Investigation of salt deposits on NJV3 IP2-turbine, revision 2008

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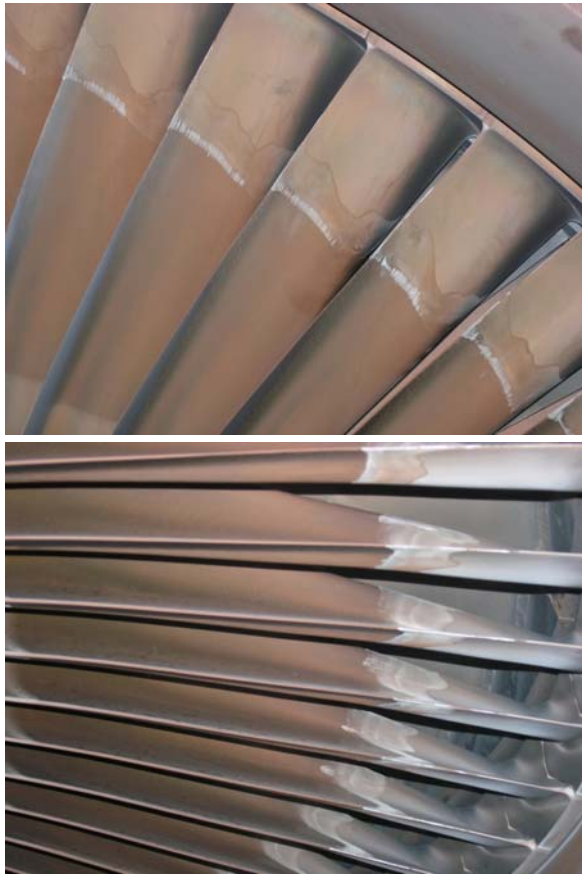
Visual inspection of IP2 turbine – 75.200 operation hours



Salt deposits on 3rd row

Possible explanation on bands of deposits:

Condensate forms on the coolest parts of turbine blades.

Condensate moves outwards to slightly warmer materials.

Reevaporation takes place and salts are deposited.

Evenly distributed salt layer on dry zones stems from deposition from supersaturated steam or evaporation of condensate droplets.

Corrosion in diaphagma

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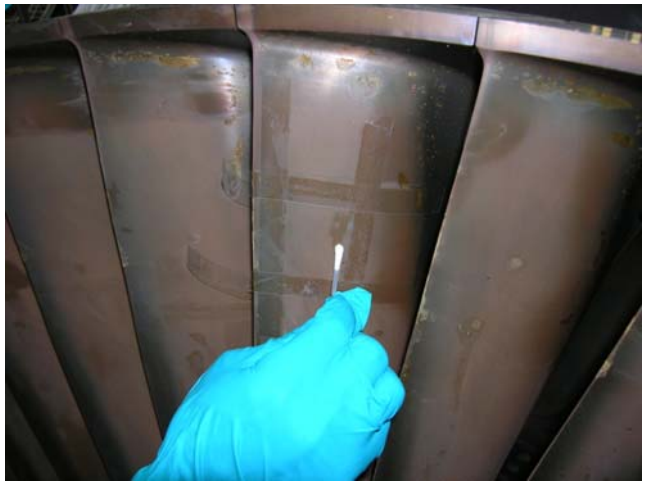
Sampling

Flushing of well-defined area (app. 13x14 cm²) with ultrapure water (UPW).

Funnel formed from clean PVC-foil.

Analysis of ions by ion chromatography.



Wash of well-defined area (app. 5x5 cm²) with sticks wrapped with cellulose fibers.

Sticks moistened with UPW prior to application.

Sticks extracted in UPW after application.

Area around corrosion attack bounded by means of tape and flushed with UPW.

Corrosion products scraped of with scalpel for further analysis by means of ICP.

