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Washing and preserving turbines with film-forming amines – experiences with the use of Octadecylamine (ODA)

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Preliminary Note

Characteristics of Octadecylamin (ODA)

Procedures and Examples

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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
  - planed 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

Preliminary Note

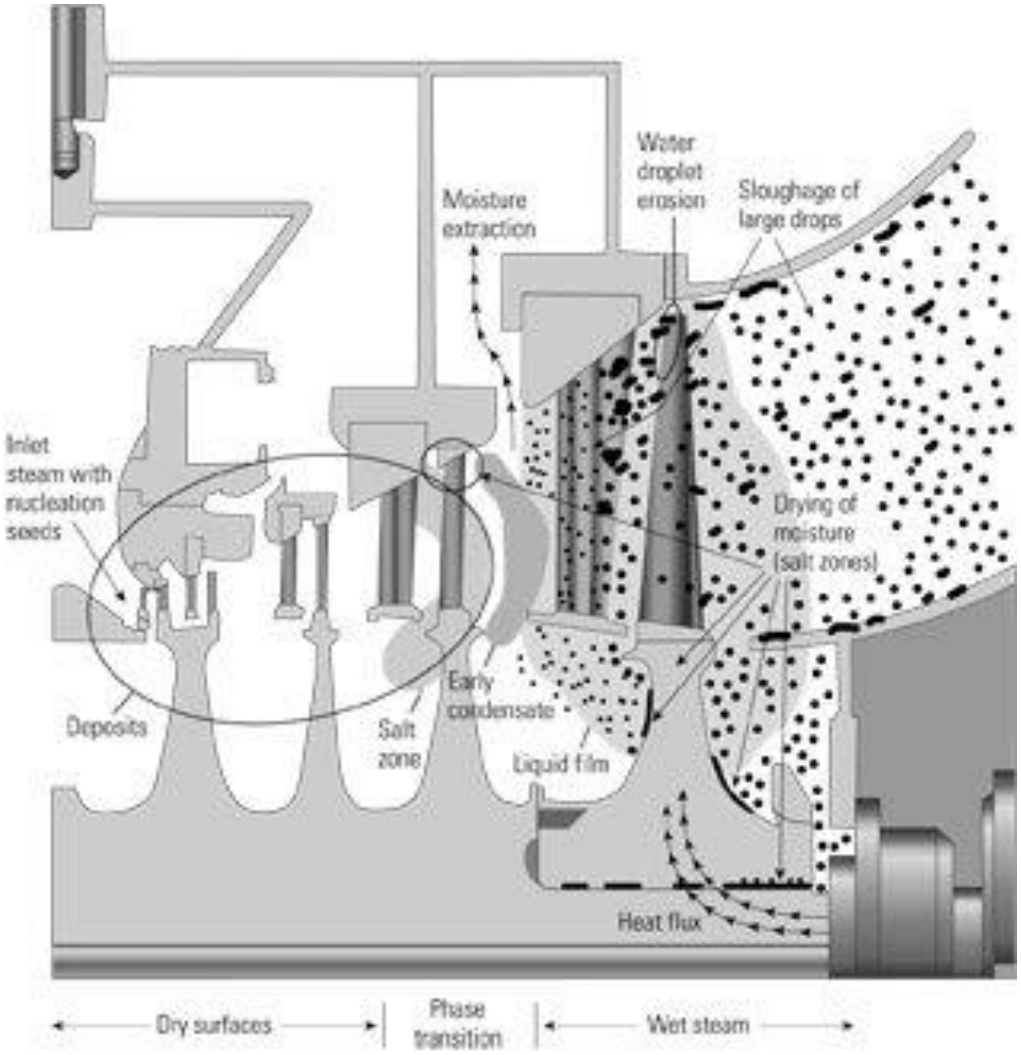

Abbildung: Dr. Jonas, O. Designing steam cycles to avoid corrosion, www.powermag.com, 15.04.2006, http://www.powermag.com/designing-steam-cycles-to-avoid-corrosion/?printmode=0

