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Amine proves effective alternative to hydrazine

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Converting from hydrazine to amine feedwater conditioning at the HKW Süd cogeneration plant has proved highly beneficial, with no evidence of any of the problems that some plants have encountered, eg due to oxide layer removal or magnetite deposits. A key benefit of film-forming amine is improved corrosion protection during frequent startups and shutdowns. This allows high steam quality during startup to be achieved much quicker, with consequent economic benefits.

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Figure 1. The HKW Süd plant

Organic substances are generally considered undesirable impurities in high-pressure boilers and steam turbines, as they can cause operating problems and corrosion in ion exchangers and cooling water systems, boilers, and turbines.

Sources of such impurities may be the make-up water gained from surface water (humic substances), cooling water leaks or resin fines. It is important to recognise such impurities at an early stage to be able to minimise them using appropriate chemical and physical cleaning methods.

The HKW Süd plant

In the HKW Süd (Southern) cogeneration station (Figures 1, 2, 3 and 4) the high-pressure (HP) plant consists of two identical units commissioned in 1979. Each unit of the HP plant comprised one incineration boiler, one high-pressure boiler and one extraction condensing turbine, generating 125 MW (gross) of electric power, or 95 MW of electric power and 145 MW heat for the district heating. By the end of 1997, the incineration units had been taken out of service, due to lack of refuse delivery, and have been under wet layup since then.

The HP plant is a standard unit with a Benson-type once-through boiler with single reheat and with an extraction condensing turbine. Pressurised water flows through the boiler, is heated and evaporated. Main steam (540°C, 200 bar) supplies the HP part of the turbine. Partially expanded steam then passes through the reheater. At around 45 bar, the steam is reheated from 350°C to 540°C, increasing the overall efficiency of the plant. The reheated steam passes through the IP and ultimately through the LP part of the turbine.

At different locations in the turbine, steam can be extracted for the feedwater heaters, and more important, for supply to the district heating system. Certain amounts of steam may be extracted after the reheater, reduced to a pressure of 18 bar in a bypass system, and fed into the 18 bar header supplying the district heating system.

The hydrazine regime

Until the early 1990s, HP units IV and V were operated in baseload to supply the requirements for electricity and district heating. Demineralised water was used and hydrazine (0.5-1.0 mg/l) was added for feedwater treatment. However, after startup of the HKW North plant, the HP units of the Southern plant were used mainly for peaking power generation, subjecting the system to frequent startups and shutdowns. Dry air was used for conservation during extended offload periods. Nevertheless, increased iron levels were found in main steam after startup, and steam had to bypass the turbine, sometimes for up to three hours, until sufficient purity levels were achieved to allow steam to be directed to the turbine. Figure 5 shows the typical main steam parameters of Unit IV, with hydrazine conditioning.

Conversion to amine

Because of the cycling and peaking operation and the conservation and corrosion problems, a more effective system of chemical conditioning was needed. Building on experience with other power plants using amine conditioning and considering that amine conditioning had been used successfully since 1994 for three hot-water systems and a 6.5 km condensate return line, the decision was made in 1996 to convert the plant cycle treatment for the two HP units from hydrazine to amine (Helamin) conditioning. This decision was based on the assumption that film-forming amines, in contrast with other organic impurities, would have a positive effect on the Benson boilers.

