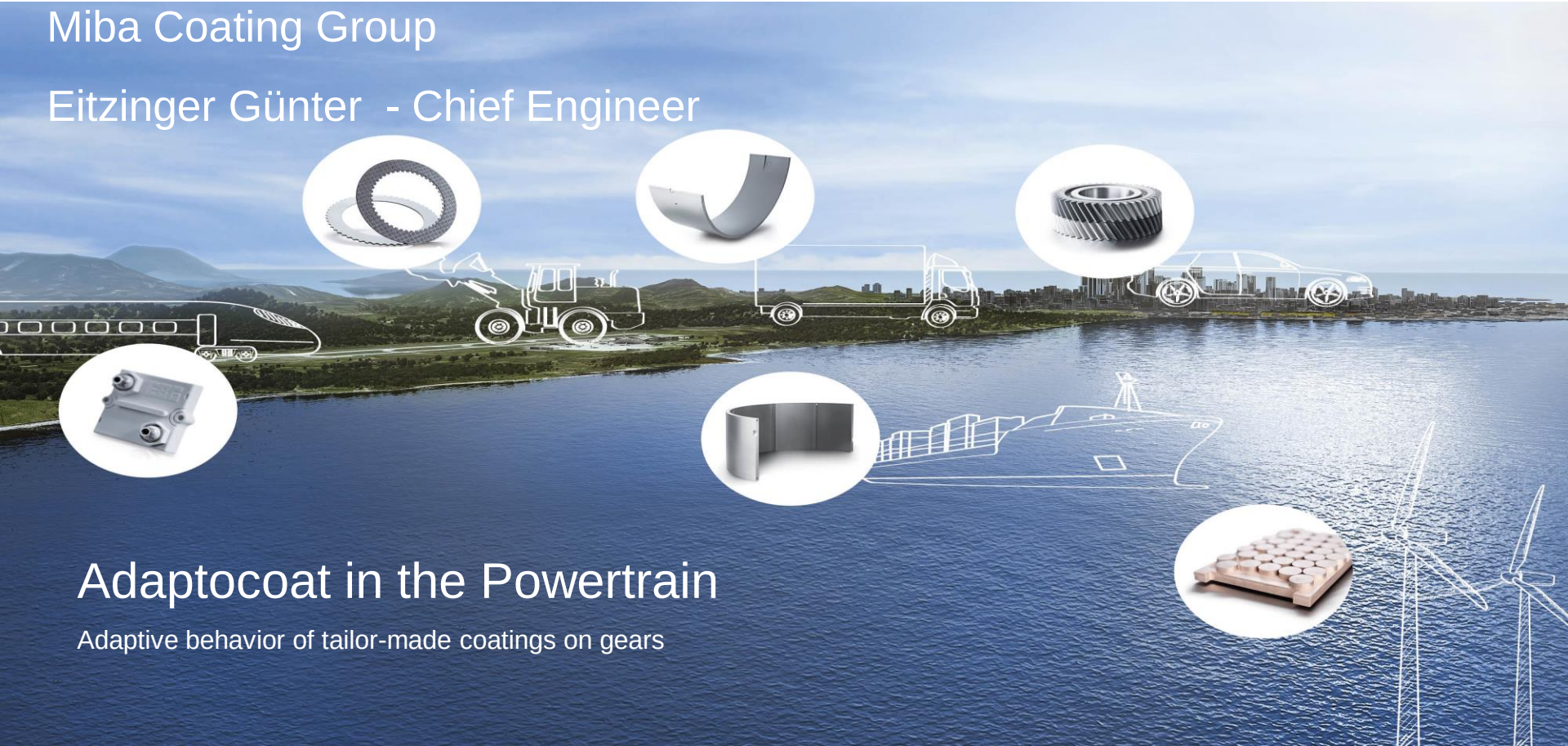
Innovation in Motion

Miba Coating Group

Eitzinger Günter - Chief Engineer



# Adaptocoat in the Powertrain

Adaptive behavior of tailor-made coatings on gears

# Production and sales sites Miba Group

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## Miba Sinter Group

**Miba Sinter Austria**
Vorchdorf, Austria

**Miba Sinter Slovakia**
Dolný Kubín, Slovakia

**Miba Sinter USA**
McConnelsville, OH, USA

**Miba Precision Components (China)**
Suzhou, China

**Sintercom India ***
Pune, India

**Mahle Metal Leve Miba Sinterizados ***
Sao Paulo, Brazil

**Miba Italia**
Rosignano Solvay, Italy

**Miba France**
Paris, France

**Miba Deutschland**
Stuttgart, Germany

## Miba Bearing Group

**Miba Gleitlager**
Laakirchen, Austria

**Miba Bearings US**
McConnelsville, OH, USA

**Miba Precision Components (China)**
Suzhou, China

**Miba Bearings Materials**
Aurachkirchen, Austria

**ABM Advanced Bearing Materials ***
Greensburg, IN, USA

**Miba Far East** Singapore

## Miba Friction Group

**Miba Frictec GmbH**
Roitham, Austria

**Miba Steeltec**
Vráble, Slovakia

**Miba HydraMechanica** Sterling Heights, MI, USA

**Miba Precision Components (China)**
Suzhou, China

**Miba Drivetec India**
Pune, India

**Fibertec Štětí**
Štětí, Czech Republic

## Miba Coating Group

**High Tech Coatings**
Vorchdorf, Austria

**Miba Precision Components (China)**
Suzhou, China

**Teer Coatings**
Droitwich, Great Britain

## New Technologies Group

**EBG Elektronische Bauelemente**
Kirchbach, Austria

**DAU**
Ligist, Austria

**DAU Thermal Solutions North America**
Macedon, NY, USA

**EBG Shenzhen ***
Shenzhen, China

**EDMS ***
Šentjernej, Slovenia

**EBG Resistors ***
Middletown, PA, USA

Production site

Sales site

**Miba Automation Systems**
Aurachkirchen, Austria

**Miba Engineering Center India**
Pune, India

- All companies are wholly-owned investees except Advanced Bearing Materials (50%), Mahle Metal Leve Miba Sinterizados (40%), EBG Resistors (70%), EBG Shenzhen (55%), Sintercom (26%) and EDMS (49%)

# Adaptocoat

## Ideas behind



- Assembly coated gears with minimum backlash in between
- If there will be interferences caused by the gear tolerance or temperature elongation or … the adaptive deformation in a specified range will avoid whine noise.
- If there is a very small loaded area on the gear caused by machining or assembly tolerances the coating will adapt to lower the specific load
- Plastic deformation increase the hardness of the remaining coating
- The tribological improved behavior is a possible enabler for the usage of low viscosity fluids
- Rattle noise is minimized caused by low backlash values
- Hardness adjustable in between 100 – 1000 HV

