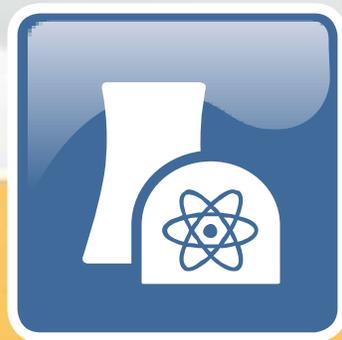


## Consequences of flexible power plant operation

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## Operational regime of coal fired plants in Germany **in the past**

- Regularly the plants had more than 7,000 full load operational hours
- Plants were only shut down for maintenance
- Creep was the main damage mechanism on the components
- Number of starts in correlation to the operational hours was low nearly no impact on lifetime consumption
- In the VGB guidelines best practices were defined to optimize:
  - Operation
  - Inspection
  - Maintenance

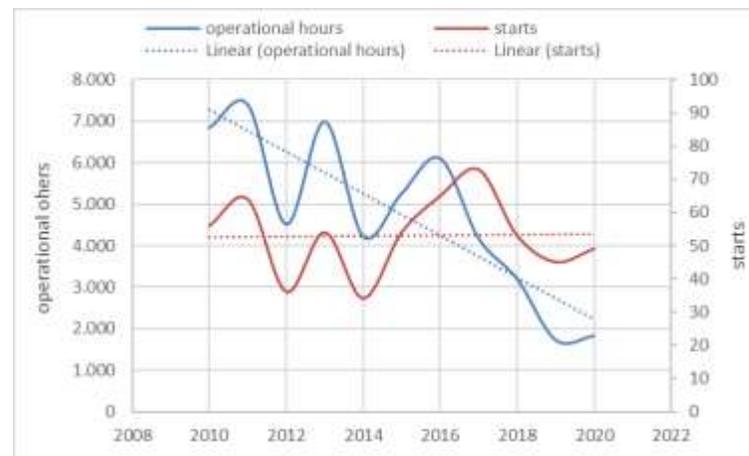
# Operational regime of coal fired plants in Germany **over the years**

- Number of starts in correlation to the operational hour is increasing → more flexible operation
- Operational hours clearly decreasing in the last decade at all locations → less creep exposure
- Number of starts very dependent on plant location → partly higher exposure
- Lifetime consumption due to cyclic exposure becomes more dominant at some locations
- Lifetime consumption at lots of the locations is not significantly influenced due to reduced operation

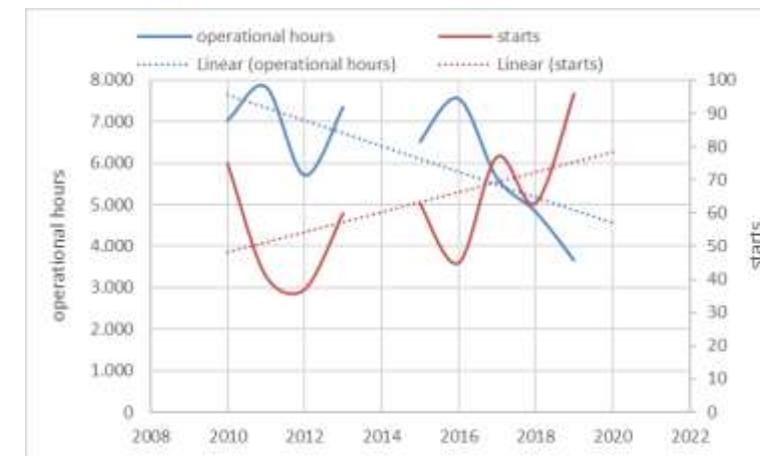
Plant A North of Germany



Plant B Mid of Germany



Plant C South of Germany



## Consequences of changing the operational regime

- Consequences are very plant depended and can differ
- For many plants no negative effect on the “yearly” lifetime consumption expected
  - Expected to reach year 2035 without “flexibility” damage
- Longer periods of non-operation → preservation concepts
- Cycling → Generally more complicated lifetime monitoring
  - Different inspection methods
  - Water Chemistry OT/AVT mode
- Some plant are more affected by cycling
- Up to now no significant increase in damages due to cyclic operation observed
  - However some specific failure occurred



