



# FATIGUE TESTING OF THE 4 STUDIED STEELS AND SURFACE HARDENING TECHNOLOGIES

Eachen, April 08th, 2025

Final Workshop

Lateana – CRF



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for Coal and Steel under grant agreement No 101033989

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## General Overview

- Heat Treatment and Material selection
- Tribological assessment: scuffing phenomena
- Fatigue assessment: plane bending tests



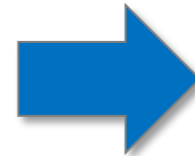
# FATIGUE TESTING OF THE 4 STUDIED STEELS

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- Tribological assessment: scuffing phenomena
- Fatigue assessment: plane bending tests



Conventional gear - ICE



new generation gear - EV

	STEEL MATERIALS	SURFACE HARDENING TREATMENT
Reference Material	27MnCr5	Conventional Carburizing

	STEEL MATERIALS	SURFACE HARDENING TREATMENT
Investigation	21NiCrMo2	LPC-WMQ
	35MnVS4	NITRIDING
	35MnVS4	NITROCARBURIZING
	42CrMo4	NITRIDING
	42CrMo4	NITROCARBURIZING

## General Overview

- Heat Treatment and Material selection

	Test n.1	Test n.2	Test n.3	Test n.4	Test n.5
Steel Alloy	20NiCrMo2	35MnVS4	35MnVS4	42CrMo4	42CrMo4
Heat Treatment	LPC-WMQ	Nitriding	Nitrocarburizing	Nitriding	Nitrocarburizing
Hardness Surface* (HV)	700-900	900-1200	600-900	900-1200	600-900
Hardness Core* (HV)	300-400	350-450	350-450	350-500	350-500

\*expected value after heat treatment

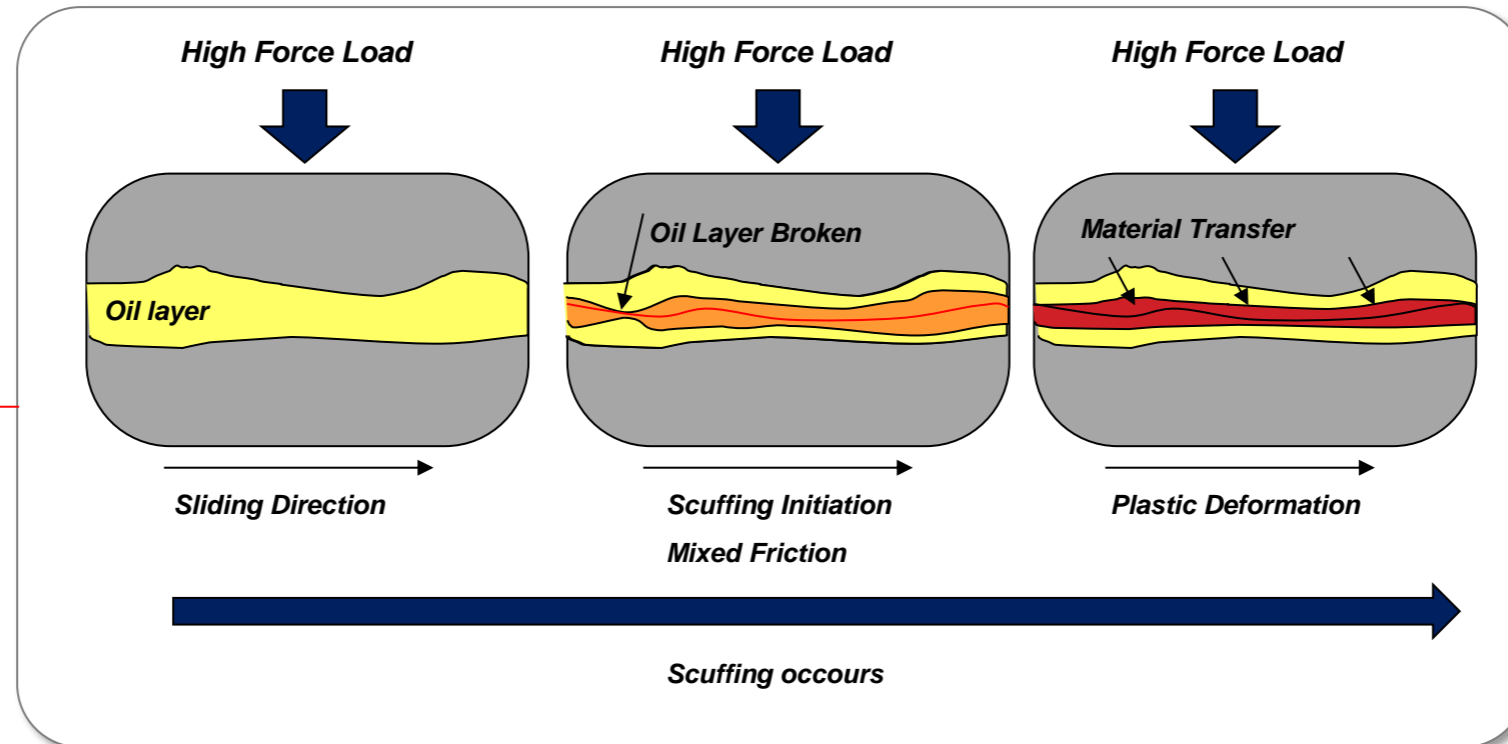
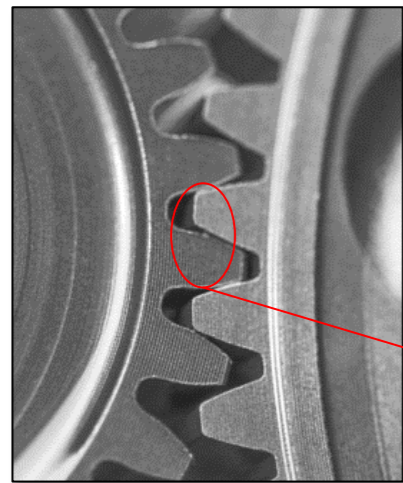
# FATIGUE TESTING OF THE 4 STUDIED STEELS