# Key Applications in Powertrain

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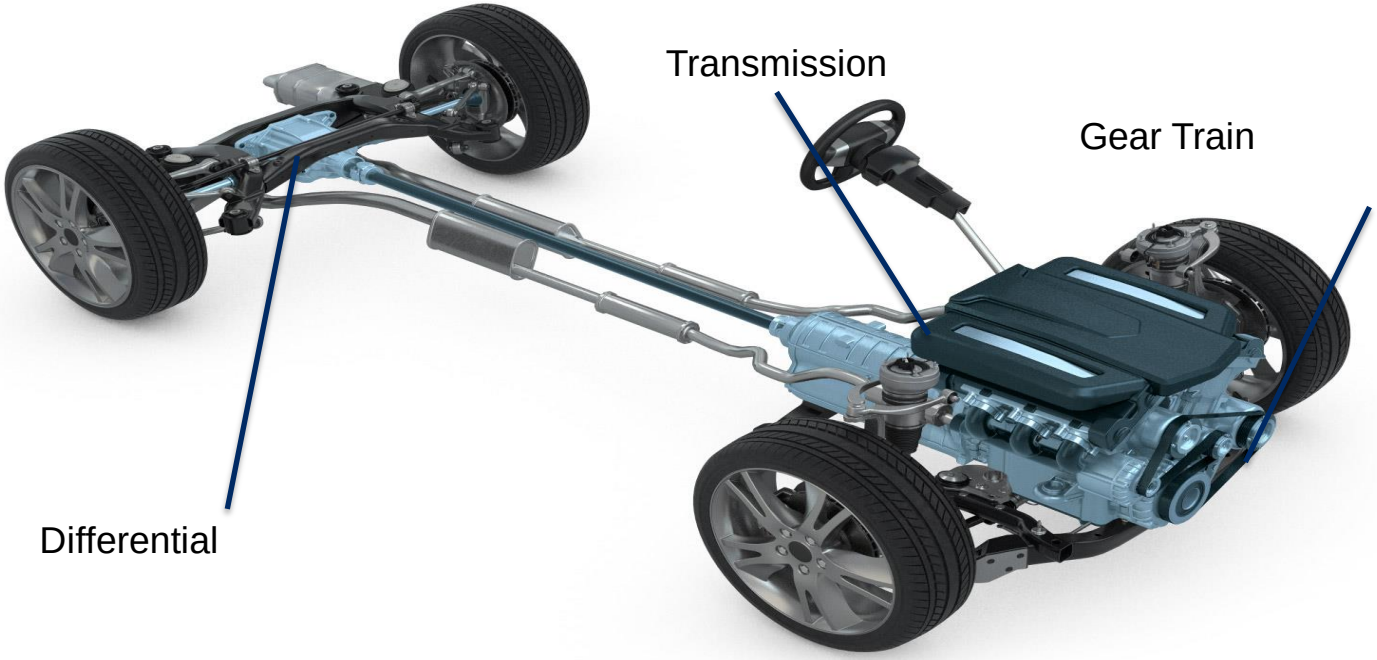
To review the market and technical potential individual applications in the powertrain are selected and tested together with lead customers



# Adaptocoat

## Test Gear Definition

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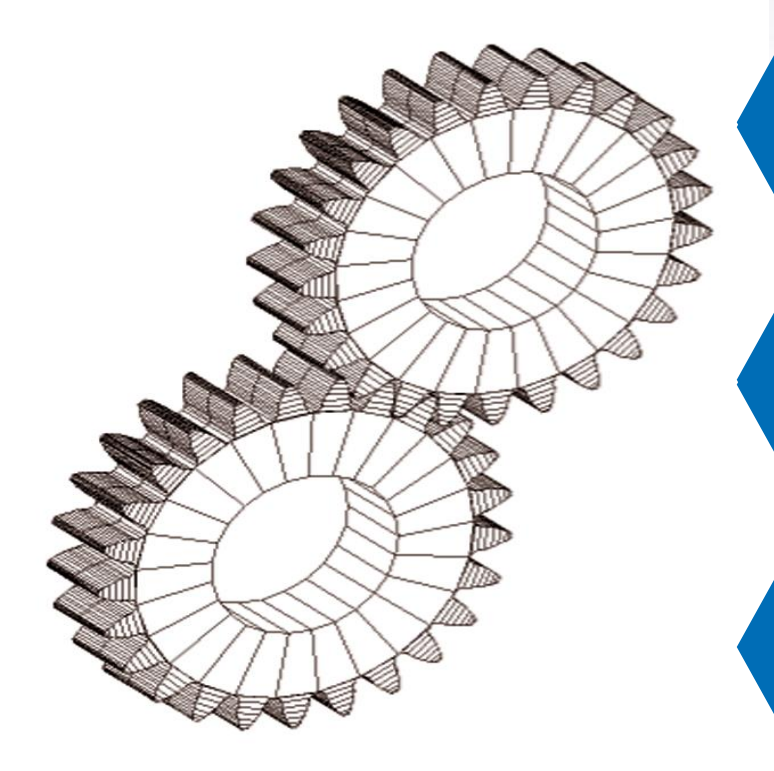
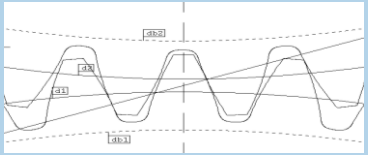


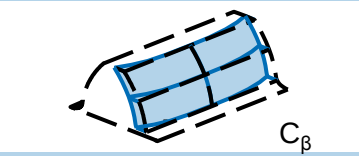
### Macrogeometry



Examples

- Number of Teeth
- Module
- Pressure / Helix Angle

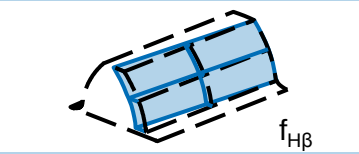
### Microgeometry




Examples

- Lead Crowning
- Profile Crowning
- Tip Relief

### Defined Geometrical Deviations




Examples

- Flank Topography
- Eccentricity
- Pitch Error

# Gear Variation

## Test Gears

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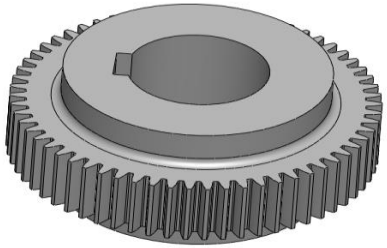
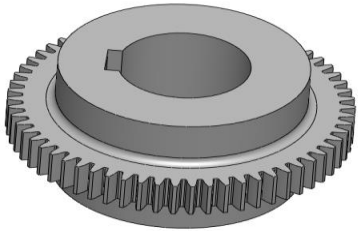
### Referenz REF

