Surface Development of Trailing Arms During Fully Automatic Production: Challenge and Innovation

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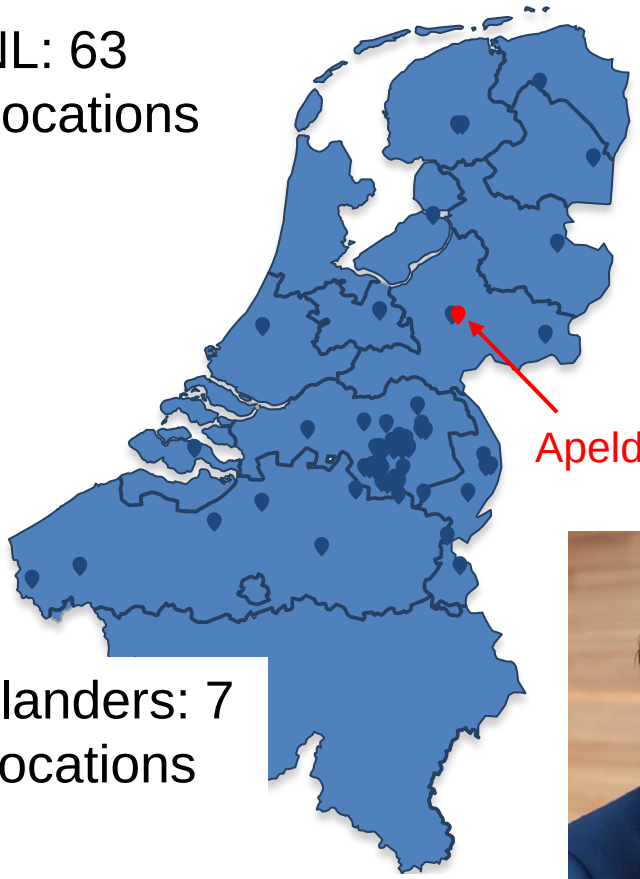
4TU Joint Workshop: Surfaces, Interfaces & Coatings

VDL Group 31-12-2019: VDL Weweler is a VDL company

NL: 63
Locations



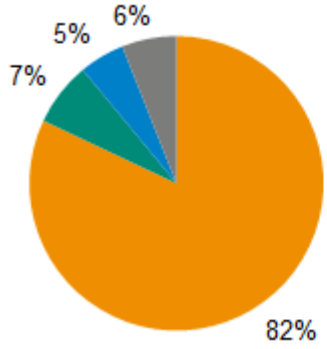
Flanders: 7
Locations

Total: 104 companies

Turnover: 5.780 M€

Weweler : 184

The number of employees:



Netherlands	12,944
Belgium	1,063
Other European countries	778
Other countries worldwide	949
Total	**15,734**

VDL Group has 4 divisions:

- Subcontracting
- Car Assembly
- Buses & Coaches
- Finished products

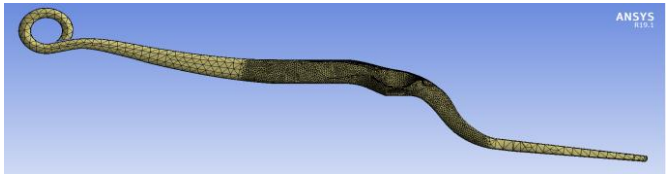
VDL Weweler B.V.

- 1924: Established by Mr. Dirk Weweler
- 1948: Production facility opened in Apeldoorn
- 2001: Weweler Group was taken over by VDL Group
- 2014: Moved from Kayersdijk to Ecofactory

