Test Design of the cooperation project between Institute of Product Development and Machine Elements of the Technical University of Darmstadt and SENSITEC GmbH

Test bench at pmd TU Darmstadt:

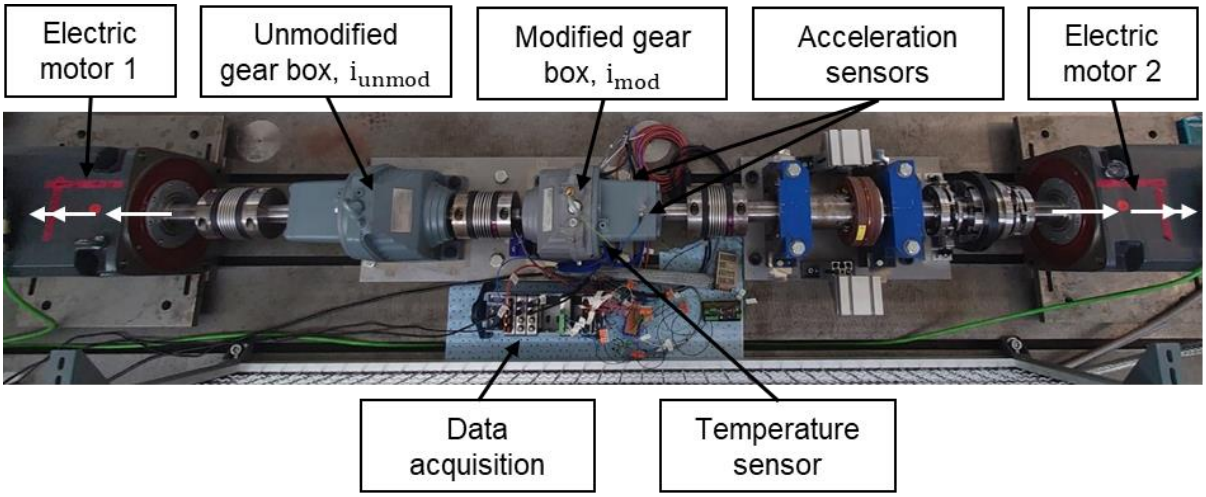
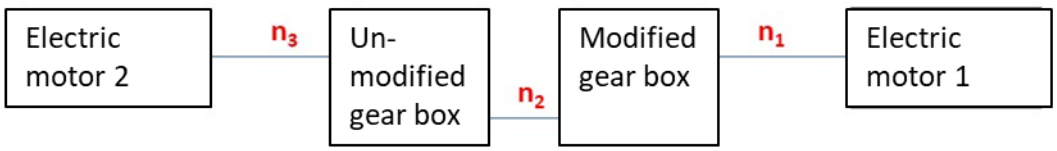


Figure 1: Test bench at pmd TU Darmstadt

- Electric motor 1 is speed controlled
- Electric motor 2 is torque controlled
- The speed and torque direction is defined as shown in Figure 1.
- The gear boxes are RX77/AD4 of SEW



Based on the number of teeth the gear ratio is calculated → $i_{unmod} = -\frac{21}{51} = -0{,}411$ $\quad i_{mod} = -\frac{78}{24} = -3{,}25$

Four quadrants oft the test bench:

Electric Motor 1 is speed controlled and Electric Motor 2 is torque controlled

- Q1: Electric Motor 1 negative speed, Electric Motor 2 positive torque
- Q2: Electric Motor 1 negative speed, Electric Motor 2 negative torque
- Q3: Electric Motor 1 positive speed, Electric Motor 2 negative torque
- Q4: Electric Motor 1 positive speed, Electric Motor 2 positive torque

Sensor integration:

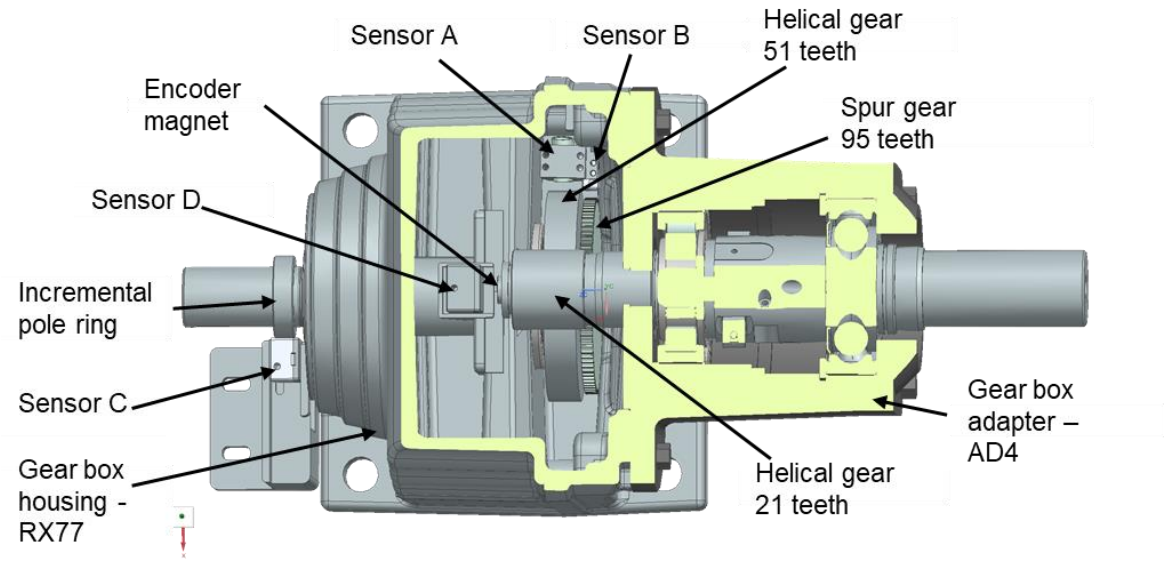


Figure 1: Integration of Magneotresisitive sensors CAD-illustration

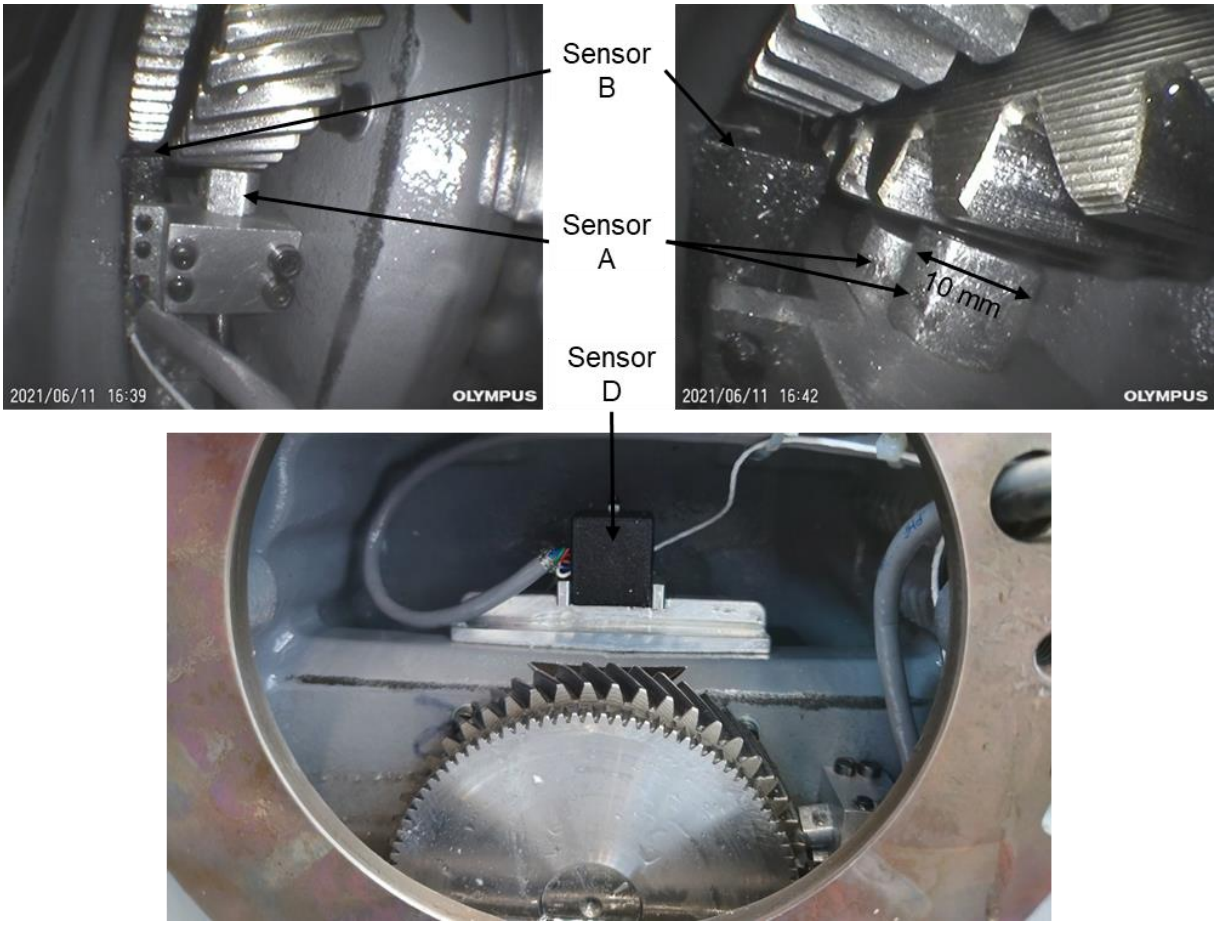


Figure 2: Integration of the magnetoresistive sensors in the gear box

Table 1: Measuring Scale of the magnetoresistive sensors

Sensor	Measuring scale
A	Straight toothed gear, $z_3 =$ **51 teeht**
B	Spur gear, $z_2 =$ **95 teeth**
C	Incremental pole ring, $z_1 =$ **256 poles**
D	Encoder magnet with north and south pole

Data acquisition

Table 2: sampling frequency of the NI-DAQ System

Chassis	Analog signals (Sensors B, C, D)	Analog signals (Sensor A)	Digital signals (Sensors C and D)	Acceleration sensors	Temperature Sensor (PT1000)
NI cDAQ 9178	NI9205 40kHz per Input	NI9215 100kHz per Input	NI9401 1MHz per Input	NI9234 51,2 kHz per Input	NI9215

Data preprocessing

The analogue signals were corrected to an amplitude of +/-1 Volt. With the arcus tangens function the angle is calculated based on the sine and cosine data. The sensors B, C and D generate a sine and cosine signal. Sensor A generates one sine signal, to generate a shifted signal two sensors are integrated and the upper one is shifted at 7/4 pitch.