- b = 24 mm
- Without Modification



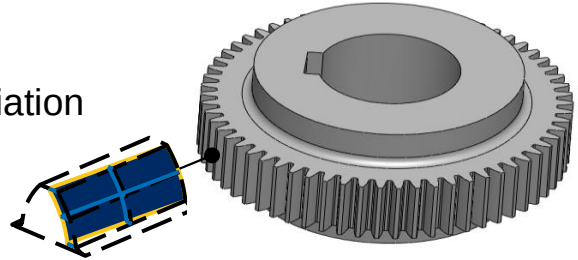
### Mating Gear CG

- b = 14 mm
- Crowning
  $C_\alpha$ = 6 µm
  $C_\beta$ = 8 µm



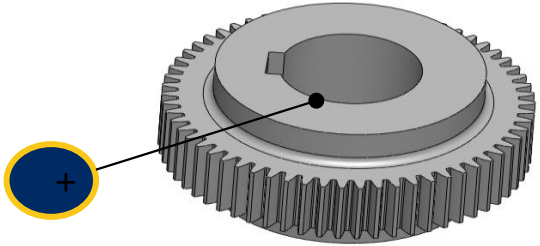
### Tumbling Error TTA

- b = 24 mm
- Tooth trace variation
  $|f_{H\beta}| \leq 35$ µm
  (Tumbling)



### Excentricity gear EXC

- b = 24 mm
- Excentricity
  e = 35 µm



# Test Results

Deformation and wear versus time

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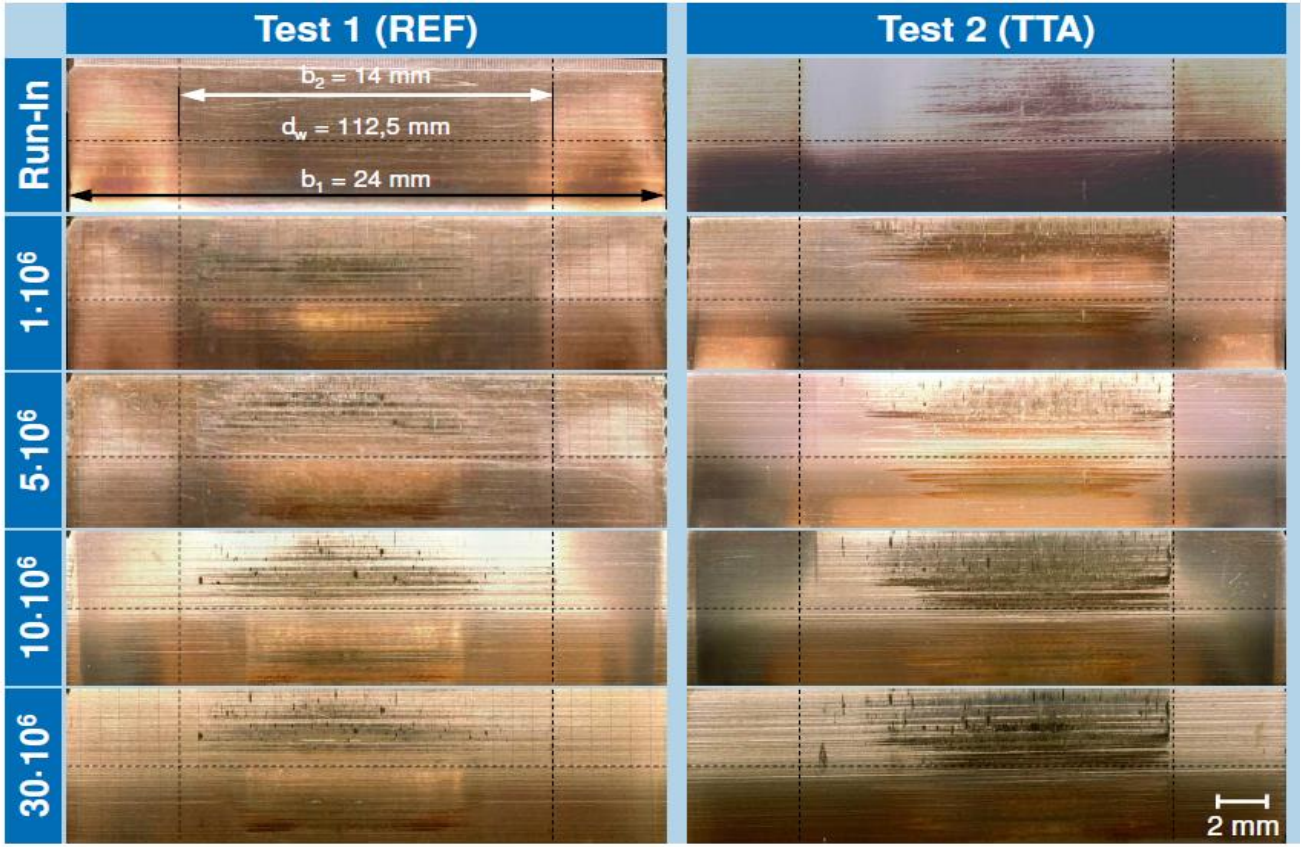
## Variant 1:

15 µm Cr Stainless Steel
CuSn graded

Hardness
1000 HV – 200 HV



# Test Results

„Perfect gear“ versus gear with tumbling error

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## Steel-Bronze-15 µm

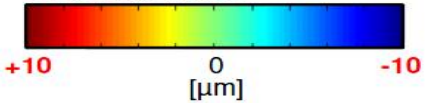
- **Gear Data**

  $m_n$ = 1.8 mm
  $z_{1/2}$ = 62 / 62
  $b_{1/2}$ = 24 / 14 mm
  $f_{H\beta,REF/TTA}$ = 3 / -29 µm

- **Stylus Tip**
  (Diameter, Spreading)