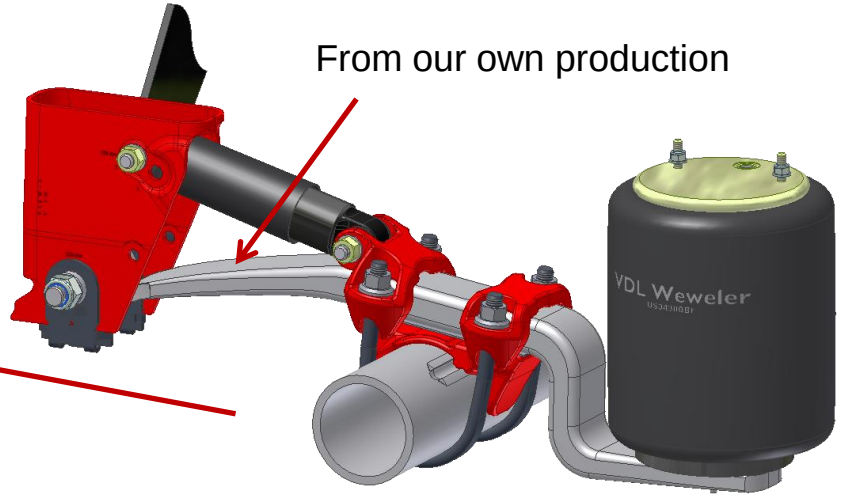
Kayerdijk, 1970’

Ecofactory, 2014

VDL Weweler Products



From our own production



VDL Weweler BV develops, produces and sells various air suspension systems (>100 types) in Europe (~40% market share) and in the world (~ 20% market share) for trailers, trucks and buses.

Fully automatic production lines

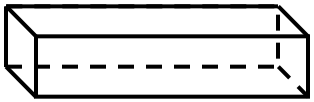
Industry 4.0 –
smart industry

- Production time per trailing arm reduced from 5 days to 5 hours
- Robot is part of process; improved grippers
- Internal transport via AGV in forklift-free zone

Process Flow

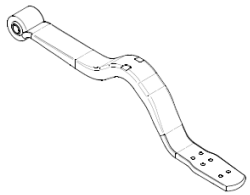
51CrV4 steel
~ 49 x 95 x 975 mm

C	Si	Mn	P	S	Cr	Ni	Mo	V	Cu	Al	Sn
0.54	0.22	0.98	0.010	0.011	1.15	0.13	0.03	0.14	0.19	0.010	0.012



Induction heating → Descaling → 3D Hot rolling

Eye-making → Punch and Hot-bending



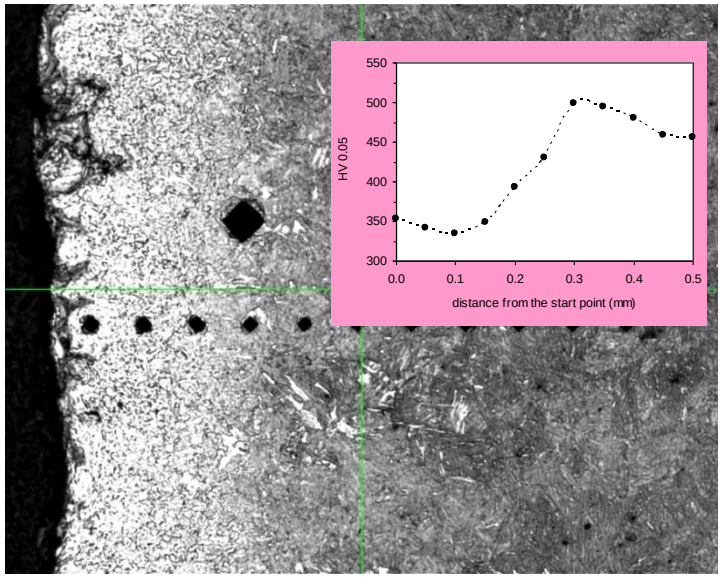
Austenitization → Quench, Tempering and Cleaning

Shot Peening → Painting

the surface changes during almost every production step:
inevitable and challenging!