Preliminary Note

- 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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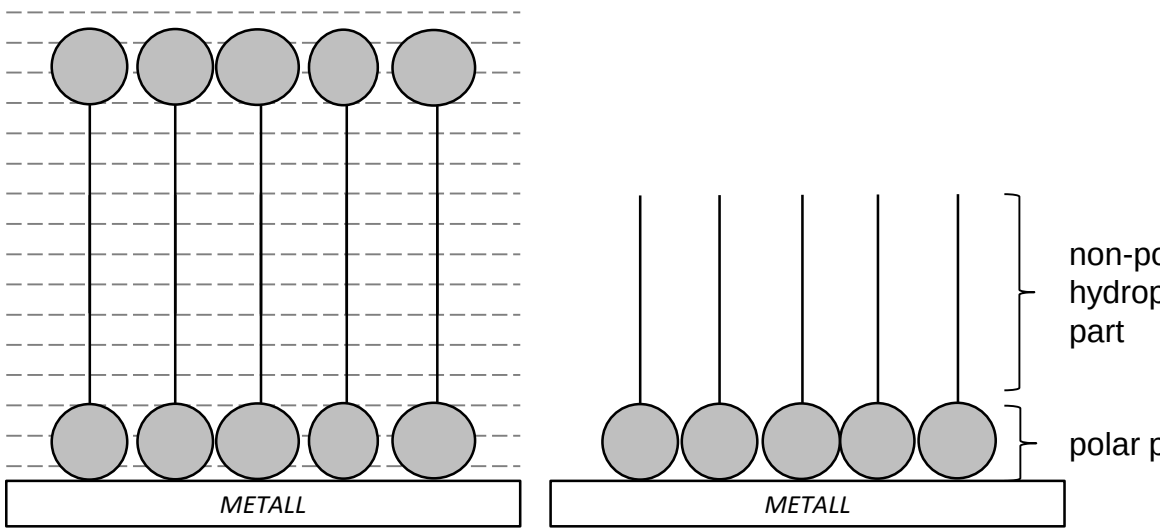
Characteristics of ODA and ODACON

- substance Octadecylamine (ODA):
  - Long-chain, aliphatic amine with chemical structure $C_{18}H_{37}NH_2$
  - Primary amine content > 99 %
  - waxy, solid substance, non-soluble in water
  - → The substance in it´s pure form is not useful for industrial application.

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

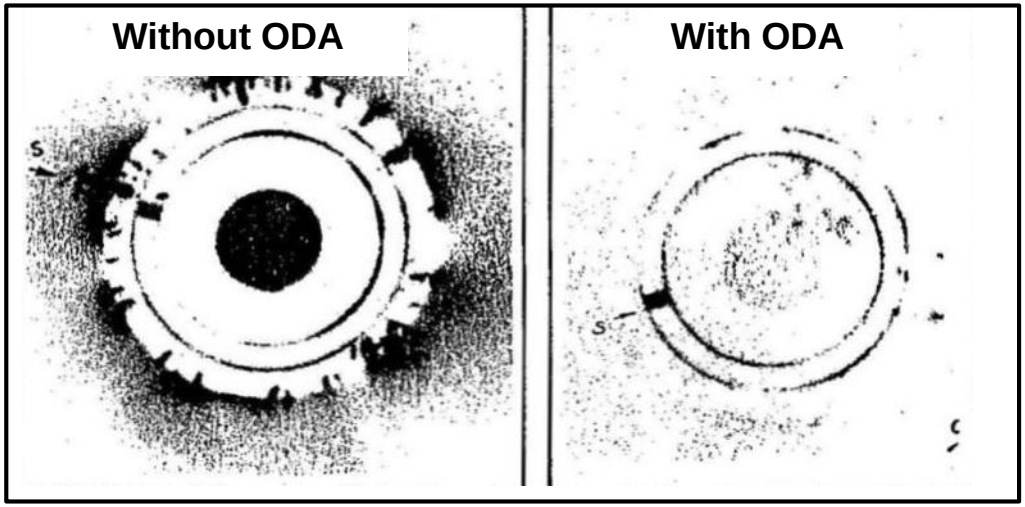
Adsorption

- distribution coefficient nearly the same as Ammonia
- Formation of mono- / bi-molecular, diffusion-resistent 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