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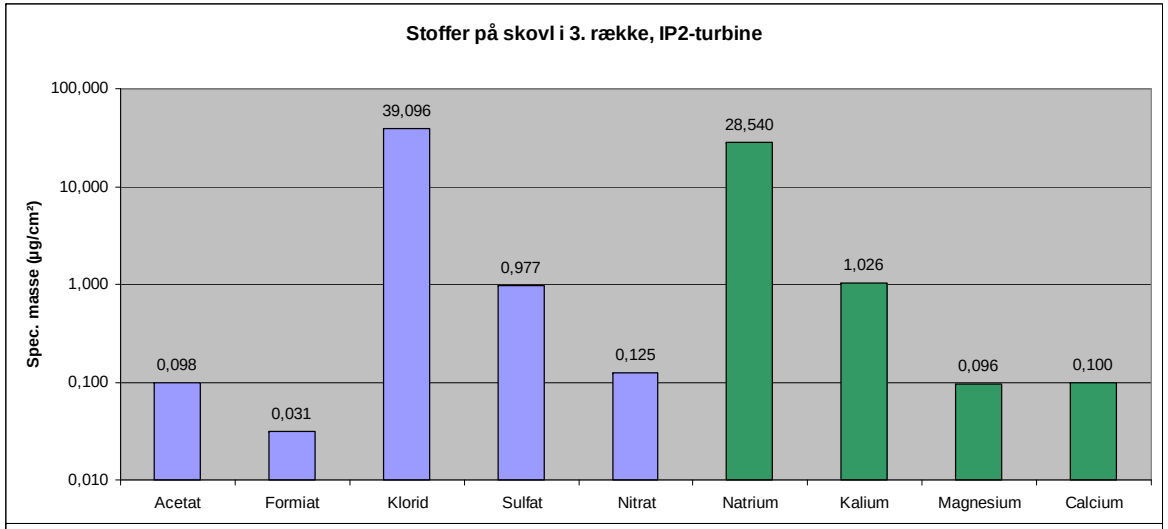
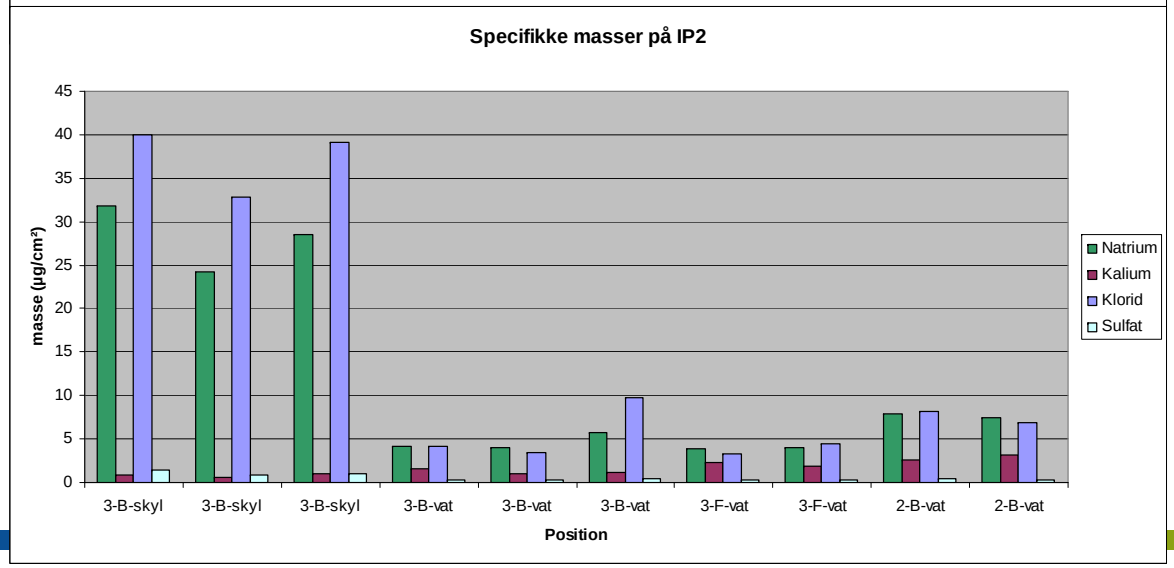
Results – salt deposits on blades





Deposits consists mainly of sodium chloride, NaCl.

In the charge balance there is a deficit of 10-20 % anions. From earlier experiences this is due to hydroxide, that means the deposits are mainly NaCl with 10-20 % NaOH and Na_2SO_4.

Explains the hygroscopic character observed.

