Figure 1 FZG gear test rig at IK4-TEKNIKER facilities (left) and detail of the gear test box (right)

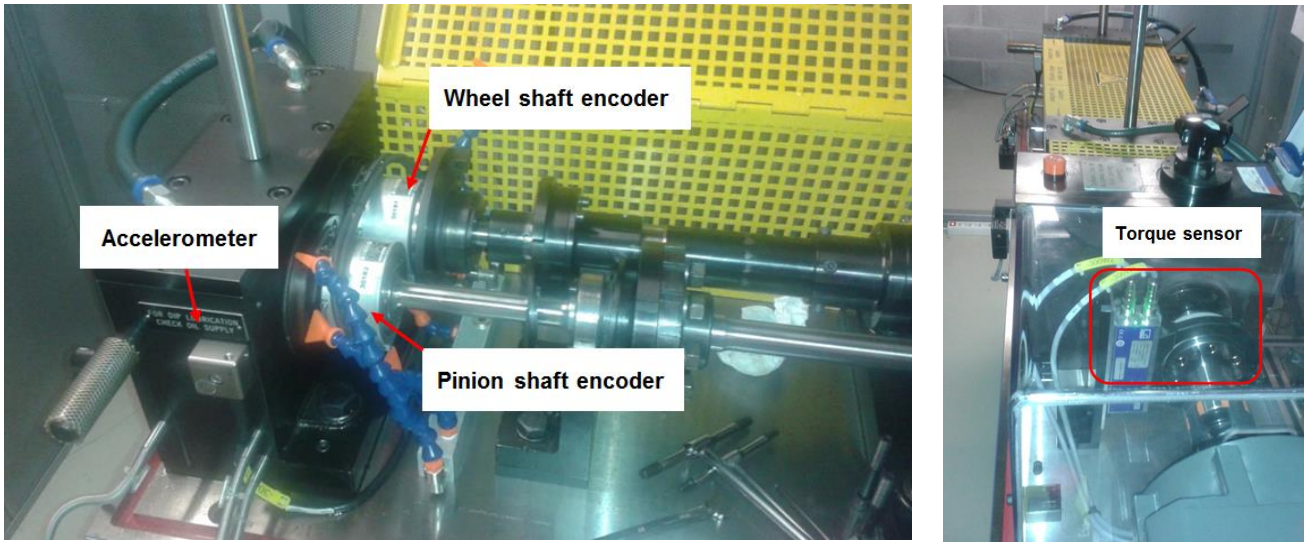
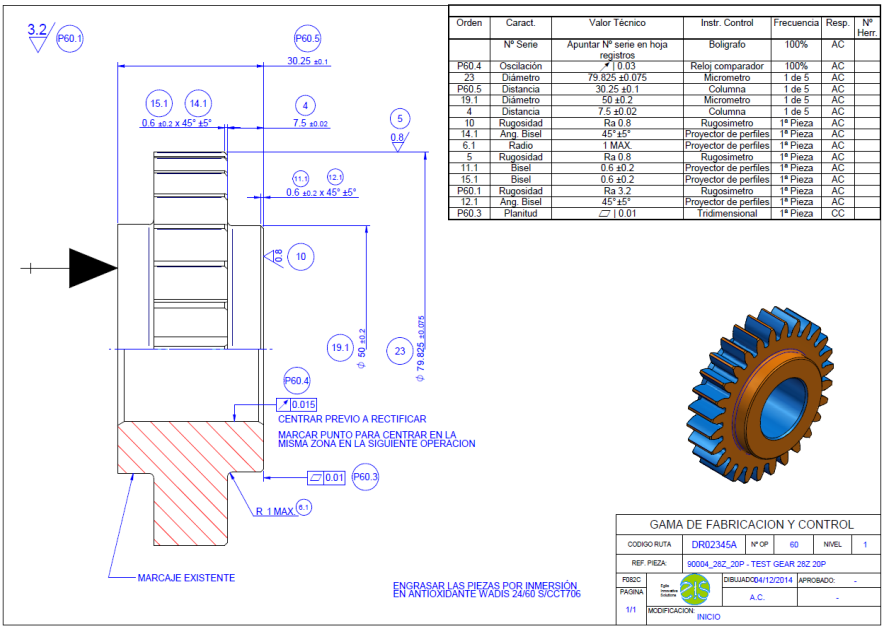