## Tribological assessment

- Scuffing Phenomenon Analysis

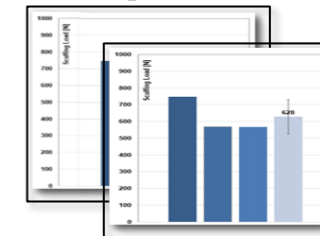
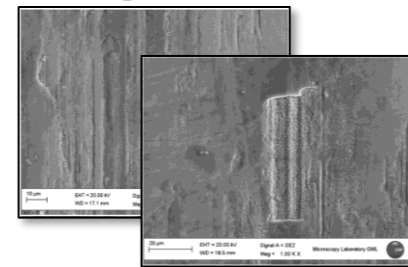
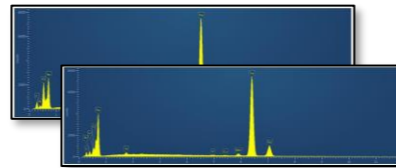
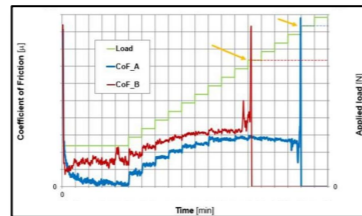
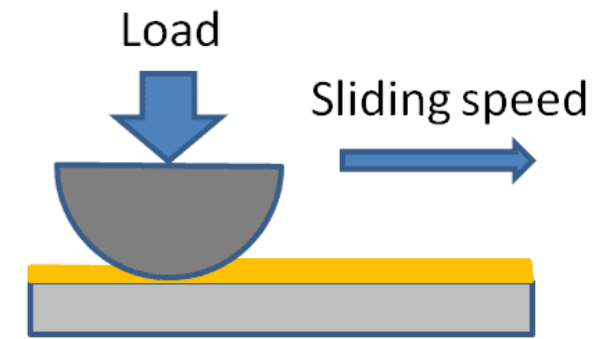


Example of scuffing phenomena



## Tribological assessment

- Scuffing Phenomenon Analysis
- Tribological Setup to Reproduce a Lubricated Sliding Wear Test (Block-on-Ring Configuration)
- Surface Wear Resistance Evaluation and Friction Force Measurement
- Representative X-ray microanalysis (SEM-EDS) and 1000x the micrograph material