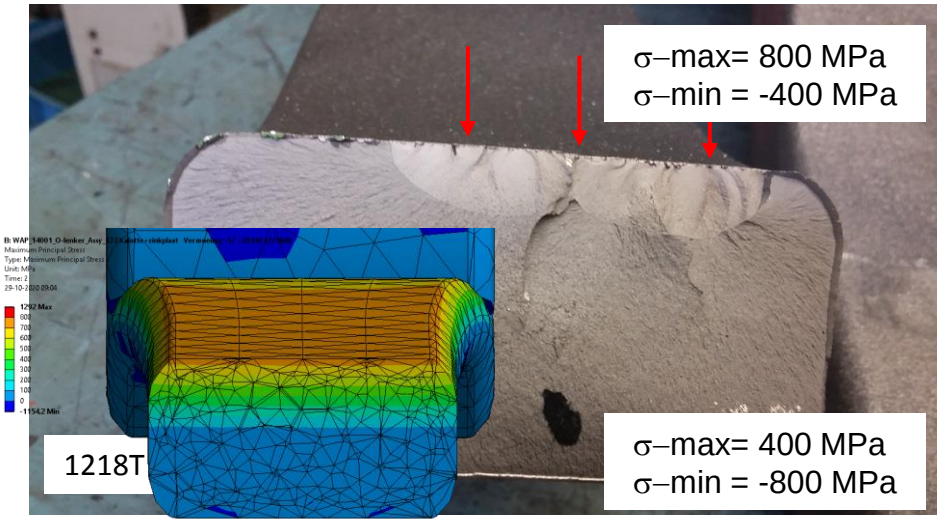
What is surface of a product?

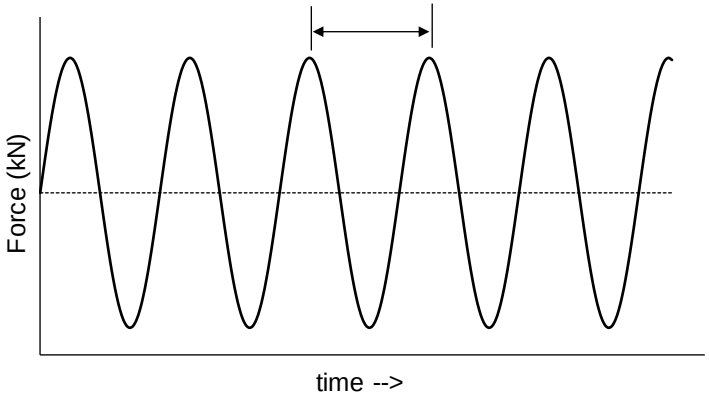
important surface factors	
outer	Smoothness
surface	Disontinuities
	Corner transition
	Cracks or/and scratch
	Shot peening coverage
	Paint layer
	Oxide and rust
	…
inner	Decarburized layer
(sub)	Internal oxide
surface	Underneath oxide
(< 1 mm)	Stress field
	(Micro) cracks
	…



Well controlled surface is not only essential for the quality of product, but also important for production.

all cracks initiated from the upper surface !