Figure 2 a) Installed encoders and accelerometer (left) and Installed torque sensor (right) in the FZG test rig



Orden	Caract.	Valor Técnico	Instr. Control	Frecuencia	Resp.	Nº Herr.
	Nº Serie	Apuntar Nº serie en hoja registros	Boligrafo	100%	AC	
P60.4	Oscilación	⌰ | 0.03	Reloj comparador	100%	AC	
23	Diámetro	79.825 ±0.075	Micrometro	1 de 5	AC	
P60.5	Distancia	30.25 ±0.1	Columna	1 de 5	AC	
19.1	Diámetro	50 ±0.2	Micrometro	1 de 5	AC	
4	Distancia	7.5 ±0.02	Columna	1 de 5	AC	
10	Rugosidad	Ra 0.8	Rugosimetro	1ª Pieza	AC	
14.1	Ang. Bisel	45°±5°	Proyector de perfiles	1ª Pieza	AC	
6.1	Radio	1 MAX	Proyector de perfiles	1ª Pieza	AC	
5	Rugosidad	Ra 0.8	Rugosimetro	1ª Pieza	AC	
11.1	Bisel	0.6 ±0.2	Proyector de perfiles	1ª Pieza	AC	
15.1	Bisel	0.6 ±0.2	Proyector de perfiles	1ª Pieza	AC	
P60.1	Rugosidad	Ra 3.2	Rugosimetro	1ª Pieza	AC	
12.1	Ang. Bisel	45°±5°	Proyector de perfiles	1ª Pieza	AC	
P60.3	Planitud	▱ | 0.01	Tridimensional	1ª Pieza	CC	

Figure 3 Step 60 of DR02345A

StdOrder	RunOrder	CenterPt	Blocks	ALPHA	FA	FB	FP
1	1	1	1	20.0	0.006	0.008	0.018
2	2	1	1	22.5	0.006	0.008	0.018
3	3	1	1	20.0	0.018	0.008	0.018
4	4	1	1	22.5	0.018	0.008	0.018
5	5	1	1	20.0	0.006	0.012	0.018
6	6	1	1	22.5	0.006	0.012	0.018
7	7	1	1	20.0	0.018	0.012	0.018
8	8	1	1	22.5	0.018	0.012	0.018
9	9	1	1	20.0	0.006	0.008	0.055
10	10	1	1	22.5	0.006	0.008	0.055
11	11	1	1	20.0	0.018	0.008	0.055
12	12	1	1	22.5	0.018	0.008	0.055
13	13	1	1	20.0	0.006	0.012	0.055
14	14	1	1	22.5	0.006	0.012	0.055
15	15	1	1	20.0	0.018	0.012	0.055
16	16	1	1	22.5	0.018	0.012	0.055

FACTORS OF THE EXPERIMENT:

- **PRESSURE ANGLE (ALPHA)**
- **TOTAL PROFILE DEVIATION (FA)**
- **TOTAL HELIX DEVIATION (FB)**
- **TOTAL CUMULATIVE PITCH DEVIATION (FP)**

Figure 4 Simulation scenarios

Sensor	Magnitude	Reported values
Accelerometer	Vibrations (m/s^2)	RMS (X, Y, Z) Crest factor (X, Y, Z) [-] GMF (X, Y, Z) Growth ratio (X, Y, Z, Mod)(*)
Microphone	Noise (dB)	RMS, Peak, GMF
Torque meter	Torque (Nm)	RMS, GMF, Peak to Peak
Angular Encoders	Transmission error (mrad)	RMS
Current sensor	Current intensity (A)	RMS, Peak, GMF
Torque meter and Angular Encoders	Power loss (W)	RMS