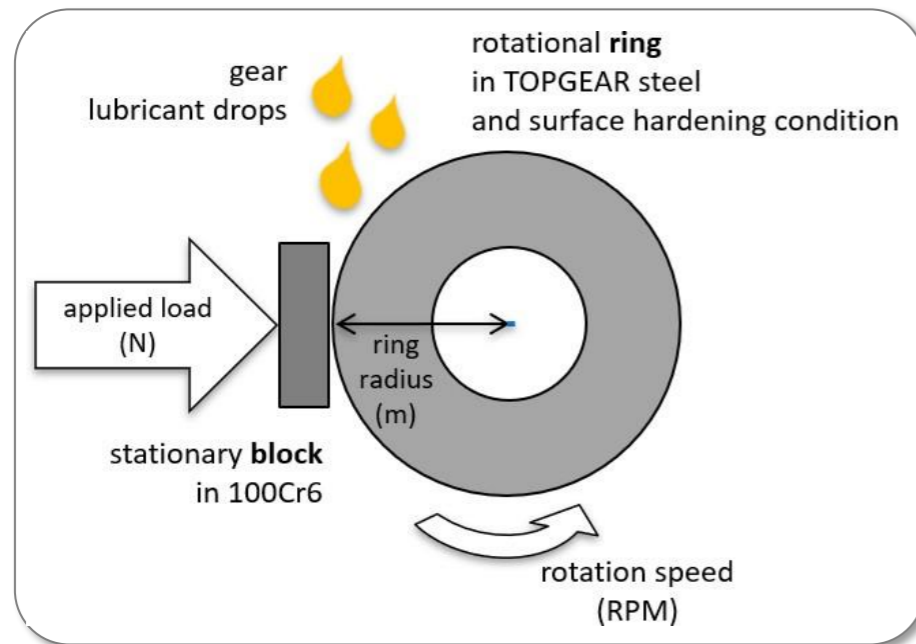


## Tribological set up

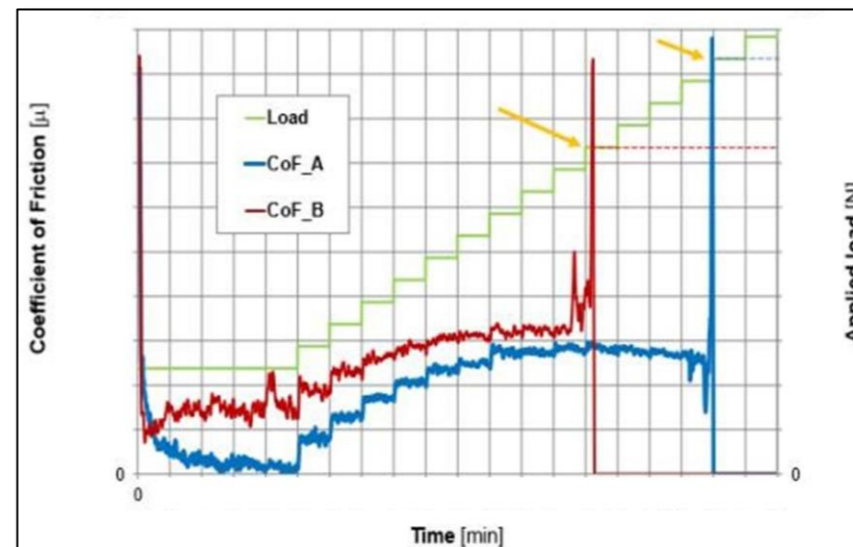
- Tribological Setup to Reproduce a Lubricated Sliding Wear Test (Block-on-Ring Configuration)
- Surface Wear Resistance Evaluation and Friction Force Measurement



Experimental Lab configuration



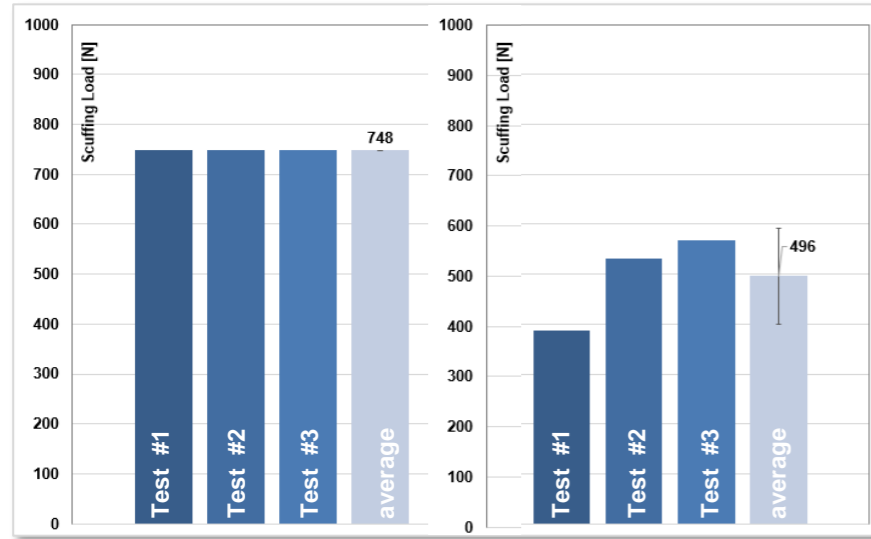
Tribological Set-up



Example of correlation between progressive load VS Friction coefficient

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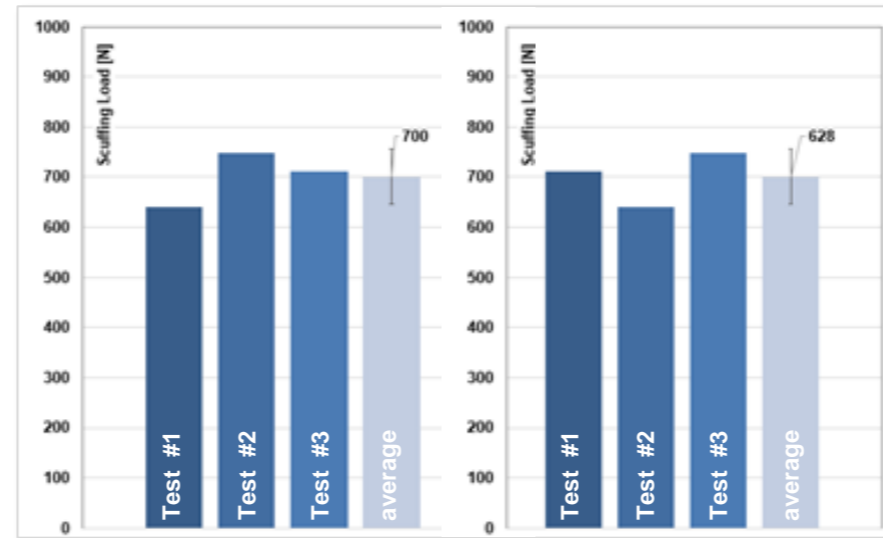
## Tribological results