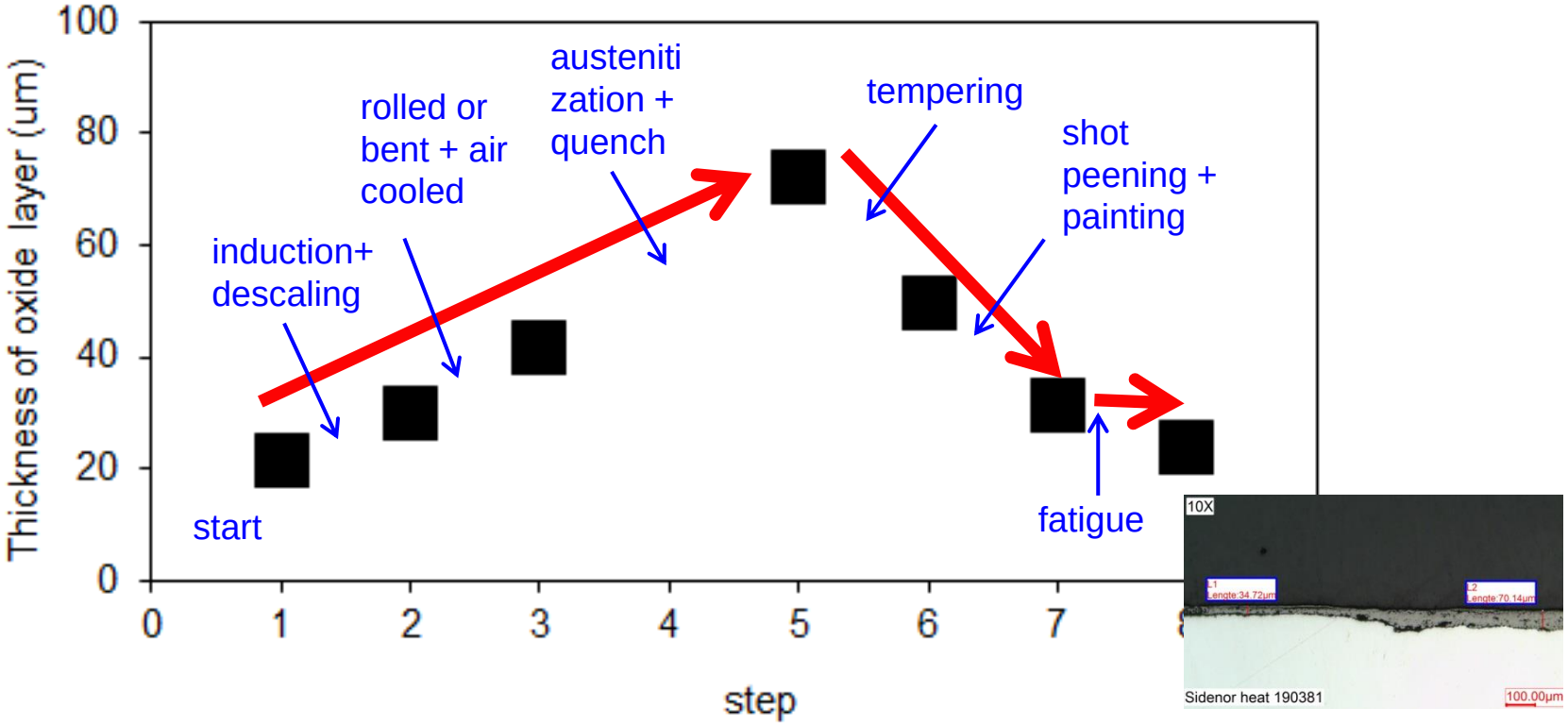




Road simulator

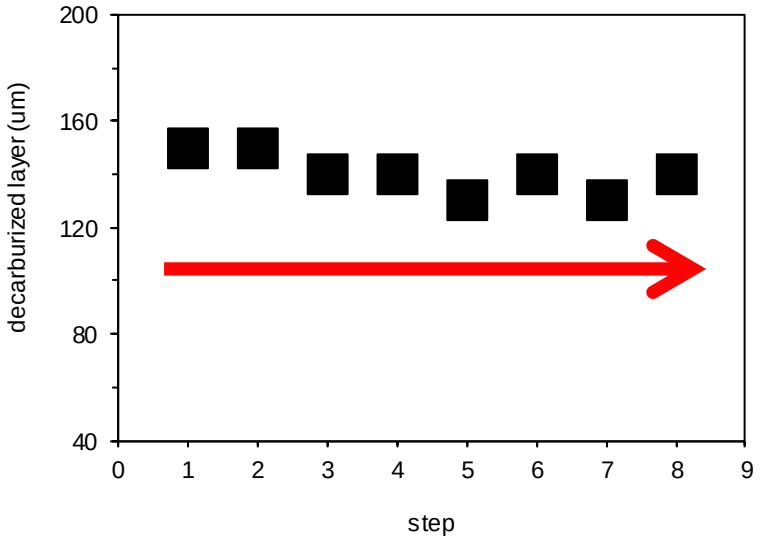
- The upper surface bears highest tensile stress, thus cracks are always initiated from the upper surface
- The cause of the crack initiation is due to surface imperfections: decarburized layer (soft surface and quenching cracks), internal or underneath oxide, corner transition, surface discontinuities.