(*)

$$GrowthRatio = \frac{VibrationRMS(t = 120\,h)}{VibrationRMS(t = 0\,h)}$$

$$Mod = \sqrt[2]{vibRMS\_X^2 + vibRMS\_Y^2 + vibRMS\_Z^2}$$

Table 1 Reported values by sensors

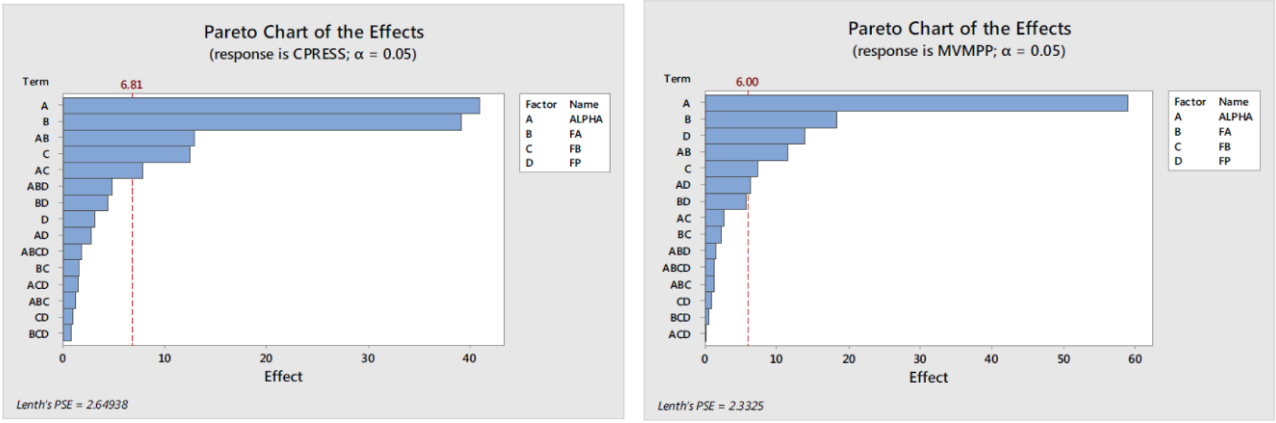


Figure 5 Effect of manufacturing errors in Contact Press -CPRESS and Maximum Von Mises stress on Pinion -MVMPP

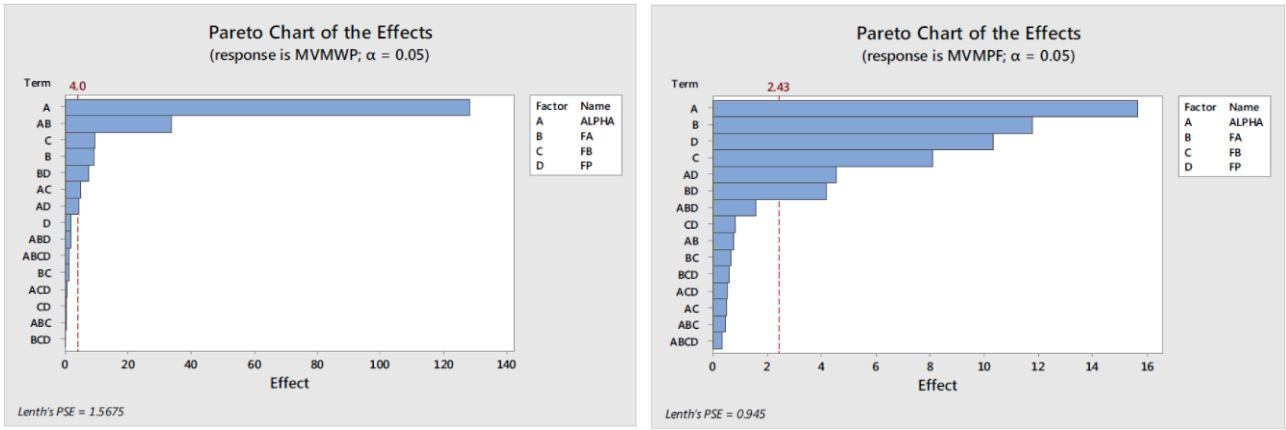


Figure 6 Effect of manufacturing errors in Maximum Von Mises stress on Wheel -MVMWP and Maximum Von Mises stress on Pinion Fillet -MVMPF