35MnVS4

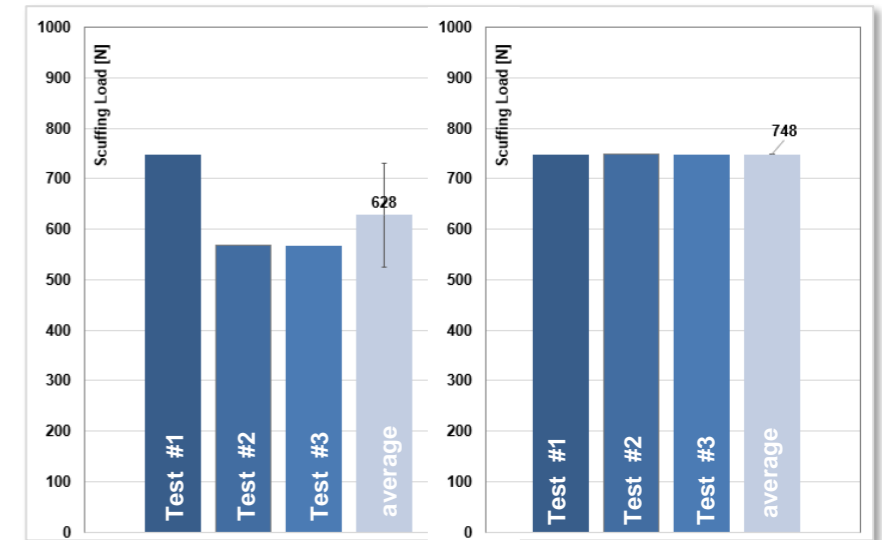
42CrMo4

NITRIDING



27MnCr5  
LPC

21NiCrMo2  
LPC-WMQ



35MnVS4

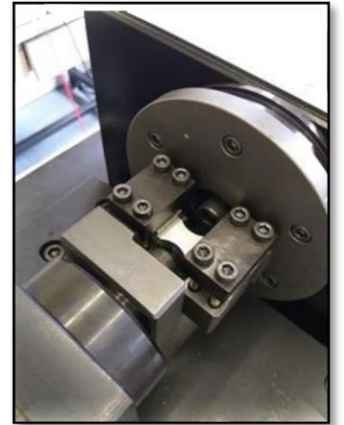
42CrMo4

NITROCARBURIZING

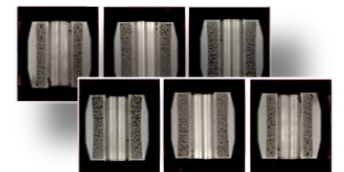
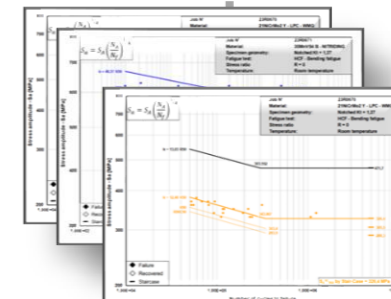
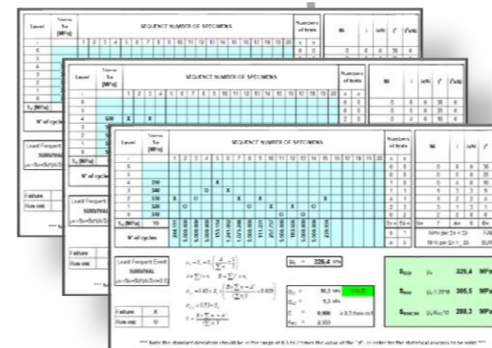
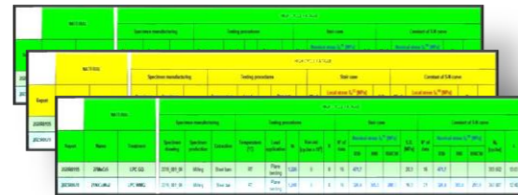
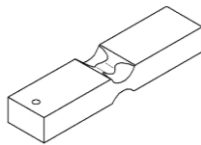
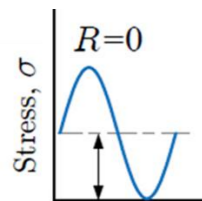
# FATIGUE TESTING OF THE 4 STUDIED STEELS

## Fatigue assessment

- Fatigue limit determination on plane bending fatigue configuration
- Specimen tested for each heat treatment and steel configuration
- Before test: residual stress status, hardness and metallurgical analysis
- After test: fractures examined (Light Optical Microscope and Scanning Electron Microscope)
- Specific specimen geometry, Staircase method (ISO12107)

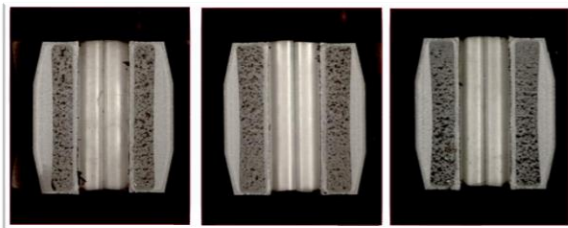
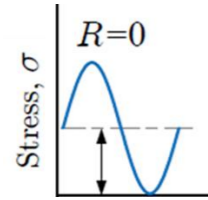