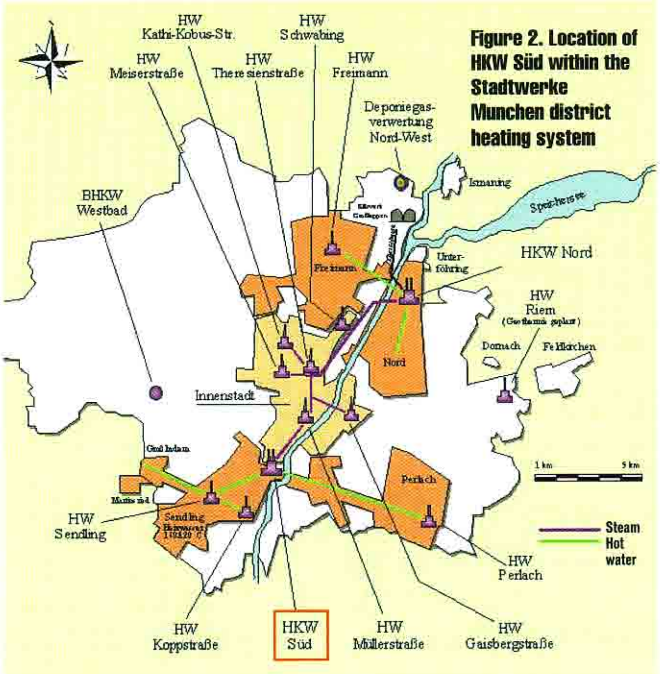

Figure 2. Location of HKW Süd within the Stadtwerke Munchen district heating system

The change was accomplished without a major engineering effort. It was possible to make use of the existing hydrazine measuring and diluting containers as well as feed pumps. One dosing line was installed into the feedwater pump suction line; a second joined the condensate return line after the polisher. Worth noting is that in this system condensate is polished 100 per cent. To remain on the safe side and stay within VGB guidelines for pH and conductivity, amine concentration was targeted to be as low as possible (1 mg/kg). During startup, pH was equal or above 9, and cation conductivity below 0.2 µS/cm. In practice, conductivity reached to 0.5 µS/cm during startup, even under perfect amine dosing, then came down below 0.2 µS/cm during steady-state operation. The elevated startup value may have been caused by carbon dioxide.

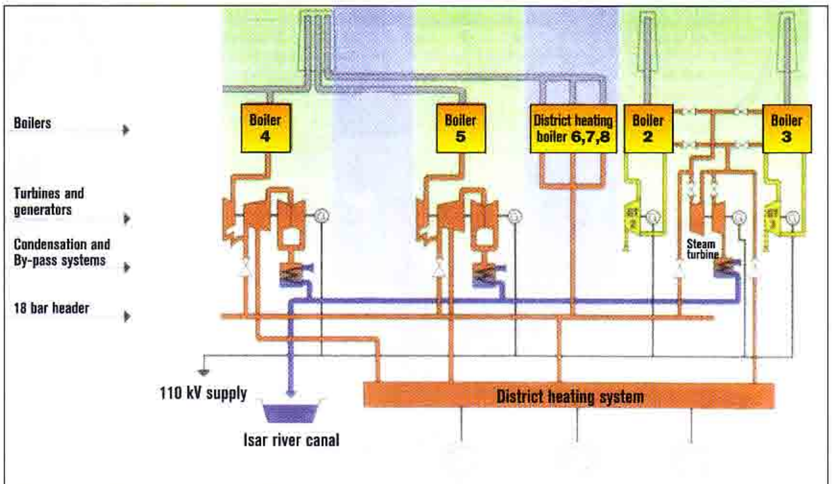

Figure 3. HKW Süd, heat distribution system

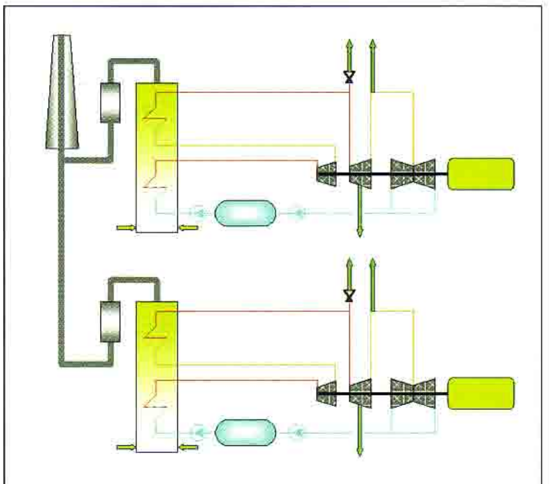

Figure 4. HKW Süd, schematic of the HP systems

Amine experience

Even after extended shutdowns, amine conditioning was found to shorten the time needed to achieve the required level of steam purity. This has resulted in faster turbine starts, providing a clear advantage over the previous hydrazine regime.