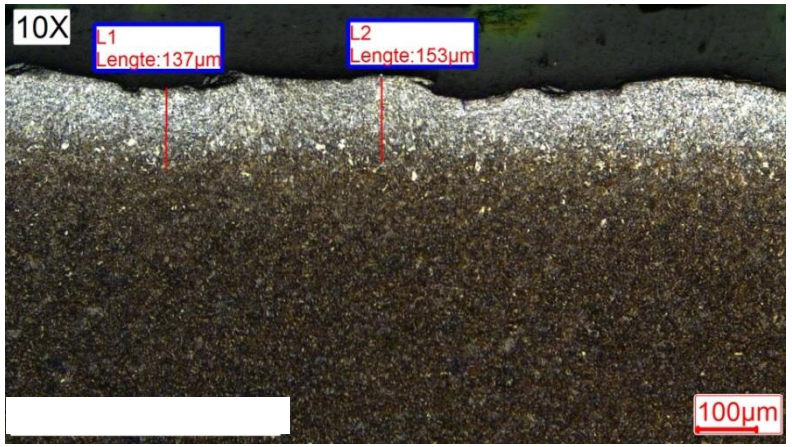
Oxide development during production



- The thickness of oxide is not uniform (each point of the average of 10 locations) and oxide layer itself is not homogeneous (with a sponge type microstructure)
- Significance for our process: 10 um-thick oxide -> ~ 20 g per trailing arm -> 20 kg/day
- Internal oxide could act as the initiation point of fatigue crack

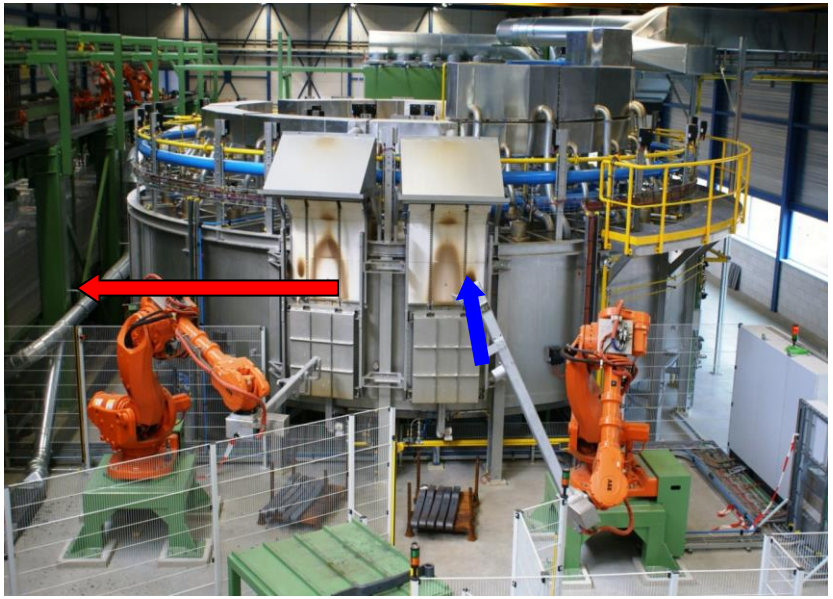
Decarburization during production





- The decarburized layer normally does not change during our processing.
- All layers are only partially decarburized.
- The thickness of decarburized layer looks uniform from microscopic photos, but Vickers hardness profile often gives a deeper layer (2 times)
- Thick decarburized layer (> 0,5 mm) can cause quenching cracks
- Certain improvement of decarburized layer can significantly improved fatigue lifetime.