Electromagnetic driven resonator

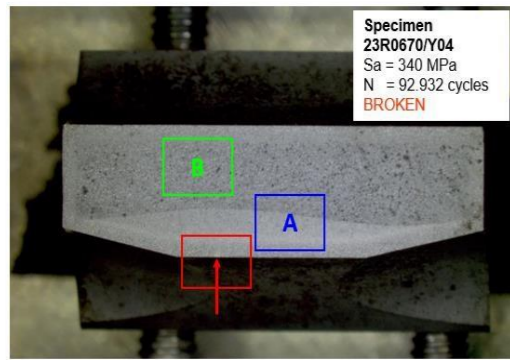


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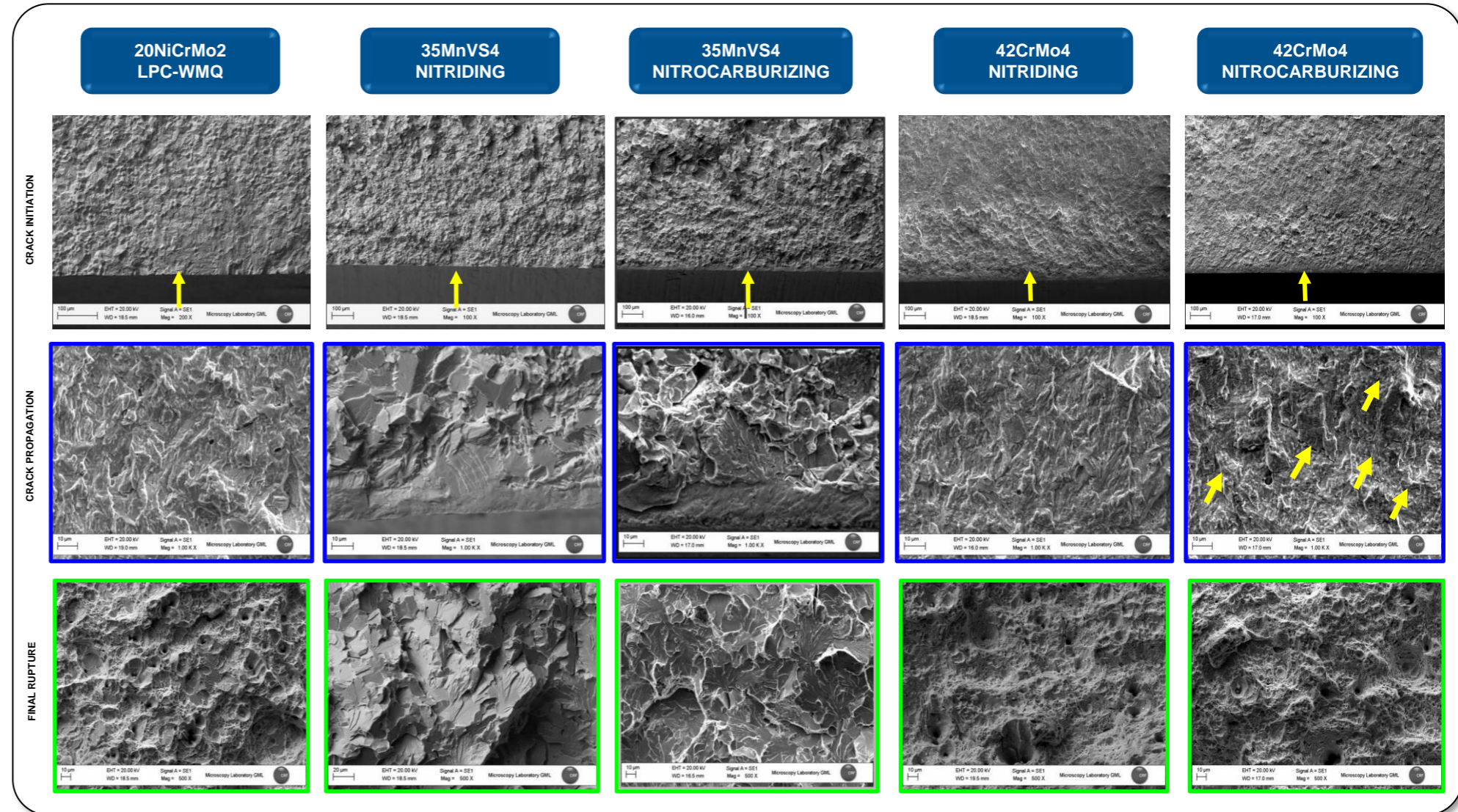
## Fracture morphology comparison