Note:

”Natrium” is sodium

”Kalium” is potassium

Levels in dry zones on last row of IP2-turbine

Sodium: 23-33 µg/cm²

Chloride: 30-40 µg/cm²

Sulphate: 0,8-1,5 µg/cm²

Potassium: 0,5-1 µg/cm²

App. same levels on front and back side of blades

App. double amounts on blades in row 2

Note:

”3” and ”2” means row 3 and row 2, respectively

”B” and ”F” means back and front side , respectively

”skyl” and ”vat” means sampling by flushing or wash, respectively

Sampling by washing gives 5-7 times lower results than flushing

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Results – corrosion attacks

Sodium chloride is most abundant in the salts in the corroded materials, app. 12 µg/cm² sodium and 13 µg/cm² chloride.

Results from ICP analysis of material from corrosion attacks	081009-1 Flushed prior to sampling	081009-2 Flushed prior to sampling	081009-3 Non-flushed
Iron (%)	44,7	50,6	41,1
Chromium (%)	0,66	0,83	0,52
Molybdenum (%)	0,42	0,44	0,38
Nickel (%)	0,04	0,07	0,05

Metal oxides cover app. 70 % of the mass, remaining part presumeably salts included in the corrosion products.

Note, that the content of metals is smallest for the non-flushed sample, this supports the conclusion.

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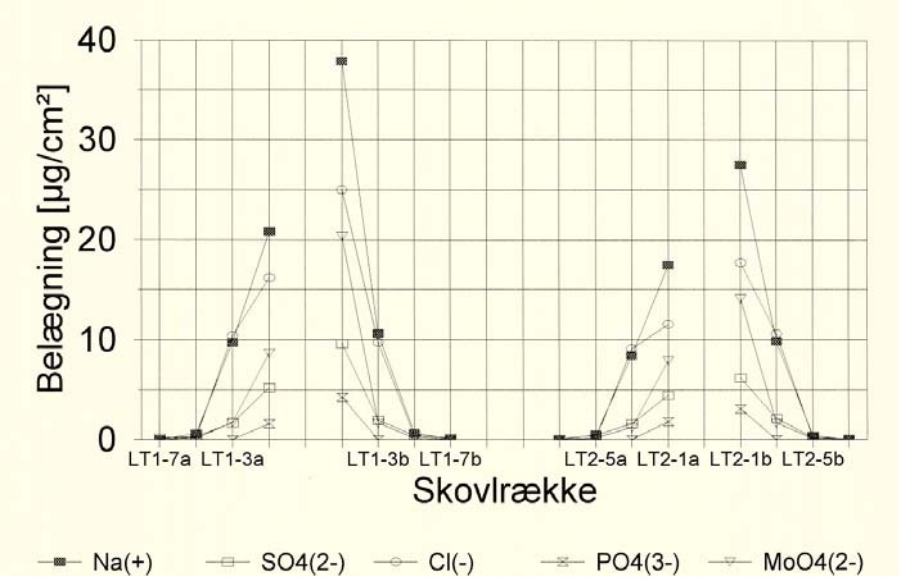
Perspectives



Salt deposits measured at twin LP-turbines (plant EV3) in 1997 after 74.200 hours operation since last turbine revision. This plant has relatively low district heating production and the turbines operate dry except the last two rows.

The amounts found in this investigation is very comparable.

Tabel 8	Afsætning af salte i turbiner - kvalitativt vurderet			
Salt	Formel	HT-turbine	MT-turbine	LT-turbine
Natriumsulfat	Na_2SO_4	xxxxxxx	xx	x
Natriumhydrogen phosphat	Na_2HPO_4	xxxx	xxxx	xx
Natriumhydrogencarbonat	$NaHCO_3$	xx	xxxx	xxxx
Natriumhydroxid	NaOH		xxxxxx	xxxx
Natriumchlorid	NaCl		xxxx	xxxxxx

Qualitatively assessment of tendency to deposition of different salts on turbines from a number of investigations during the 1990'ties.

These tendencies are perfectly explained by the solubility of the salts in superheated steam, see the next slide.

From this, the observed composition of mainly NaCl with some NaOH and Na_2SO_4 is completely in line with previous experiences.