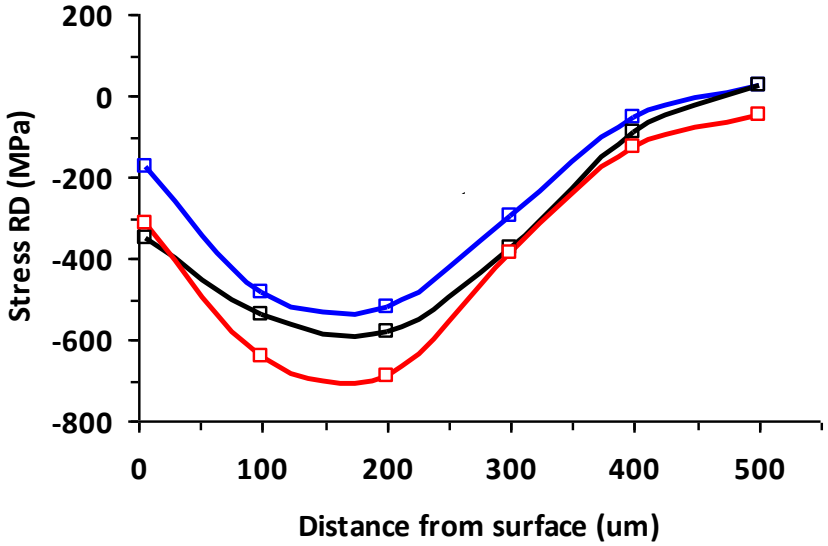
Gas carburization is impossible in automatic production line !

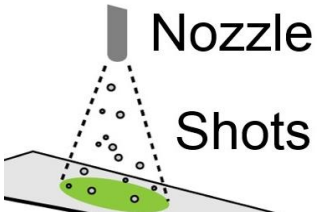


60 m^3 rotational oven

- Lab scale trials (cyanide salt, vacuum, endogas) during past decade showed proper carburization can improve the fatigue lifetimes several times.
- Due to frequent opening of the door in the oven, it is not possible to build up the required carbon potential (0,8%).
- Side-effect of endogas: significantly reduces the oxidation.
- Risks: 1) CO level; 2) soot.

Shot-peening to improve the fatigue lifetime



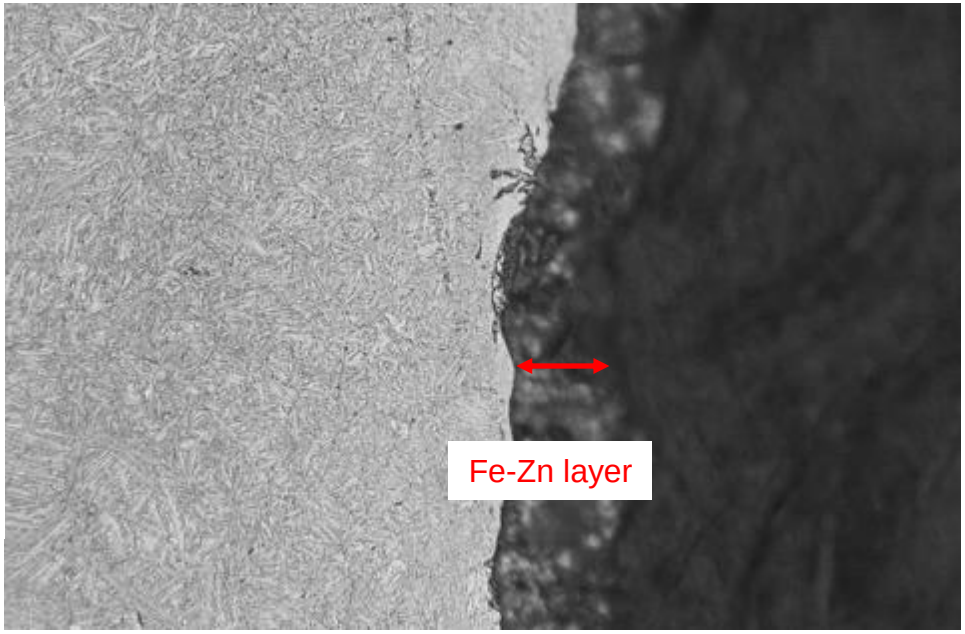


- Shot peening almost doubles the fatigue lifetimes of our products, as a compensation of the loss of decarburization
- Compressive residual stress field (CRSF) is created in a surface layer of 0,5 mm with a maximum stress at about 0,2 mm
- CRSF would be released after fatigue fracture or after reheating above 400 °C/1 hour

Sherardizing: possible to replace painting (black epoxy-ester)?