Example of Failed specimen

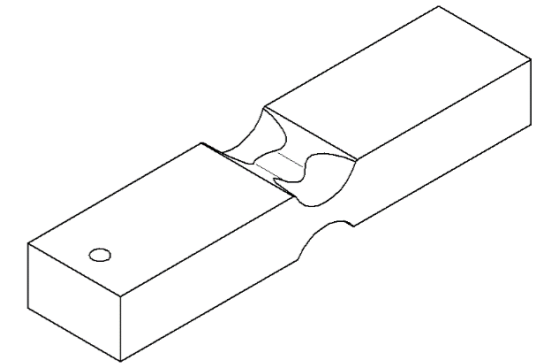
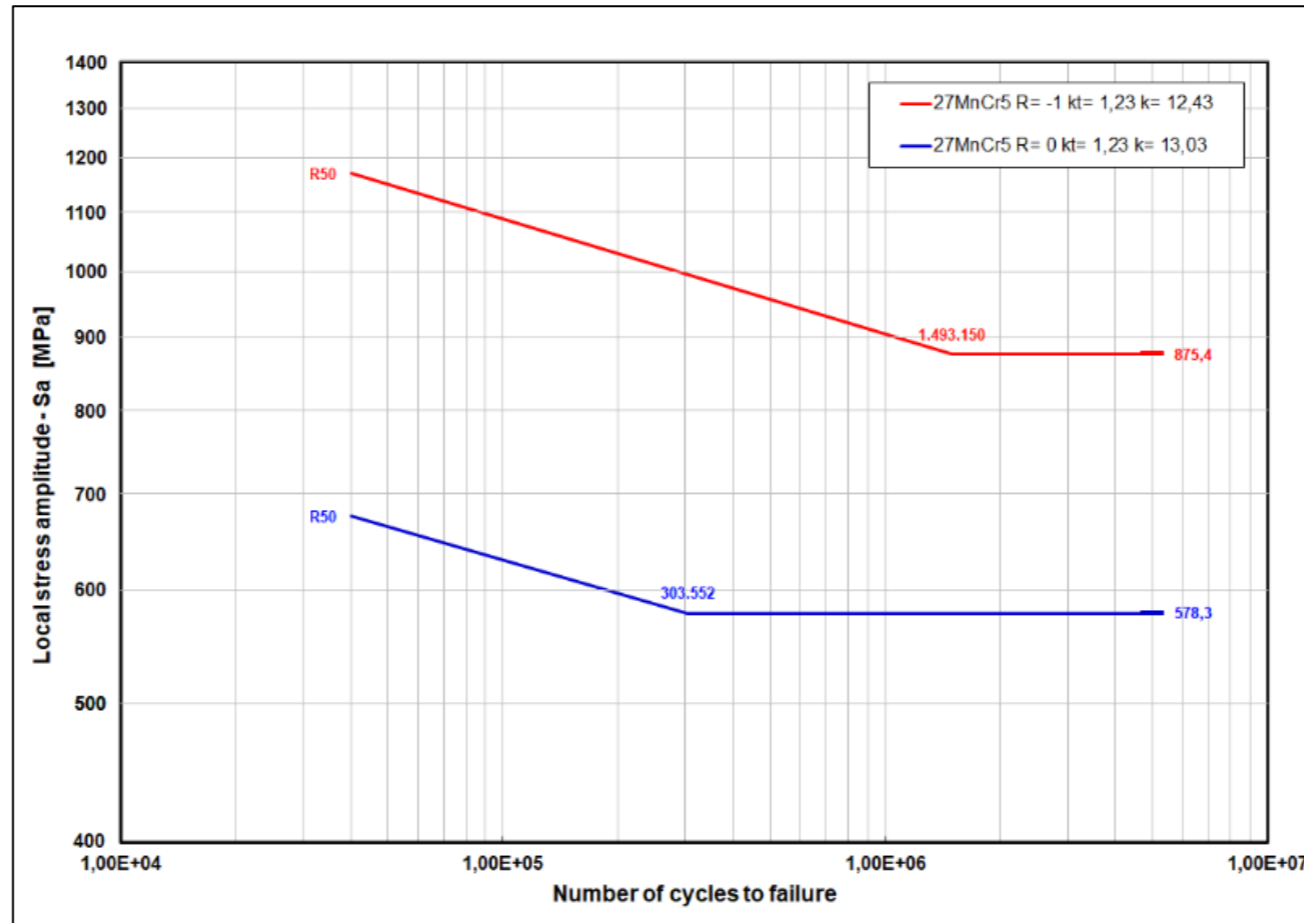


Example of Fractographic analyses



## Fatigue reference material

### 27MnCr5 – Local Stress R = -1 vs. R = 0



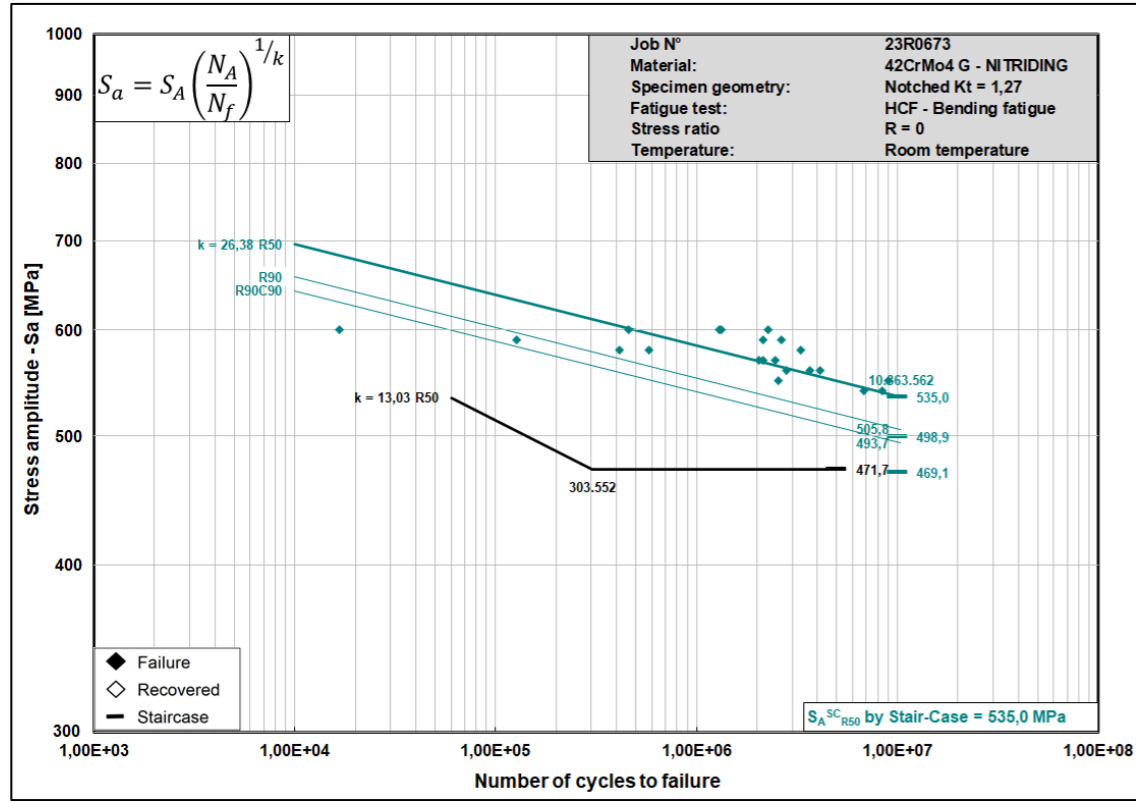
Specimen for HCF test  
Drawing 2016\_001\_06 (kt = 1,27)