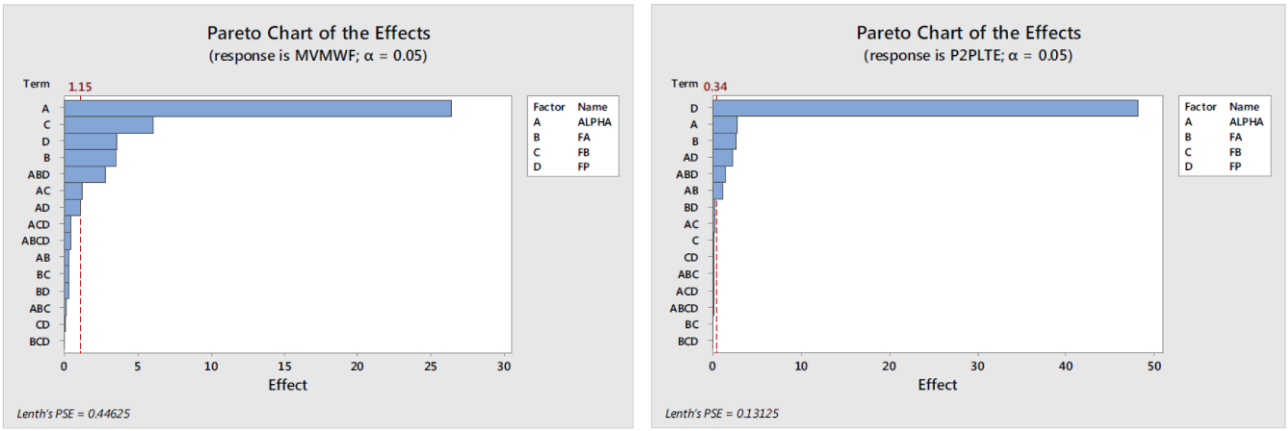


Figure 7 Effect of manufacturing errors in Maximum Von Mises stress on Wheel Fillet MVMWF and Peak-to-Peak Loaded Transmission Error -P2PLTE

Figure 8 R^2 (adj.) for each effect

Factor or Interaction factor	Number of times it appears	Number of times it appears as main factor and effects where that factor had the main interaction
α	10	6 (vibration RMS growth ratio in Z, vibration RMS at 2000 rpm in X, Y and Z, Vibration GMF at 1000 rpm in Y, noise at 2000 rpm)
Fα	4	1 (vibration RMS at 1000 rpm in Z)
Fβ	3	0
Fp	6	5 (Peak to peak transmission error at 100, 1000 and 2000 rpm, RMS transmission error at 1000 rpm, Torque 100 rpm)
α-Fα	5	0
α-Fβ	6	0
α-Fp	3	0
Fα-Fβ	1	-
Fα-Fp	2	1 (GMF vibration in Z at 100 rpm)
Fβ-Fp	2	0

Table 2 Relevance of each factor in the regression analysis

Figure 9 Results from DOE 1

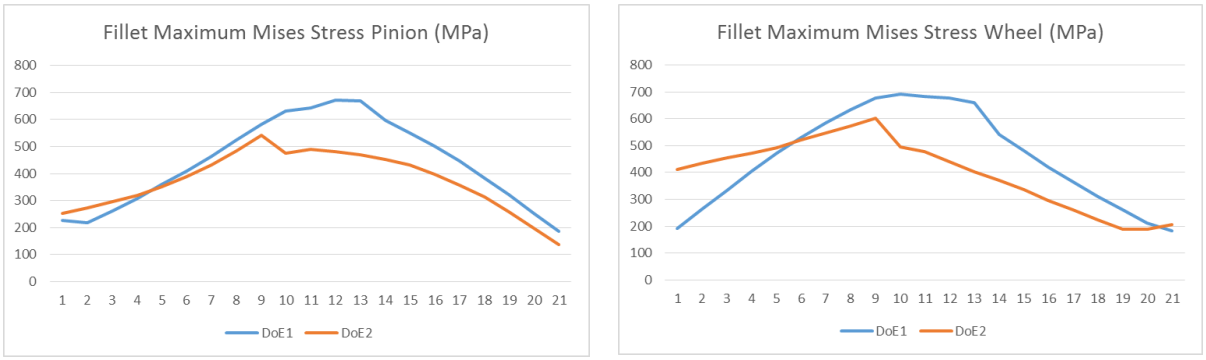
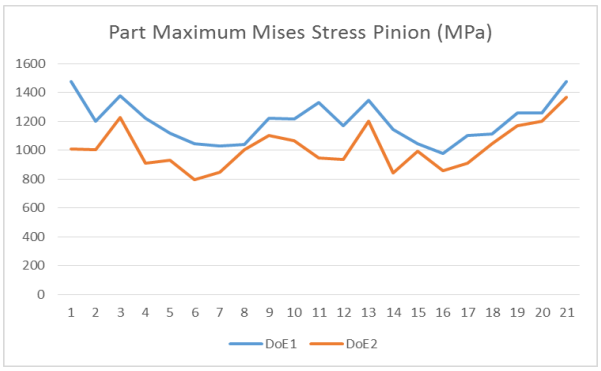