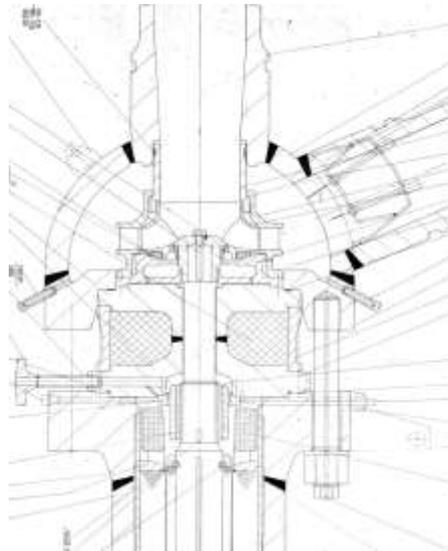
## Damage event: boiler recirculation pump

- Failure of recirculation pump led to massive damage in one plant
- Operational hours of the plant approx. 170,000 hours
- Approx. 1400 starts/stops
- Pump was inspected with conventional UT two years before
- Identification of root cause to be carried out



## Damage event: boiler circulation pump

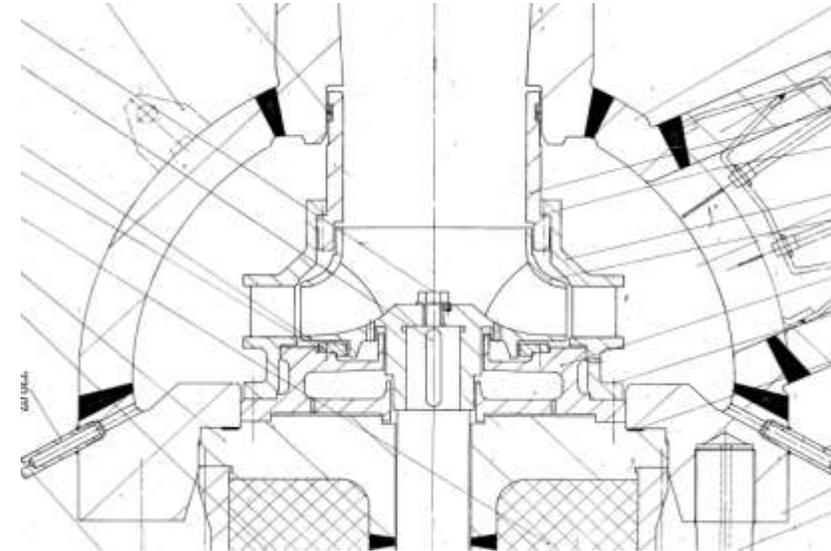
- Design of the pump not optimized for cycling operation
- 20 years of operation and changed operational regime led to damage
- Stresses are concentrated in the notch
- Many pumps with similar design were investigated



Overview drawing



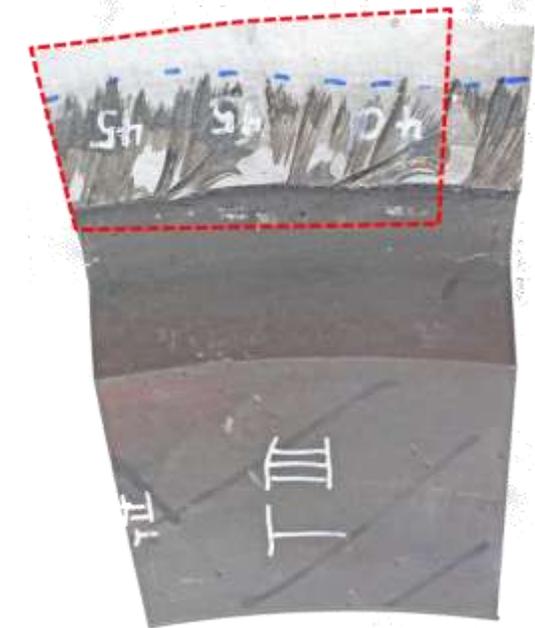
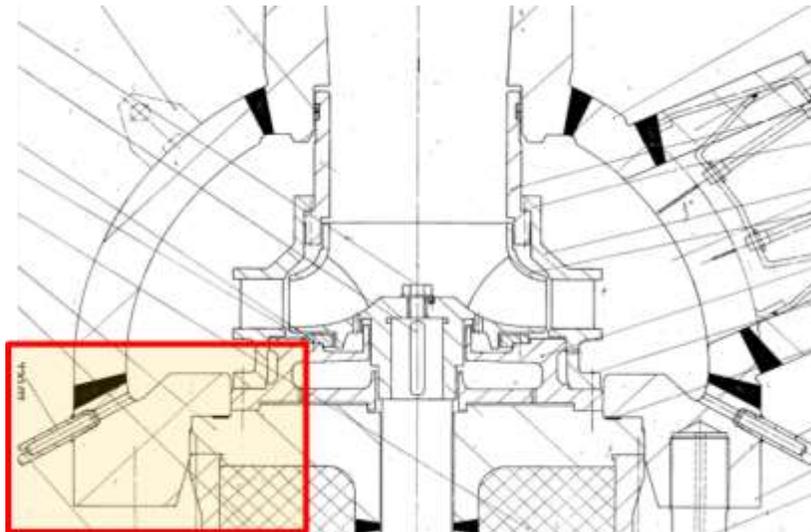
Overview picture