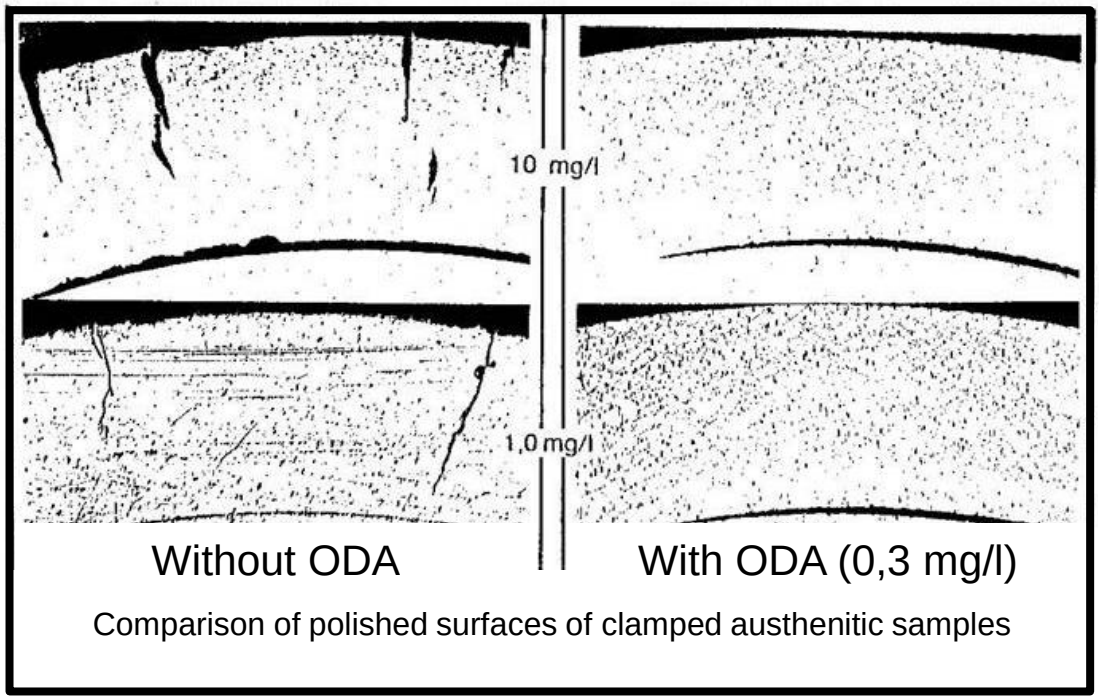


autoradiograph of clamped samples
(density level = rate of chloride accumulation)

- 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



Comparison of polished surfaces of clamped austhenitic samples

Chloride = 10 mg/l

Ø crack depth after 15 h:

without ODA: 83,1 * 10^{-2} mm

with ODA: 3,0 * 10^{-2} mm

Chloride = 1 mg/l

Ø crack depth after 39 h:

without ODA: 58,5 * 10^{-2} mm

with ODA: 5,0 * 10^{-2} mm

- Previously damaged samples showed no zeigten kein 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 directlyin 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

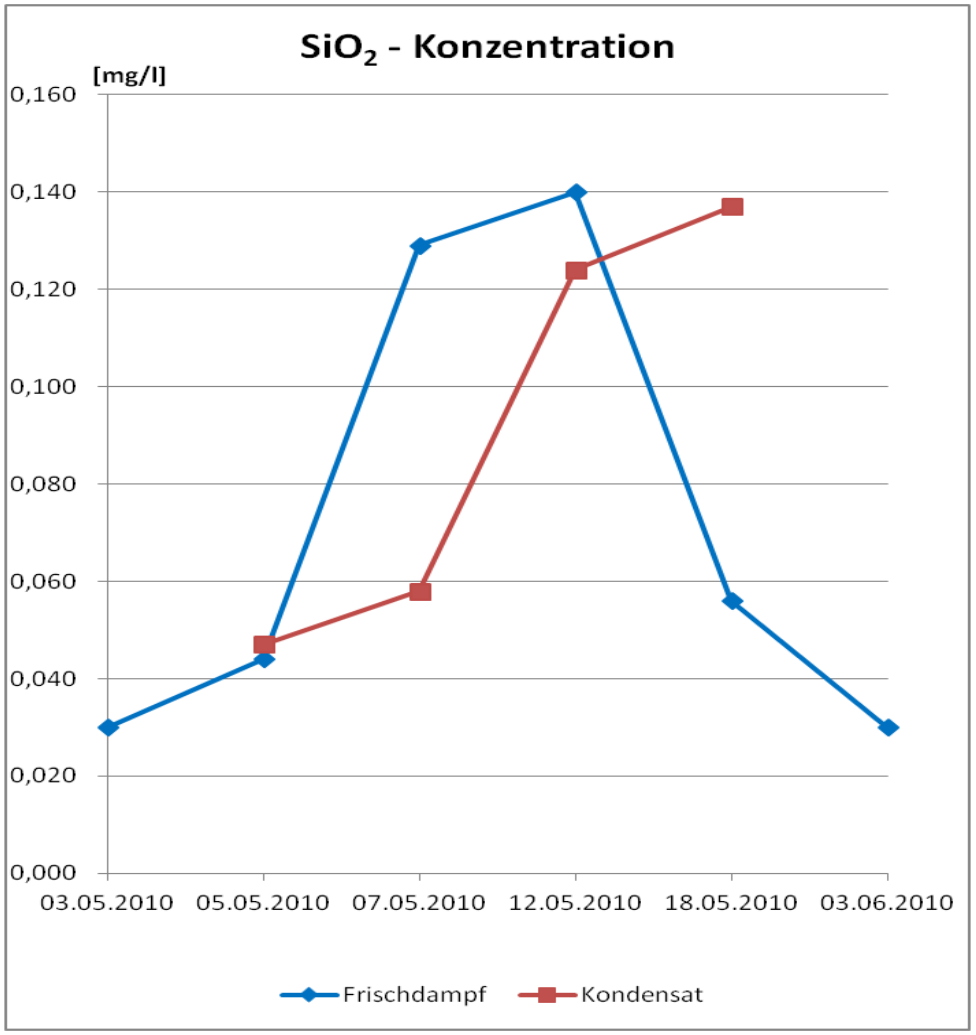
Example 2: combined cycle power plant Wiesengrund in Eisenach:

- 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

On-line cleaning

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 SiO_2 concentration in the condensate with a simultaneous reduction in steam shows the cleaning results.