Damages

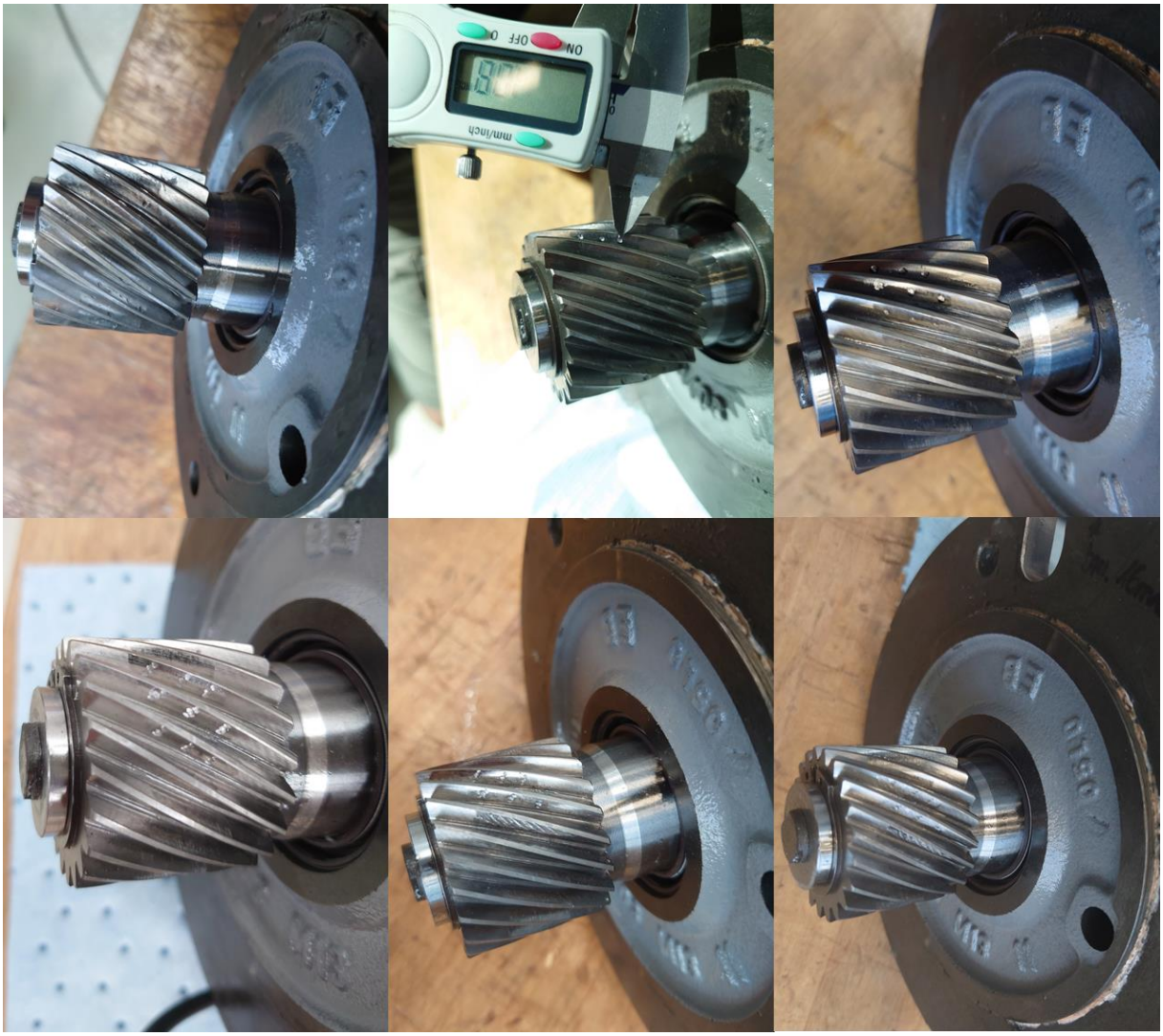


Figure 3: Picture of the artifically damaged gear. Damages as described in Table 3 starting at top left with damage "0" and "1" to bottom right with damage "6"

Test plan

Table 3: Test parameters

Speed in $\frac{1}{\text{min}}$	Torque in Nm	Damage condition
+/- 300	0	"0" - No Damage
+/- 700	+/- 20	"1" - No Damage, removal and installation of AD4-Adapter
+/- 1000	+/- 35	"2" - Small pittings at one tooth flank
+/- 1300	+/- 55	"3" - Small pittings at three tooth flanks
+/- 1600	+/- 70	"4" - Bigger pittings at three tooth flanks
+/- 2000	+/- 85	"5" - Deeper pittings at three tooth flanks
	+/- 96	"6" - Complete damage of three tooth flanks

Data naming:

The data is named based on the test parameters shown in Table 3. Every test combination of speed, torque and damage condition has its own data set containing the previously described sensor data. The data is named as follows: "DamageW_QuadrantX_TrqYNm_RevZrpm". "W" is the damage condition, "X" is the Quadrant, Y is the torque in Nm and Z is the speed in $\frac{1}{\text{min}}$.