Detailed drawing of the casing

## Failure investigation of a damaged pump

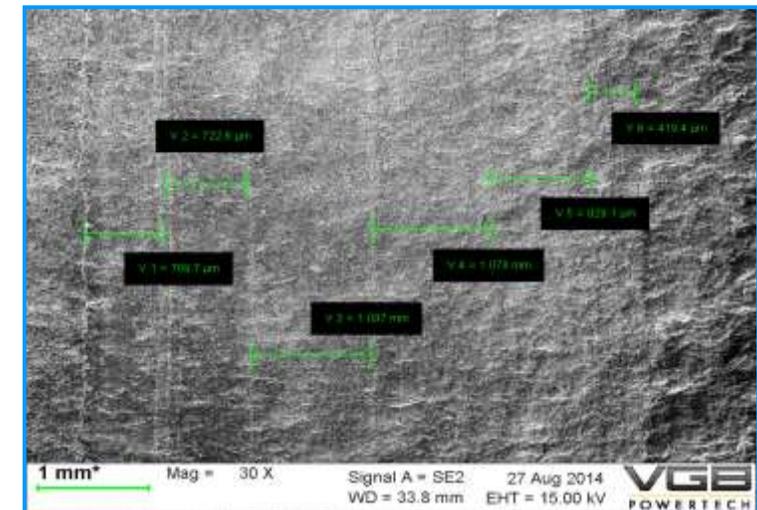
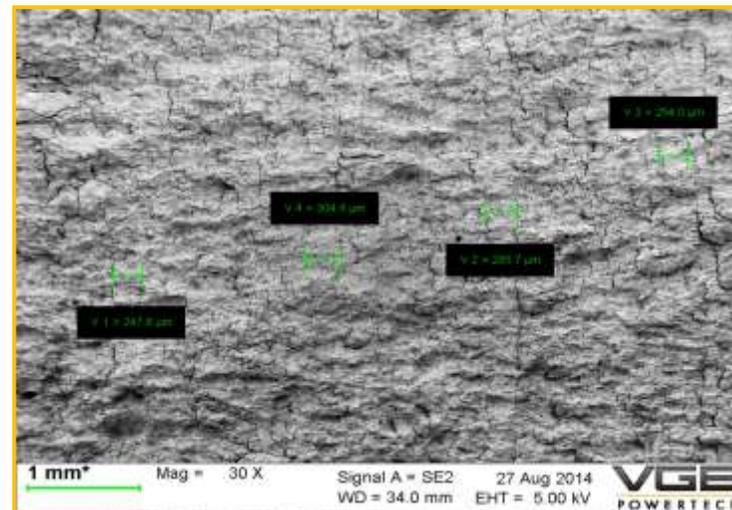
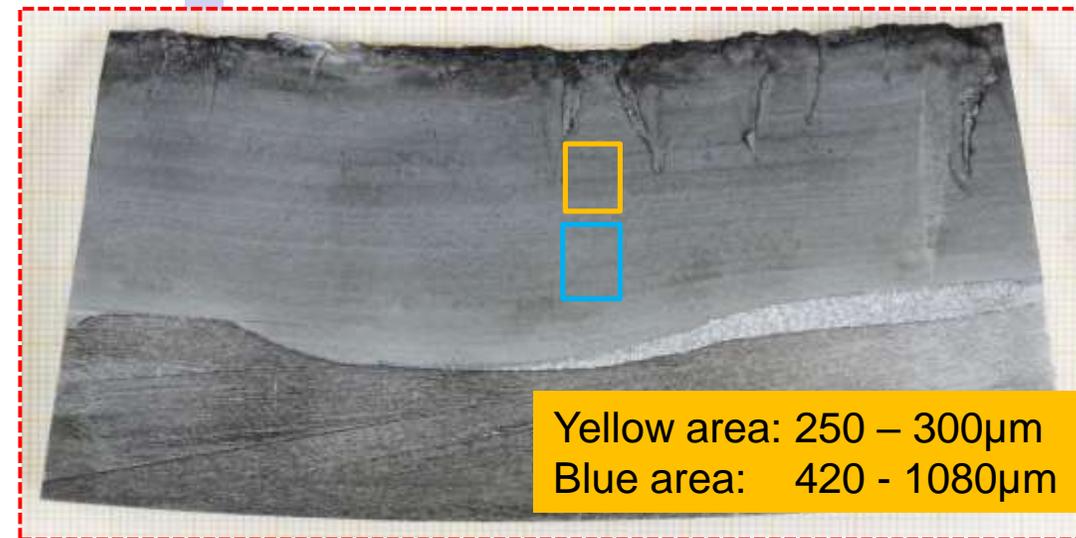
- Macroscopically clear line of crack arrest, → cyclic crack propagation
- Stresses were concentrated in the notch
- Pump was not pre-heated during periods of not operating
- Higher oxygen content present in the water allowed attack