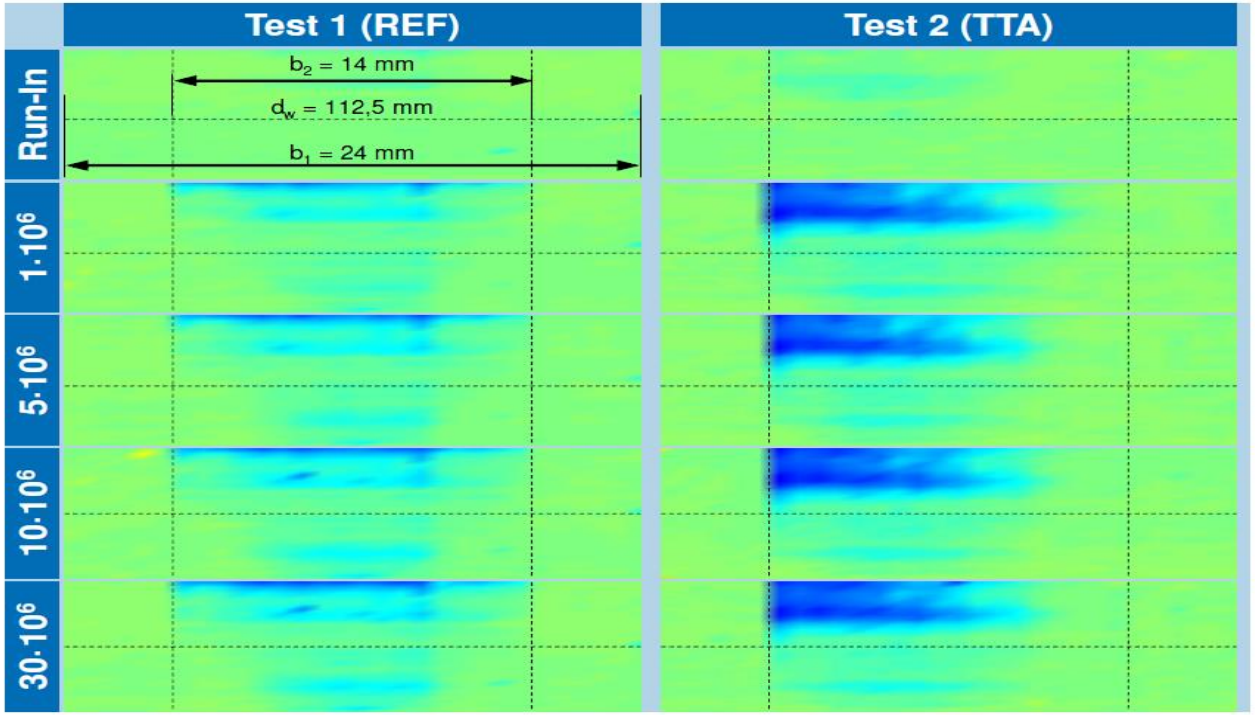
  $d_T$ = 0.8 mm
  $s_m$ = 0.2 µm

- **Difference Topography**
  to initial state




- **Wear Depth (Tip / Root)**

  $s_{REF}$ = 6.6 µm / 2.9 µm
  $s_{TTA}$ = 7.6 µm / 2.4 µm
  (strong wear at the tip edge due to little backlash between teeth)



# Test Results

Adaptive Coated Gear

Innovation in Motion

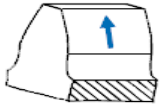
## Steel-Bronze 5 µm

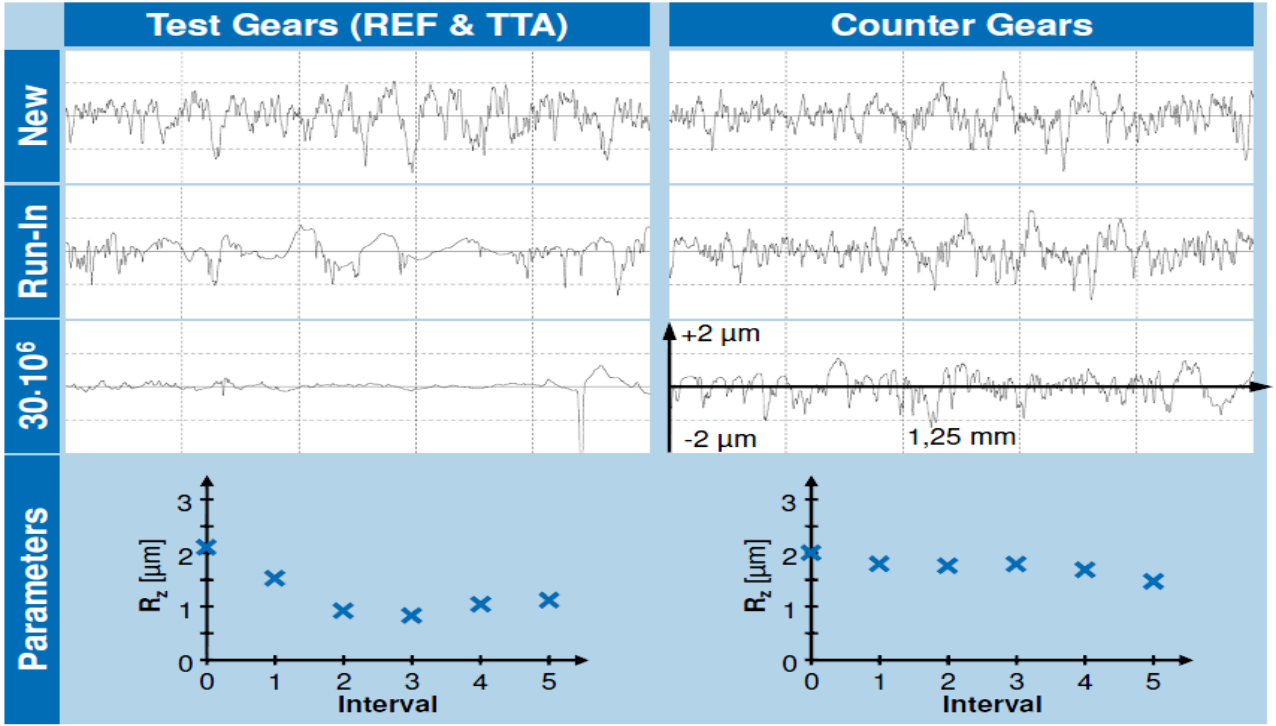
### Gear Data

| | | |
|---|---|---|
| $m_n$ | = | 1.8 mm |
| $z_{1/2}$ | = | 62 / 62 |
| $b_{1/2}$ | = | 24 / 14 mm |
| $f_{H\beta,REF/TTA}$ | = | 3 / 12 µm |
| a | = | 112,5 mm |
| $\alpha_n$ | = | 18 ° |
| β | = | 0 ° |
| $\varepsilon_\alpha$ | = | 2.155 |

### Surface Profiler

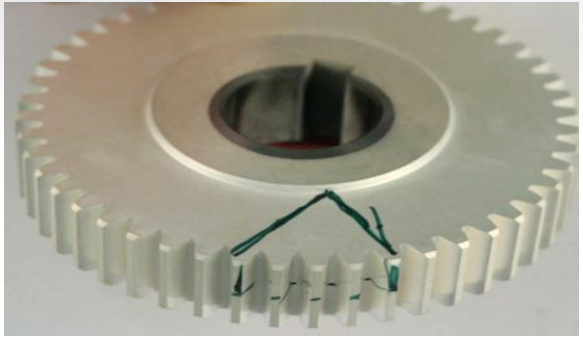
| | | |
|---|---|---|
| R | = | 2 µm |
| α | = | 90° |
| $l_m$ | = | 1,25 mm |