Figure 10 Fillet Maximum Mises Stress at Pinion and Wheel 20º



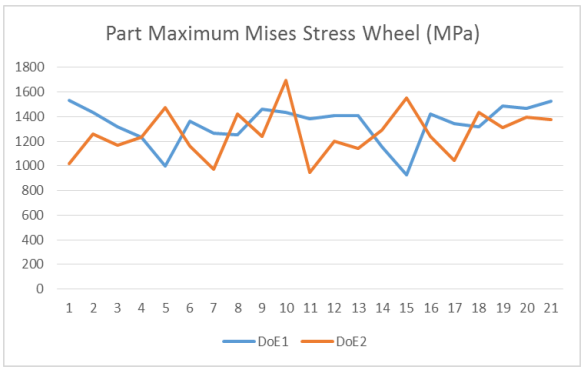
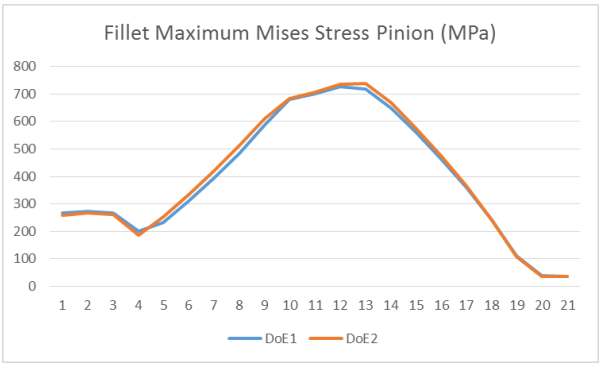


Figure 11 Part Maximum Mises Stress at Pinion and Wheel 20º



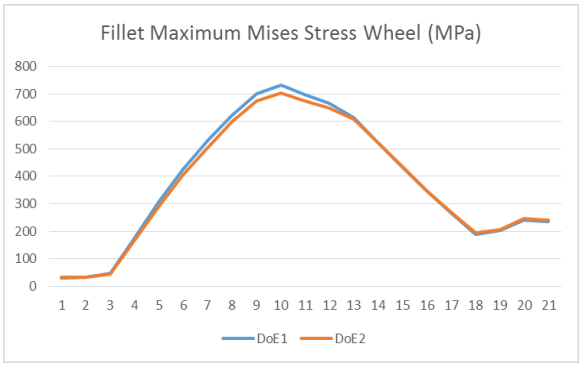
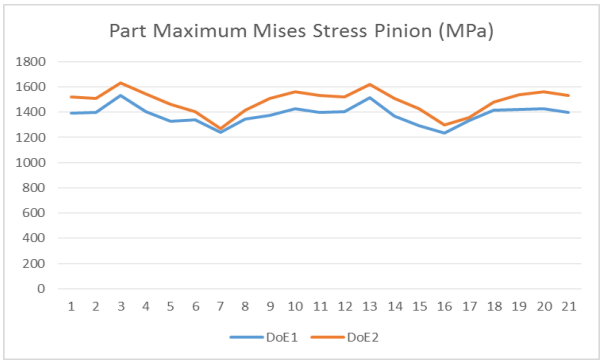