### Carburized Plane bending HCF and Testing results

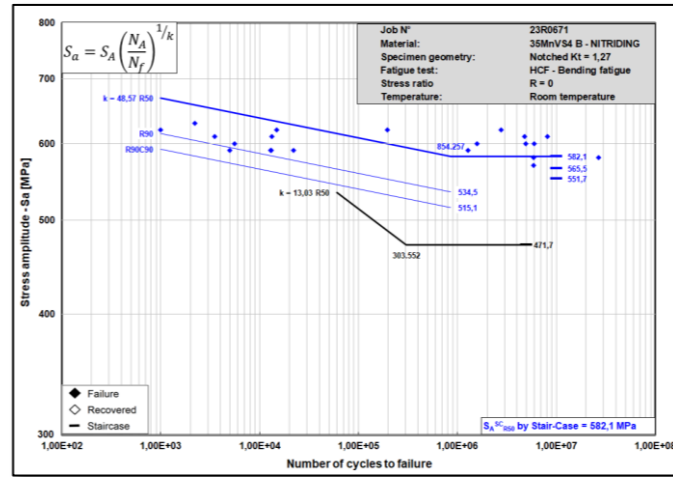
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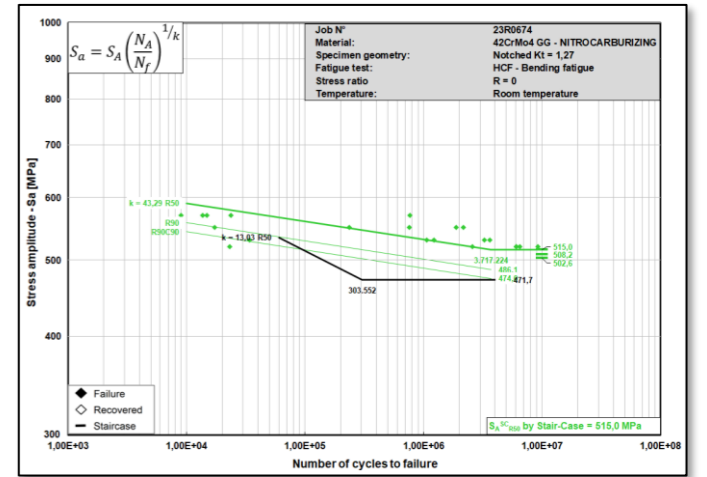
## Fatigue behavior comparison (R 0)