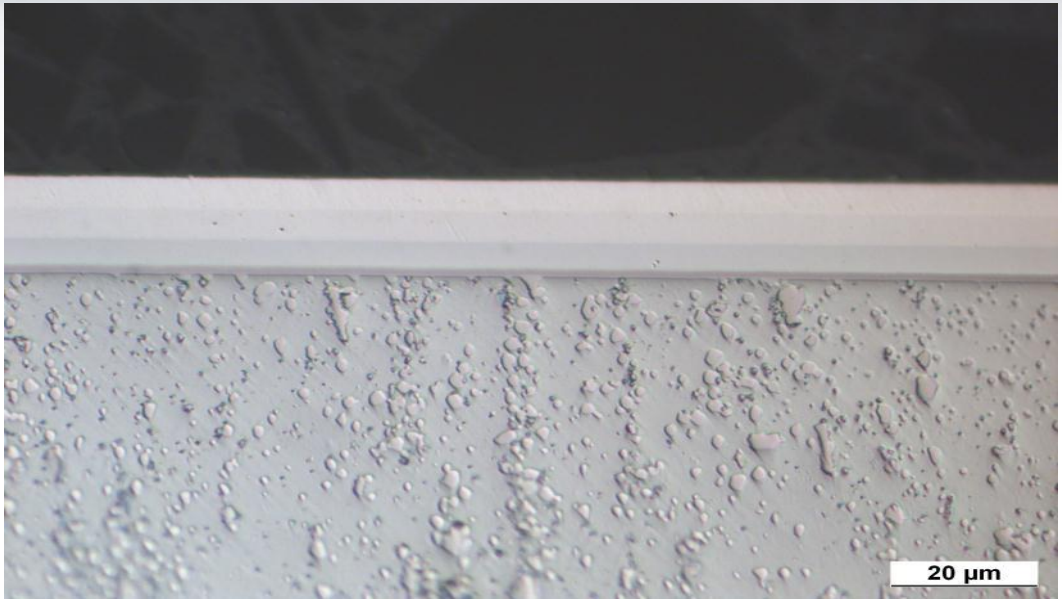




# Coating architecture

Multilayer






## CuSnC coating system:

Hardness adjustable

4 layers visible Coating thickness: 16µm

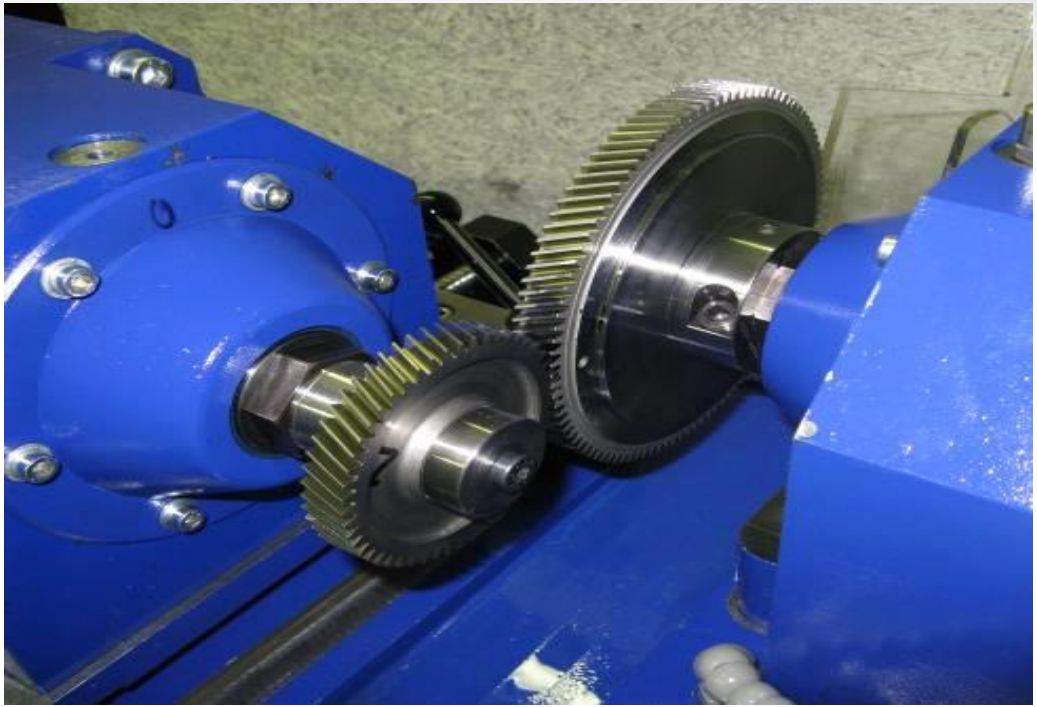
Target : Improve tribological behavior to enable the use of low viscosity fluids > lowering friction  > better NVH > Silent gear