Cleaned fracture surface

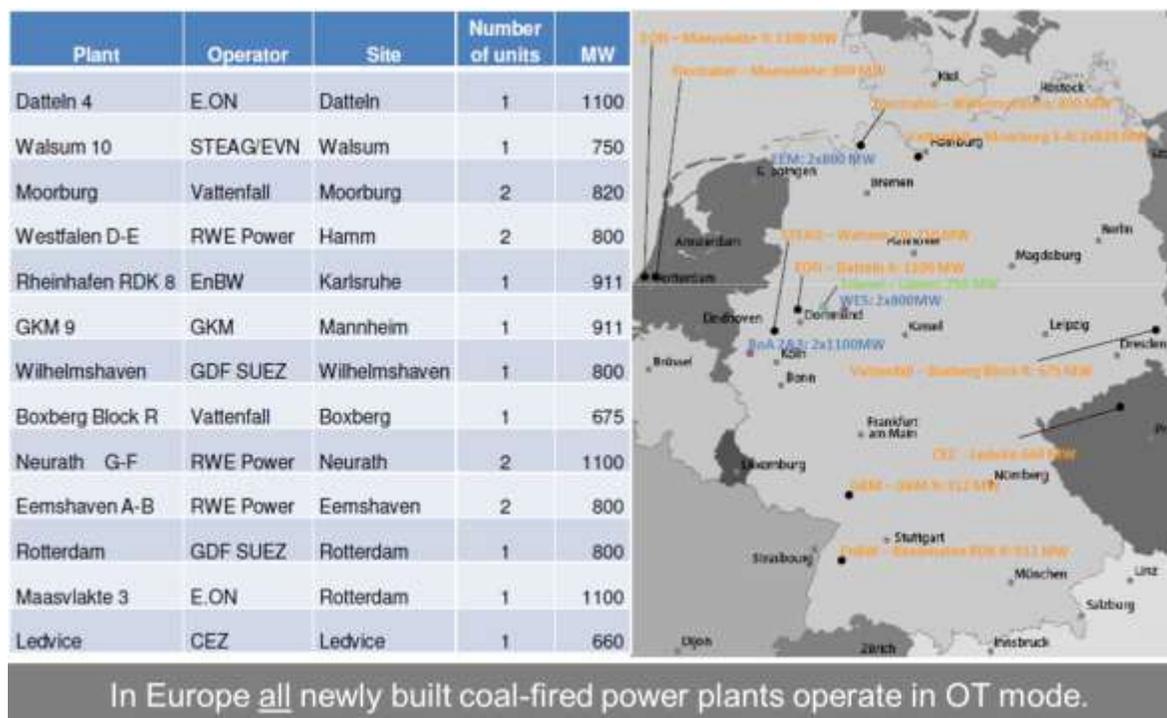
## Crack Propagation

- Crack growth per cycle differs.
- At the beginning crack propagation is less.
- The cycling operation regime of the pump has also an influence.



# New European USC Plants water chemistry for flexible operation

- Due to parameters it is necessary to operate in OT-mode
- Switch to AVT-mode before boiler is stopped
- Re-start boiler with AVT-mode and switch back to OT
- Monitor that boiler is not damaged



**Conclusion with respect to damages:**

- ✓ Several cracks are initiated in the notch
- ✓ Starting points are corrosive/oxidative attack
- ✓ Clear cyclic growth can be detected
- ✓ Clear characteristics of strain induced corrosion cracking

**Conclusion for O&M:**

- ✓ Exposure will be different from plant to plant
- ✓ Generally cyclic exposure becomes more relevant
- ✓ Different inspection methods to be applied
- ✓ Adjusting other operational parameters (e.g. water chemistry, warming-up components, preservation...)

Thank you for your attention!

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