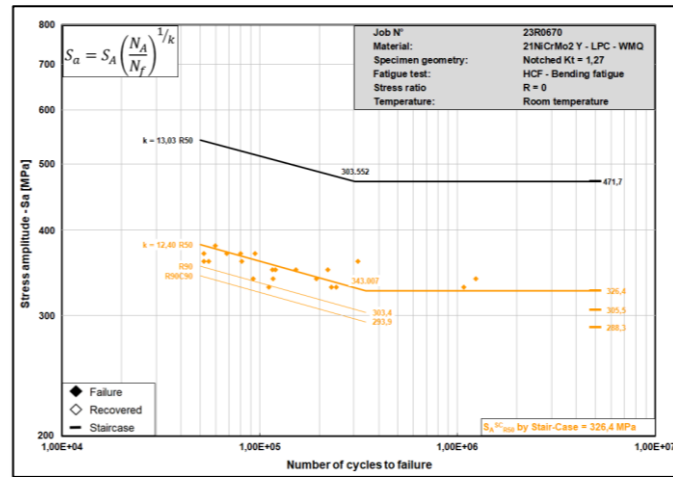
**42CrMo4  
NITRIDING**



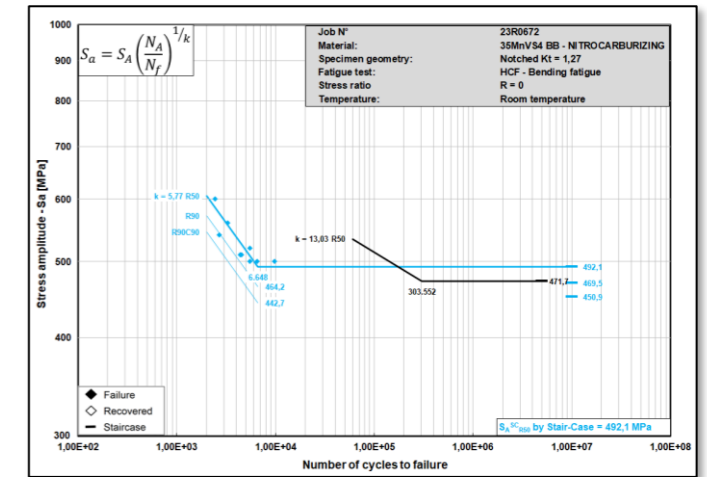
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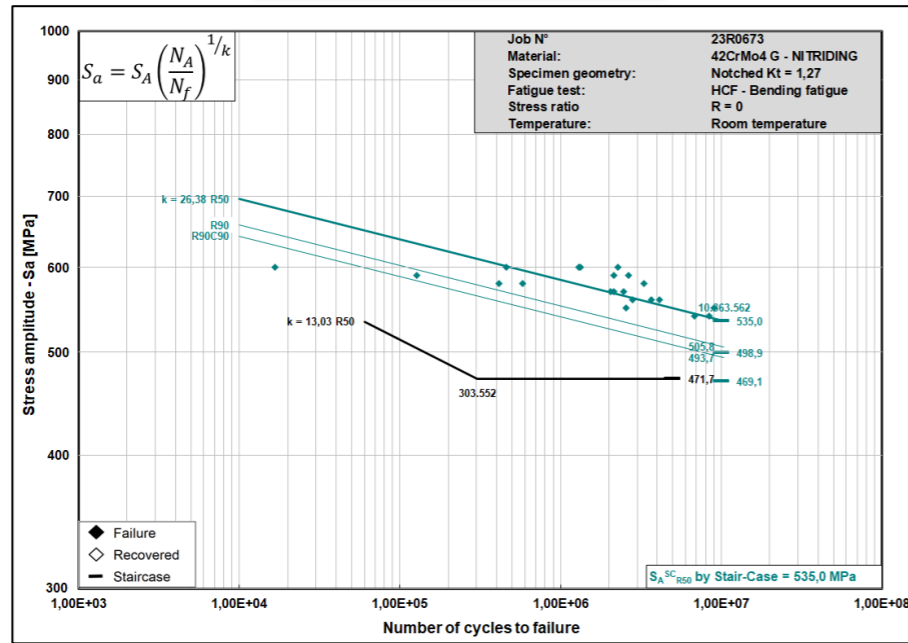
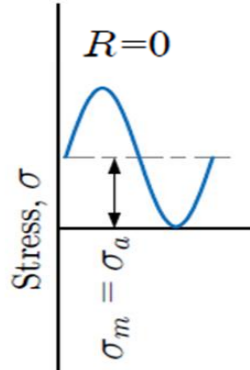
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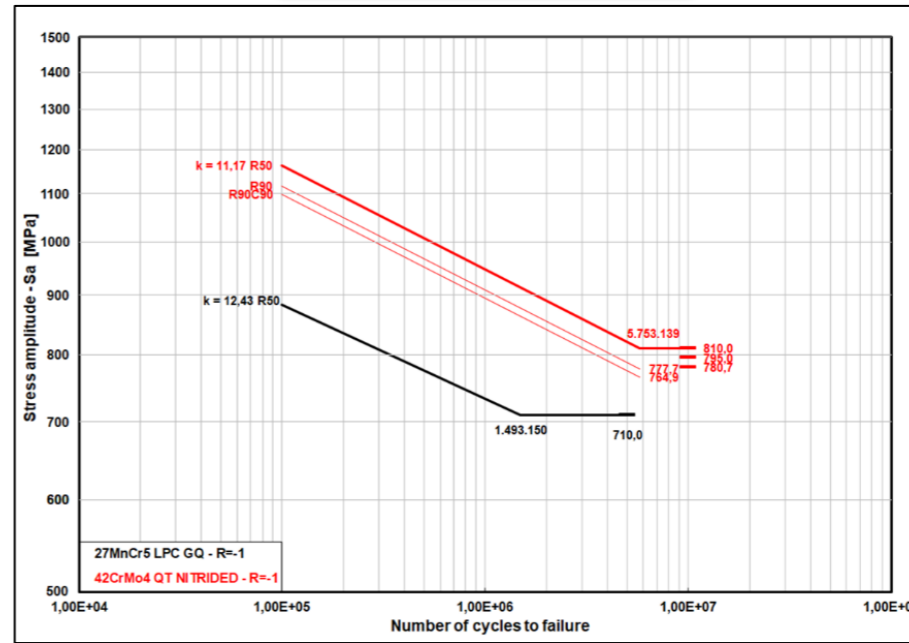
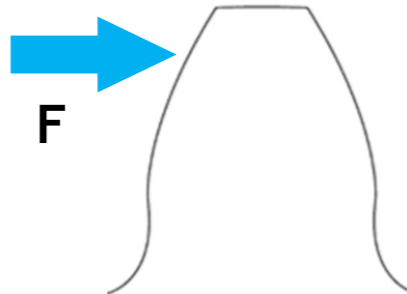
## Fatigue behavior comparison (R 0 and R -1)

42CrMo4  
NITRIDING

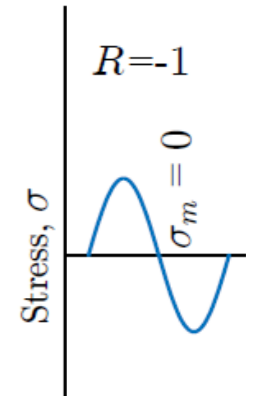
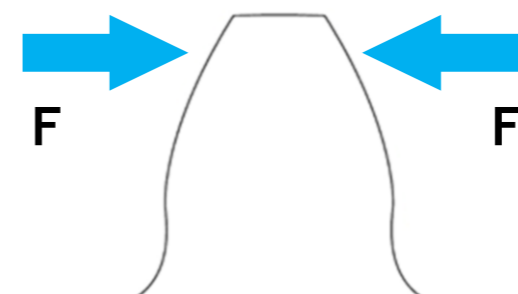
42CrMo4  
NITRIDING



R 0



R -1



## Conclusion

- Identification of Material and Heat Treatment

	Test n.1	Test n.2	Test n.3	Test n.4	Test n.5
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**Thank you for your attention!**

[www.topgear-project.eu](http://www.topgear-project.eu)



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