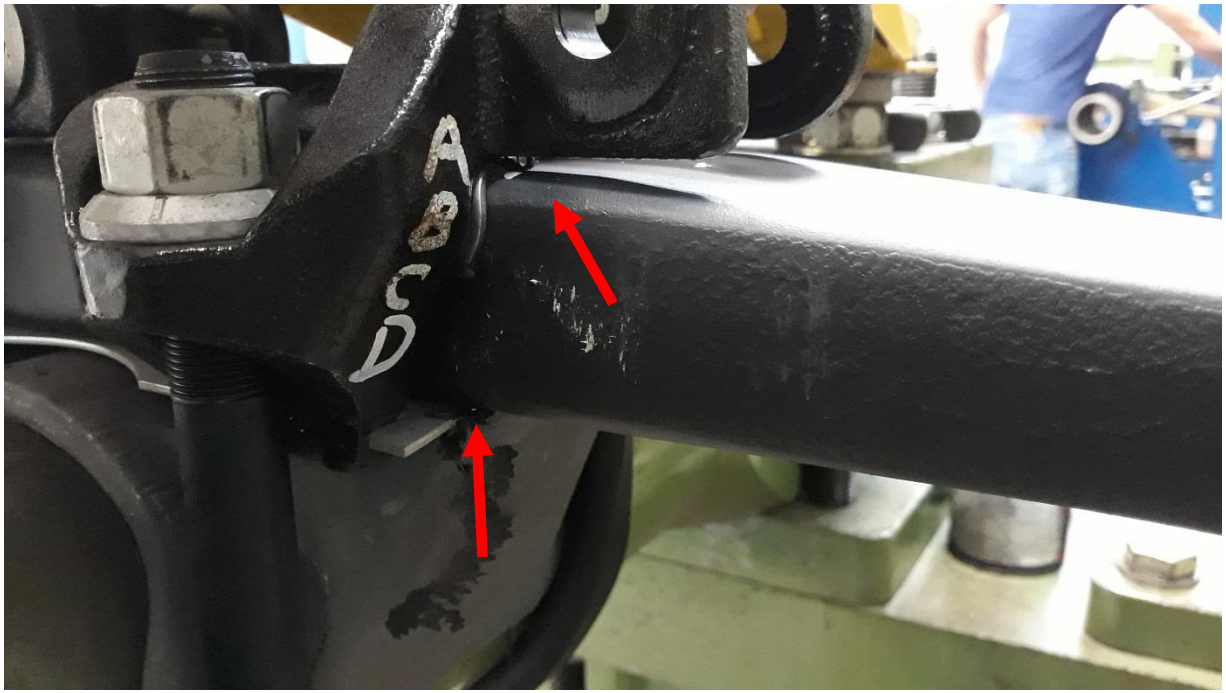
What is sherardizing?

- Zinc-coating technique
- Temperature < Tm (Zn)
- Uniform Zinc layer
- Irregular / threaded products
- Low productivity
- Low risk H-embrittlement



- Fatigue lifetime is not affected, sometimes improved.
  - *Compressive stresses from shot-peening do not destroyed*
  - *Yielding stress has been improved*
  - *(temperature for galvalizing is too high for our product)*
- Zinc layer consumed part of decarburized layer and has better adhesion to the steel.

Hydrogen-induced crack?



- Broken under clamping area is a type of failure in one of our products, not well understood yet.
- Possible mechanism: the zinc coated plate destroyed the paint -> moisture/water on the surface -> H-induced crack.

Concluding Remarks

The surface (including interphase and coating) plays an important role in our product quality and also in an effective processing.

Current innovative topics / questions:

- How to (partially) carburize our product in a relatively open atmosphere?
- Possible to replace painting by sherardizing?
- How to verify (and to prevent) H-induced crack?

Suggestions and comments? You are welcome to contact:
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