# NVH Test Rig

## Alternative torque

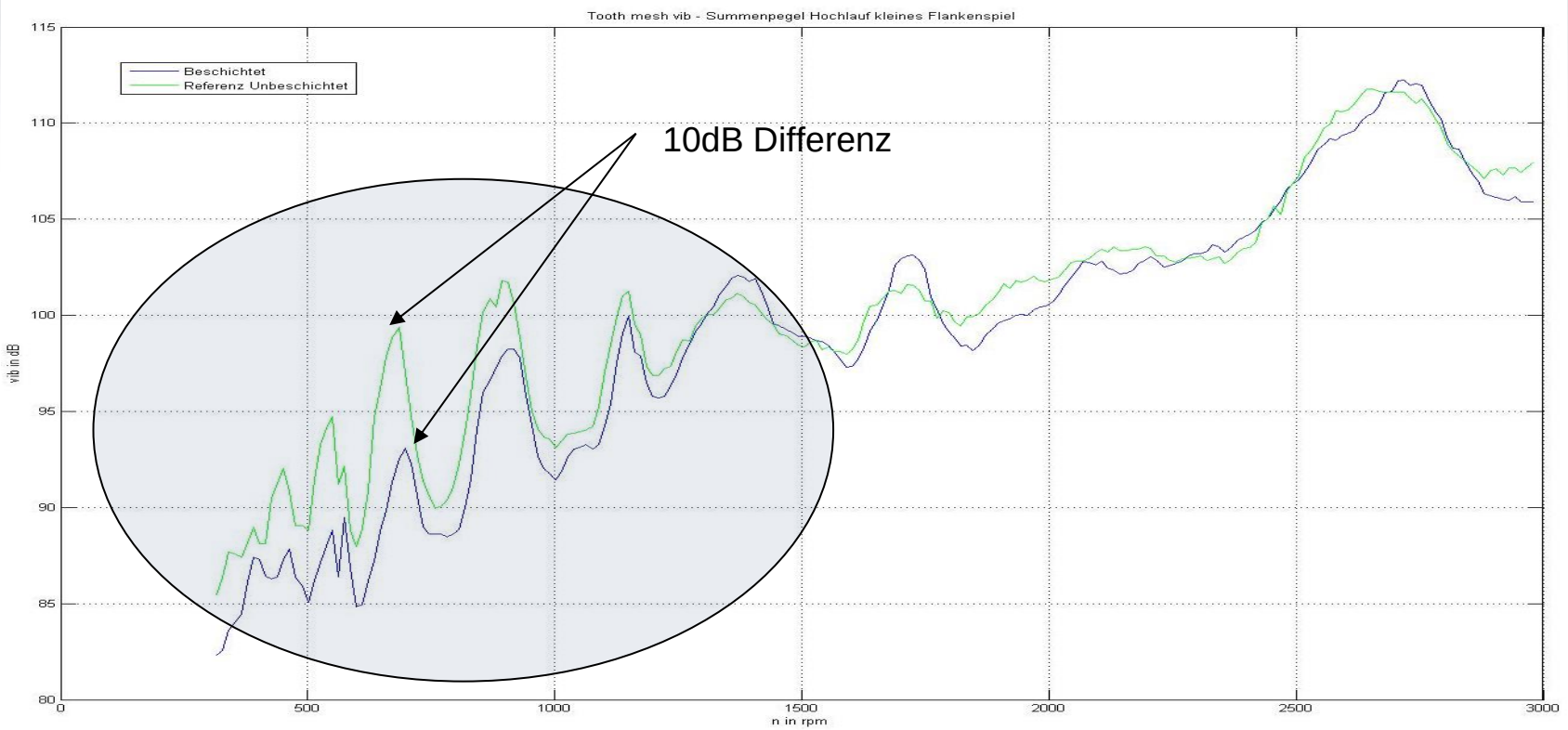


- 2 servo engines
- adjustable axis distance and backlash
- 0 – 6000 rpm
- 0 – 20 Nm oscillating torque
- up to 10 Hz



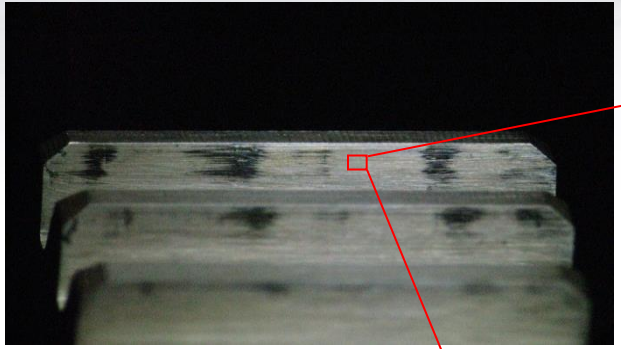
# Signal uncoated vs. coating@6Nm alternating torque