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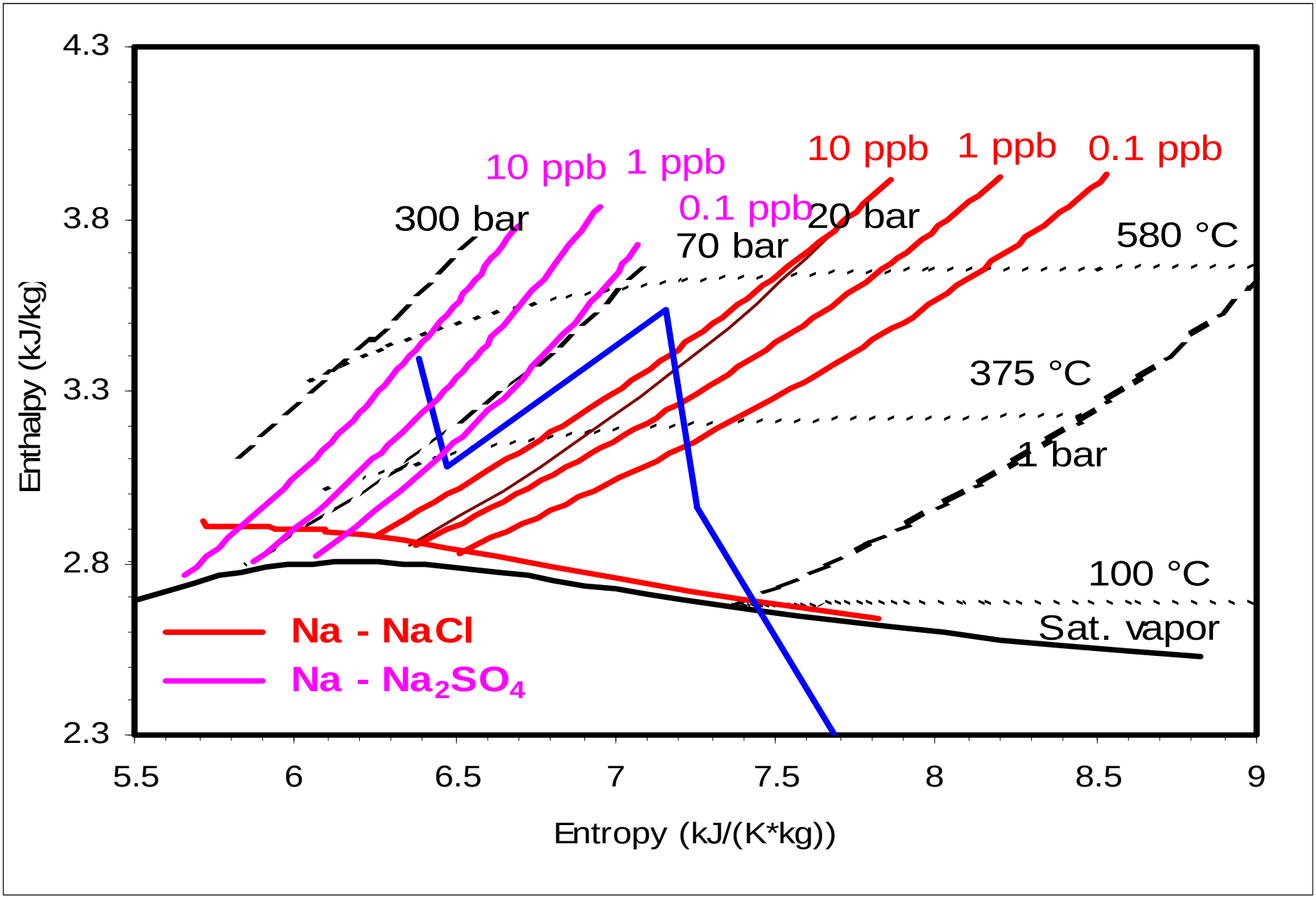

Reference: Jørgen Peter Jensen, "Phase Equilibria for Aqueous Electrolyte Systems at High Temperature and Pressure", Ph.D-thesis, 1996, Department of Chemical Engineering, Technical University of Denmark.

Conclusions

- Salts on the turbine blades and the diaphragma surface consist mainly of sodium chloride with smaller amounts of sodium hydroxide and sodium sulphate.
- The amount is sufficient to give a corrosive environment under humid conditions, *e.g.* shortly after a turbine stop.
- Corrosion attacks were observed on diaphragma surface and other inner surfaces of the turbine housing.
- A critical review of the procedure for dry conservation of the turbine after stop is recommended.

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