Figure 12 Fillet Maximum Mises Stress at Pinion and Wheel 22.5º



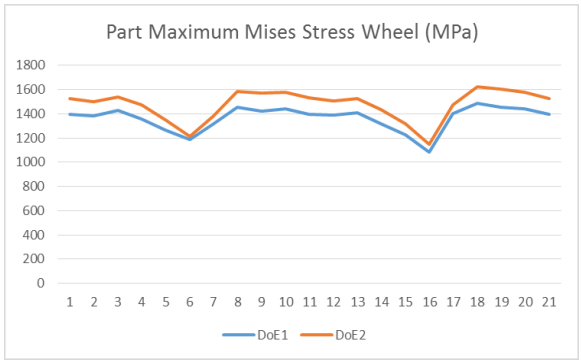
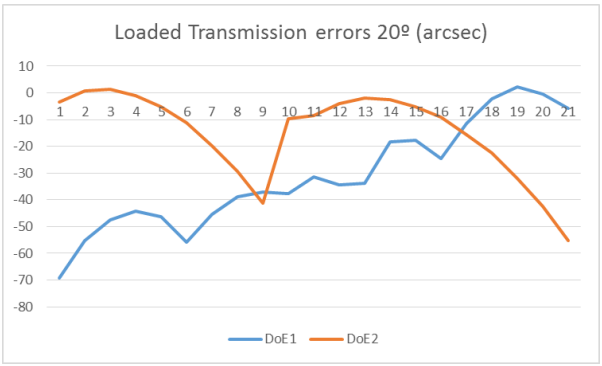


Figure 13 Part Maximum Mises Stress at Pinion and Wheel 22.5º



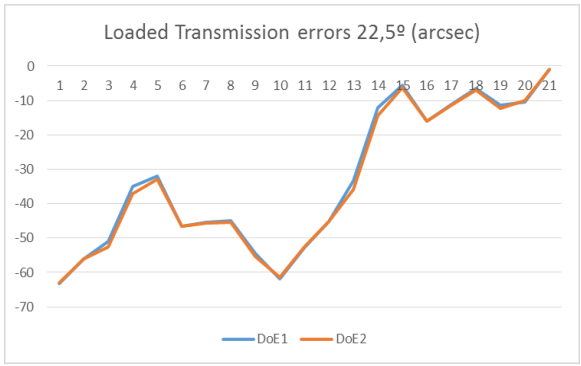


Figure 14 Transmission errors at 20º and 22.5º for DoE1 and DoE2

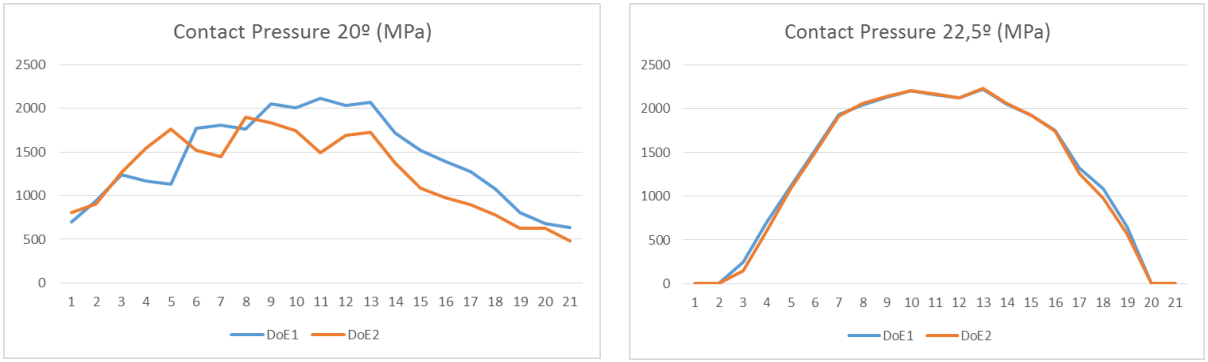


Figure 15 Contact Pressure at 20º and 22.5º for DoE1 and DoE2