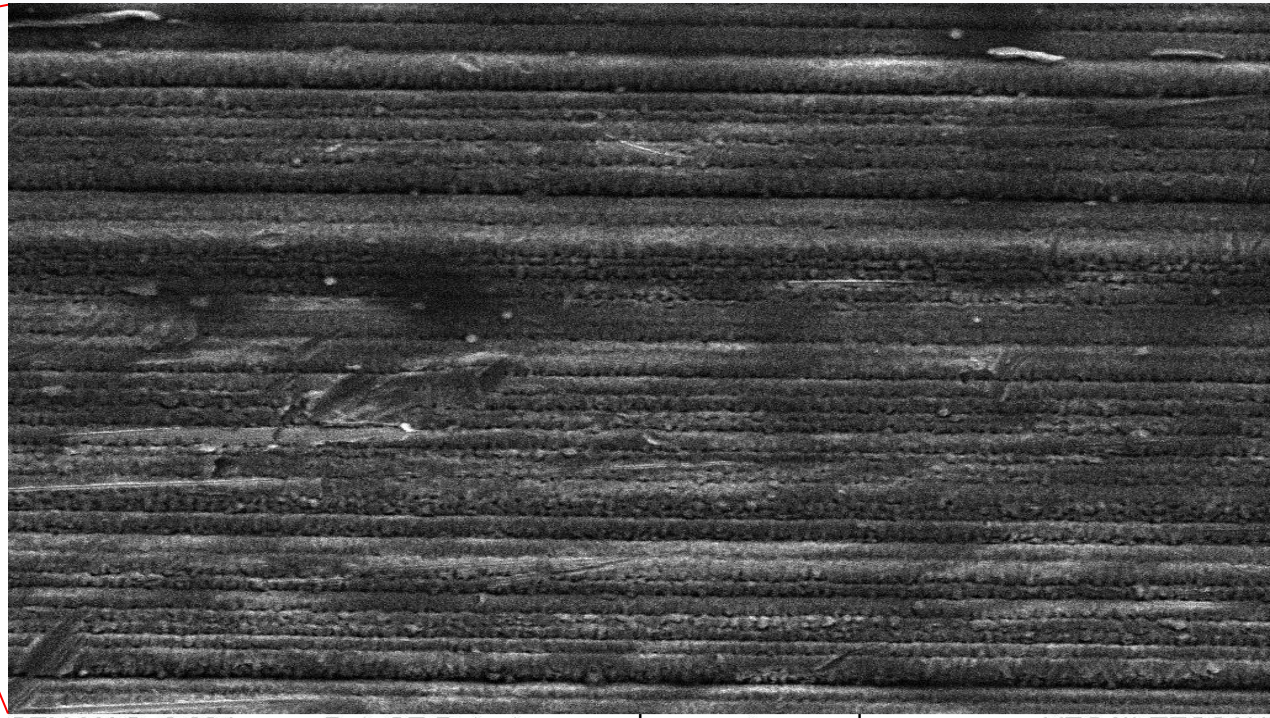
Miba Test Rig



# Result on rough machined surface

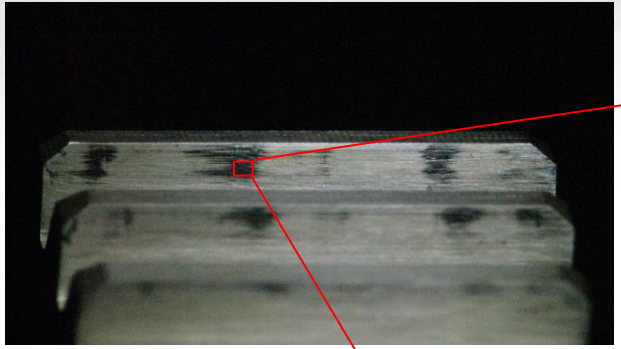
REM picture unloaded area

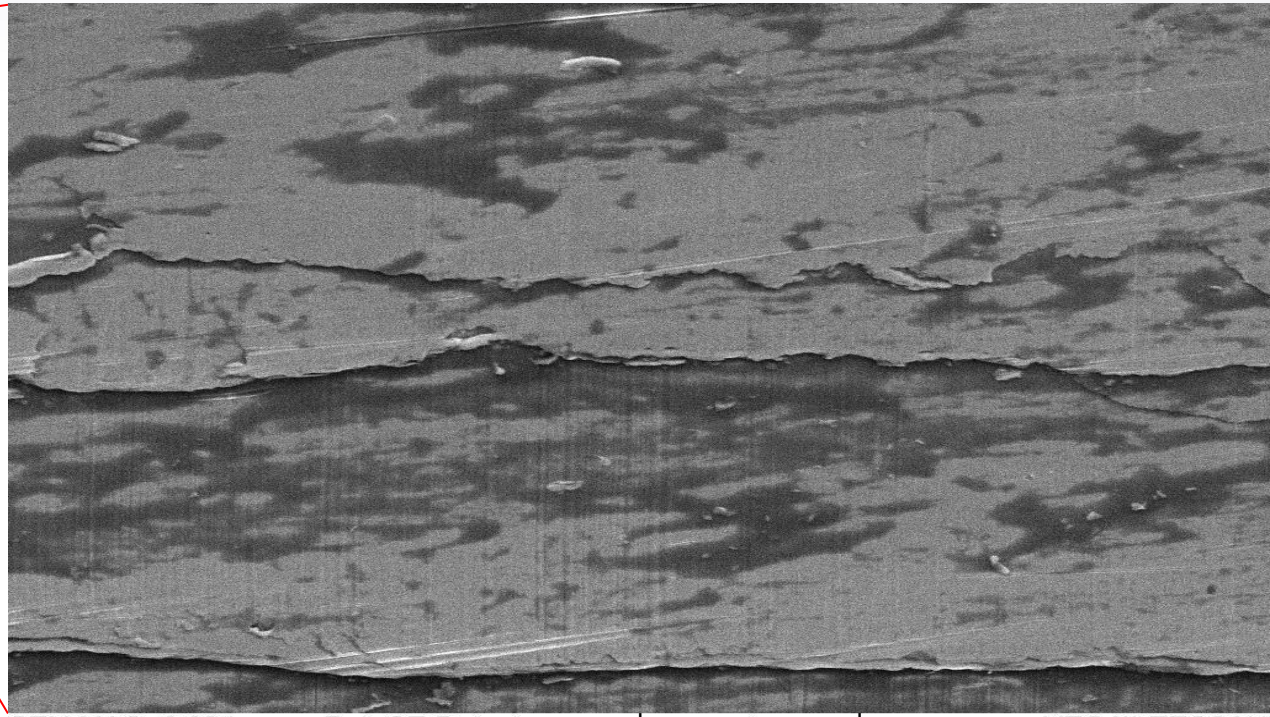




# Result on rough machined surface area after test

## Loaded area





# Rattle noise test rig

WZL RWTH Aachen

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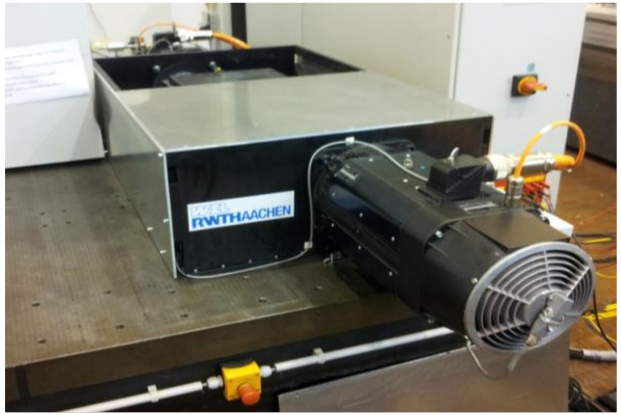
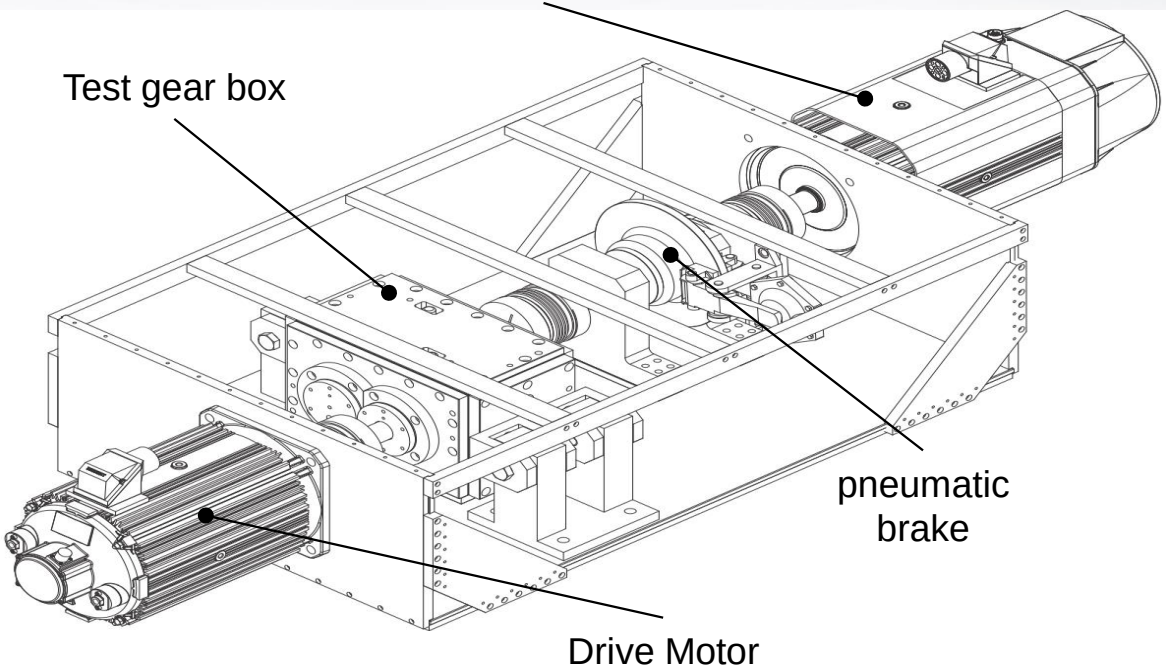
- Data
  P = 30 kW
  n = 100 - 2000 $min^{-1}$
  T = 5 - 130 Nm
  $\dot{\omega}$ = 0 - 800 $rad \cdot s^{-2}$
- Structure borne sound measurement on both shafts