Cleaning with saturaded steam

Description of the procedure :

- Injection of ODA emulsion during wet stream 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

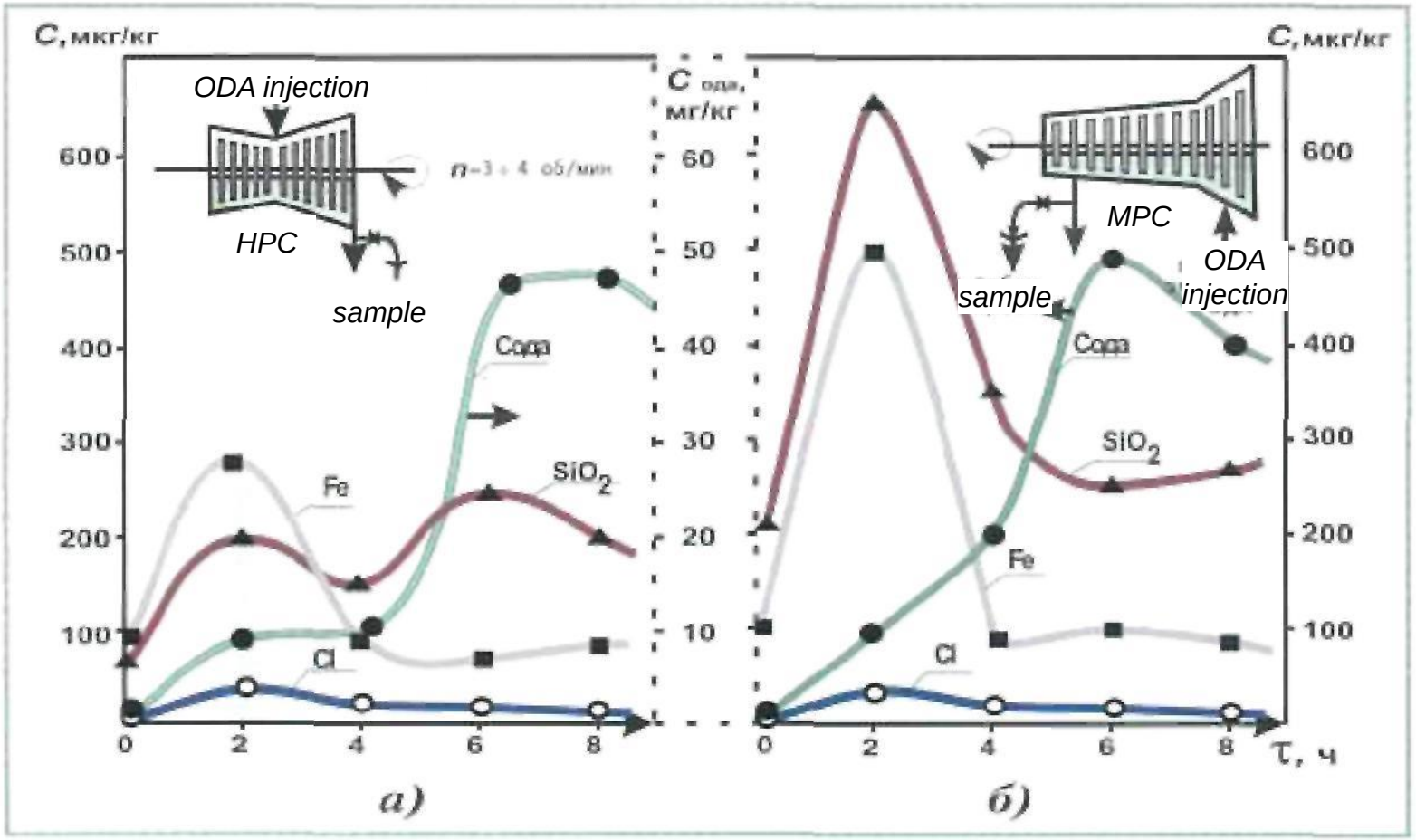
Wet cleaning with turning gear

Description of the procedure :

- Fill up the turbine casing as high as possible with an condensate – ODA - mixture
- temperature in high pressure part about 150°C, in low pressure part about 70°C
- turbine is rotated with 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" Tjazelogi Maschinostragieme, Ausg. 8 / 2002

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- 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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