As a result of improved corrosion protection during periods off load, main steam can be routed to the turbine significantly earlier, after the first chemical analysis has been completed (approximately 30 minutes). Figure 6 shows the typical main steam parameters of Unit IV with the amine treatment.

During a unit inspection on 11 October 2000, samples of main steam were taken and the results of the chemical analysis are shown in Table 1. Unit IV was in the restart process after a short period in which both turbine and boiler were off load. During this period, conductivity rose to a maximum of 15 µS/cm, but dropped back to normal shortly thereafter. Unit IV main steam sample No. 406 was taken during this phase indicating 0.48 µS/cm. Unit V was under normal operating conditions.

Sample 406 shows higher conductivity despite lower anion concentration, an indication of elevated carbon dioxide levels during startup.

Economic benefits

The two Benson boilers at HKW Süd have been operating using amine conditioning since 1996. During this period, amine-related irregularities have been reported neither with respect to the boilers nor with respect to the turbines. In addition, no problems have arisen due to removed oxide layers or with seals or brass fittings. Other issues such as rippled magnetite deposits, magnetite migration or blocking of orifices, reported from other boiler systems, have never been experienced here. Operation to date confirms that a major advantage of using film-forming amine treatment is the improved corrosion protection during frequent startups and shutdowns. Because required steam quality during startup is reached more quickly, significant economic benefits are achieved.

Table 1
Analysis of main steam
(anions determined by ion chromatography)

	Unit IV, sample 406	Unit V, sample 506
Fluoride (µg/kg)	-	8
Acetate (µg/kg)	16	34
Formate (µg/kg)	2	2
Pyruvate (µg/kg)	-	2
Chloride (µg/kg)	3.5	24.5
Nitrite (µg/kg)	0.9	-
Nitrate (µg/kg)	1.1	1
Sulphate (µg/kg)	1.6	1
Phthalate (µg/kg)	5.2	-
Conductivity after cation exchanger (µS/cm)	0.48	0.27

Reference
Paper presented to Power Plant Chemistry conference, Feedwater and boiler water treatment in industrial, co-generation, and refuse incineration plants and in units with heat recovery steam generators, Mannheim, 14-15 November, 2000.

Figure 5. Main steam pH and cation conductivity, hydrazine treatment

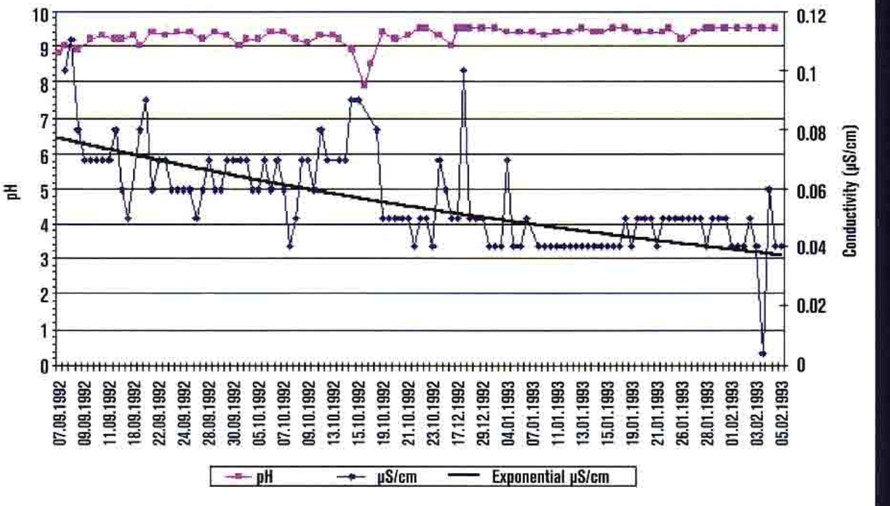

Figure 6. Main steam pH and cation conductivity, amine treatment (using Helamin)