# Example of test results

Dashed lines coated gears

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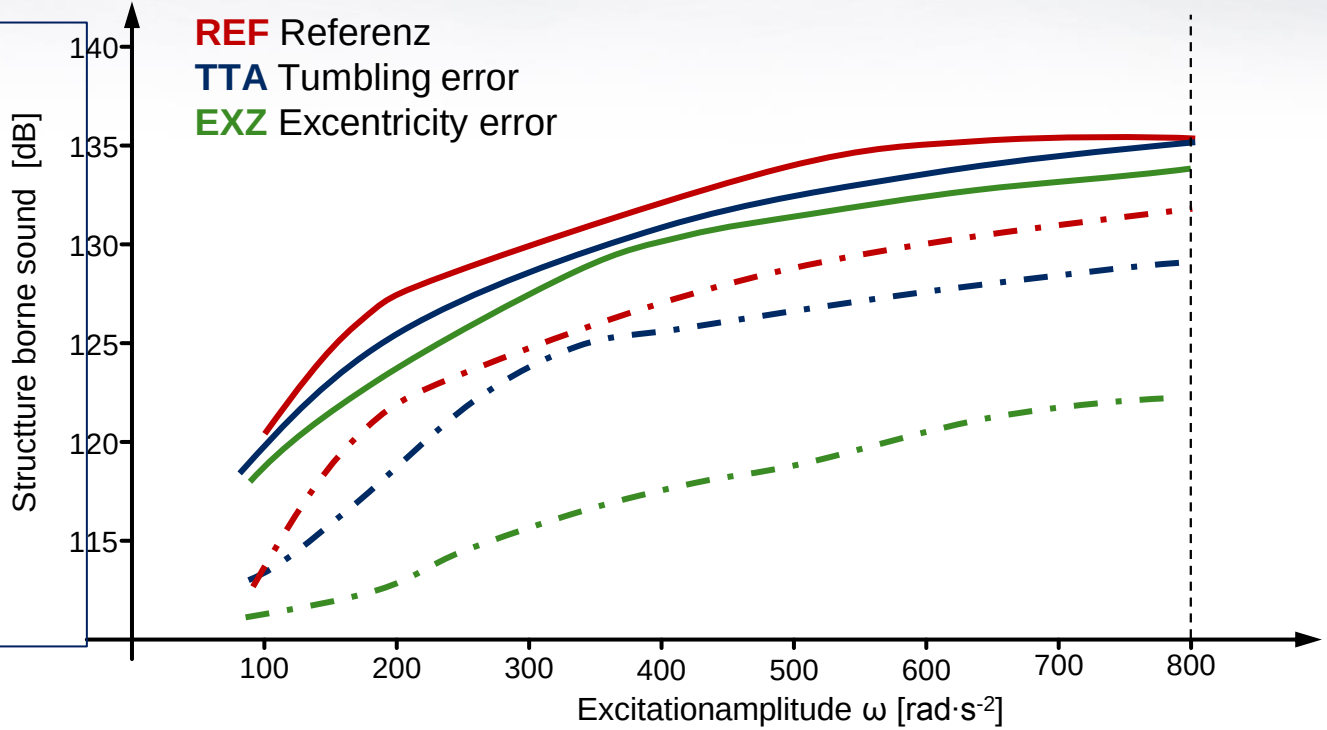
- **Gear Geometrie**
  - $m_n$ = 1,8 mm
  - a = 112,5 mm
  - $z_{1/2}$ = 62 / 62
- **Test Parameters**
  - $n_{An}$ = 1000 $min^{-1}$
  - ω = 800 $rad \cdot s^{-2}$
  - $X_{0,dB}$ = $10^{-6}$ $m/s^2$
  - Öl: 5W30

— Uncoated gears

- · · Coated gears 15 µm



# Rattle noise results

Results

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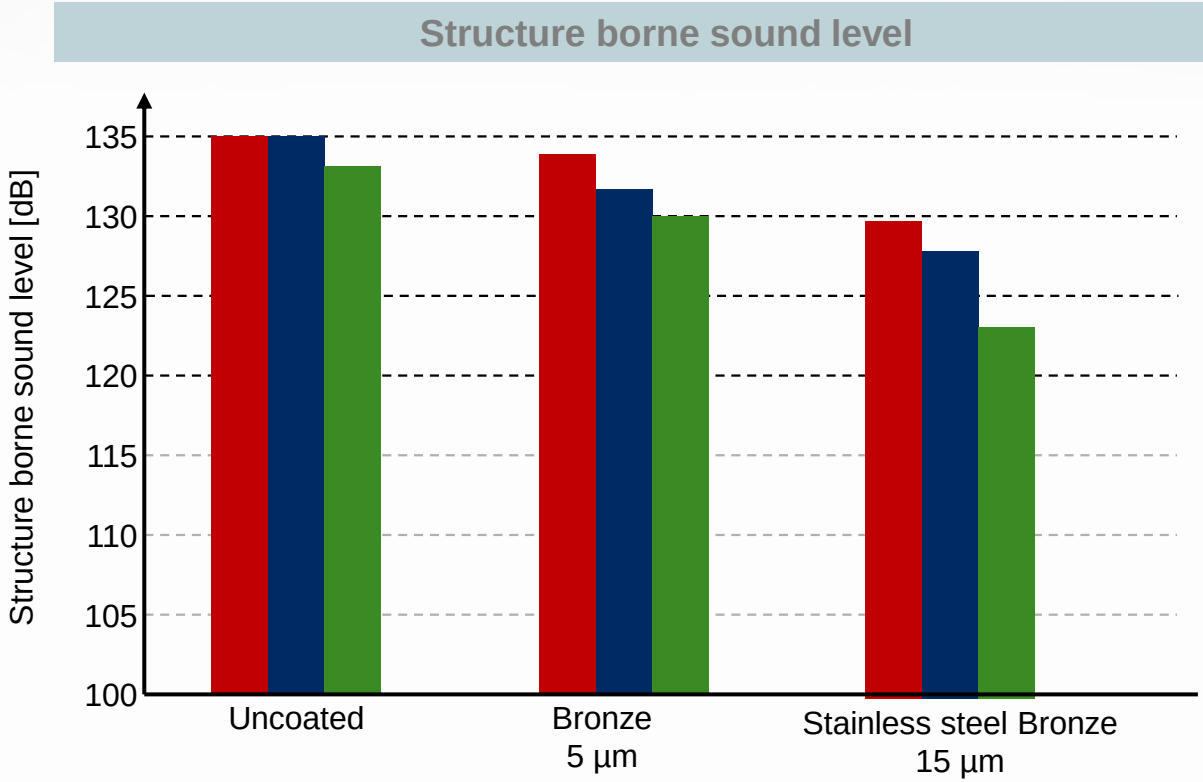
## Gear geometry

| | | |
|---|---|---|
| $m_n$ | = | 1,8 mm |
| a | = | 112,5 mm |
| $z_{1/2}$ | = | 62 / 62 |
| $\alpha_n$ | = | 18 ° |
| β | = | 0 ° |
| $b_{1/2}$ | = | 24 / 14 mm |

## Test conditions

| | | |
|---|---|---|
| $n_{An}$ | = | 1000 $min^{-1}$ |
| ω | = | 800 $rad \cdot s^{-2}$ |
| $X_{0,dB}$ | = | $10^{-6}$ $m/s^2$ |
| Öl: | | 5W30 |

Referenc
Tumbling error
Excentricity error



# Summary and next steps

## Adaptocoat



- First tests in gear drive application shows very good results
- NVH Improvements are in tests between different solutions in the top area
- Gear box applications are the next steps for validation
- The potential to be enabler for usage of low viscosity fluids is shown
- Further optimizations are in development
- No additional space needed
- No additional friction

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# Thank‘s for your attention

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