Washing and preserving turbines with film-forming amines –

experiences with the use of Octadecylamine (ODA)

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Characteristics of Octadecylamin (ODA)

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- energy policy framework:
  - substantive development of renewable energies
  - feed-in priority of renewable energy to the grid
  - highly volatile energy production capacities
  - planned shutdown of fossil and nuclear power plants
  → Increased demand on flexible energy production capacities

- Technical consequences:
  - frequent starts and stops
  - longer periods with lower capacity
  - lowering of minimum load
  → High alternating loads and shifting of the phase transition zone especially in the low pressure part of the turbine
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- **Surface damage:**
  - pitting in consequence of standstill corrosion is a starting point for cracks
  - shifting of the phase transition zone during part or low load operation leads to droplet erosion which cause damages on the turbine blade surface

- **Waterchemistry:**
  - observe the limits vor water and steam quality is more difficult during short operation times
  - Impurities in the steam can cause deposits in areas of first condensate

- **Consequences for the turbine:**
  - Formation of hard deposits – higher power loss
  - Stress crack corrosion – risk of damages to the turbine
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Characteristics of ODA and ODACON

- **substance Octadecylamine (ODA):**
  - Long-chain, aliphatic amine with chemical structure $\text{C}_{18}\text{H}_{37}\text{NH}_2$
  - Primary amine content > 99 %
  - Waxy, solid substance, non-soluble in water
  - The substance in its pure form is not useful for industrial application.

- **ODACON Emulsion**
  - Stable, pure, watery emulsion
  - No admixtures of emulsifiers, polyacrylates or poly-a-mines
  - Does not form organic acids by thermal decomposition
  - No hazardous substance, biodegradable
  - Certified for the application in nuclear power plants
Adsorption

- Distribution coefficient nearly the same as Ammonia

- Formation of mono- / bi-molecular, diffusion-resistant and hydrophobic protective layers

- Stable connection through “Chemosorption” and ion-bonding at temperatures > 100°C
Removal of deposits

- ODACON® has a mobilizing effect on oxides and corrosion active deposits
- these deposits are gradually and carefully removed
- chloride or similar harmful substances are displaced during adsorption

Protection against stress crack corrosion even in crevices
Protection against stress crack corrosion

- Even with high Chloride concentrations in the medium, stress crack corrosion is strongly reduced by addition of ODA.

  Chloride = 10 mg/l
  Ø crack depth after 15 h:
  without ODA: $83,1 \times 10^{-2}$ mm
  with ODA: $3,0 \times 10^{-2}$ mm

  Chloride = 1 mg/l
  Ø crack depth after 39 h:
  without ODA: $58,5 \times 10^{-2}$ mm
  with ODA: $5,0 \times 10^{-2}$ mm

- Previously damaged samples showed no progressing crack growth after they had been exposed in a dissolution of Chloride together with ODA.
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Turbine cleaning with ODA

procedure:

- **On-line cleaning / during shutdown**
  ODA is injected in feedwater or directly in the steam in front of the turbine during normal operation.

- **Cleaning with saturated steam:**
  Nach the turbine is washed with ODA treated wet steam after the shutdown of the turbine

- **Wet cleaning with turning gear:**
  Turbine is rotated through warm ODA-treated condensate by turning gear
On-line cleaning

Description of the procedure:

- Injection of ODA emulsion at full load in the feedwater, the condensate or directly in front of the turbine
- Setting a maximum ODA concentration of 2 ppm in feedwater or steam
- Treatment period depends on the structure and amount of deposits
- Efficiency monitoring by comparative readings in steam and condensate
- Additional benefit is the preservation of the turbine / the whole water steam cycle if the treatment is done shortly before shutdown
On-line cleaning

Example 1: combined cycle power plant at Chemiepark Knapsack in Hürth

- total power output: 800 MW
  - 2 x gas turbines each 267 MW
  - 1 x steam turbine 270 MW

- 2 x heat recovery steam generator
  - Design parameters: 114 bar, 555°C
  - Total steam capacity: 700 t/h

- no condensate polishing plant

- Unscheduled cycling operation mode
  - frequent shutdowns with unknown standstill time
  - daily starts and stops when operating
On-line cleaning

Example 1: combined cycle power plant at Chemiepark Knapsack in Hürth

Condenser

Last stage turbine blades
On-line cleaning

Example 1: combined cycle power plant at Chemiepark Knapsack in Hürth

- Cycle treatment with ODACON® improves the corrosion protection during shutdown and has a positive effect on re-commissioning at Knapsack 1:
  - The total commissioning time is reduced from about 8 hours to 4 hours.
  - The time for reaching the standard conductivity levels in steam during commissioning is decreased from 5 - 6 hours to 2 - 3 hours.

- No impact of ODACON® injection was detected to the reliability of on-line measurement equipment.

- During preservation no pH-decreasing decomposition products were detected.

- The last stages of turbine blades are cleaner the during former inspections.
On-line cleaning

Example 2: combined cycle power plant Wiesengrund in Eisenach:

- Heat recovery steam generator
  - Type: Standart Fasel
  - thermal capacity: 50 t/h

- Tap condensing turbine
  - Type: ABB G 25
  - Capacity: 10 MW

- Back pressure turbine
  - Type: KKK CFR 5
  - Capacity: 3.3 MW
Example 2: combined cycle power plant Wiesengrund in Eisenach:

- The cleaning was performed over a period of one month during normal load.

- The ODA concentration was adjusted at 1.5 – 2.0 ppm.

- Increase in SiO₂ concentration in the condensate with a simultaneous reduction in steam shows the cleaning results.
Cleaning with saturated steam

Description of the procedure:

- Injection of ODA emulsion during wet steam operation directly in front of the turbine
- ODA concentration > 2 ppm, maximum concentration depends on the temperature in the condenser
- Steam parameter and turbine speed is the same as during normal wet steam cleaning
Wet cleaning with turning gear

Description of the procedure:

- Fill up the turbine casing as high as possible with a condensate–ODA mixture.
- Temperature in the high pressure part about 150°C, in the low pressure part about 70°C.
- The turbine is rotated with the turning gear through condensate–ODA mixture.
- There is no restriction regarding the ODA concentration. It depends on the structure of the deposits and the analytical results.
Wet cleaning with turning gear

Example Konakovskaya GRES:

Removal of sediments from surfaces of the blading section components of HPC (a) and MPC (b) in the process of mothballing K – 300-240 turbine at Konakovskaya GRES.

Source: "Protection of energy equipment metals from corrosion" Tjazologi Maschinostragilemi, Ausg. 8 / 2002
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Summary
Even when demineralized feed water is used, firmly adhering siliceous deposits can form on the turbine blades. This leads to efficiency loss and to damage of the turbine.

The turbines are mechanically cleaned in order to remove these deposits. This procedure can only be performed during the standstill period and is very expensive.

The chemical cleaning process, with the use of acids or alkalis, can cause corrosion and brittleness in the base material.

Using ODACON® the turbine is cleaned without the addition of aggressive acids. The linings are gently washed away from the surface and the base material is not damaged.

The cleaning can be carried out during operation or in a separate washing process after shut down.
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