P a r t 2

WATER PROTECTION FROM DISCHARGES

2.2. Contemporary water treatment technologies at power plants and their environmental impact assessment

2.2.2. Ion-exchange demineralization of boiler make-up water

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Water for steam boilers and other purposes is demineralized in our country by the means of ion-exchange technologies, consisting of two-three stages of cationic and anionic filters. Operation experience of ion-exchange technology is about 60 years. Currently improvement of ion exchange technology and increase of ion-exchanger efficiency is performed is the way of counter-current ion-exchanger designing and improvement of quality of water treatment ion-exchange resins.

Several options for water treatment reconstruction and modernization are suggested:

- Based on the domestic counter-current ion-exchangers, designed by VNIIAM and VTI and manufactured by TKZ
- UpCore, designed by Dow Chemical
- "Amberpack", designed by Rohm and Haas
- "Schwebebet" and its modifications by Bayer GMB
- Puropack by Purolite company

The domestic technology provides an additional drainage system in the upper layer of the smallest ion-exchange resins. Regeneration and backwashing of ion-exchange resins is performed upward with disposal of waste water through the mentioned additional drainage system. Blocking water stream or waste solution is fed downward to prevent expansion of cationic layer and its mixing, and is disposed through the same additional drainage system.

The above technology was successfully implemented at Sredneuralskaya and Novocherkasskaya SDPP, Novoirkutskaya and Nizhnekamskaya TPP and at other enterprises. The results achieved showed that this technology allows decrease of reagent consumption by 1,3…1.6 times, water own needs by 2 times, ion-exchangers by 3 times, ion-exchange resins by 2.7 times [24, 25].

The above results are obtained using domestic ion-exchange resins. The ion-exchanger is designed to provide periodic backwash through the additional drainage of only an upper layer of the ion-exchange resins, which collects the main part of the feed water suspensions, thus reducing water own needs.

At the same time bulky construction of such ion exchangers and limited application area depending on feed water quality are noted [1].

In the UpCore technology the additional drainage system is installed at the top of the exchanger and the inert material of a particular size with density less than of water is loaded in a comparably small quantity. This material is concentrated in the area of additional drainage system and protects it from clattering by small ion-exchange resin fractions. There is some spare space between the inert material and the ion-exchange resin. Regeneration is performed downward, water is fed upward. During backwash the layer of ion-exchange resin is pressed to the inert material layer due to increased water speed. Then water speed is decreased and regeneration solution and rinse water are injected, with a flow rate preventing ion-exchange resin settling. After rinsing ion exchange resin settles without vivid mixing of layers.

Our country has gathered a wide operation experience of this technology at thermal power plants (TPP) and other enterprises [26, 28].

Currently this technology is applied at the following objects:

- Kalininskaya and Beloyarskaya nuclear power plants
- Novgorod TPP
- Appatiytskaya TPP
- Orshanskaya TPP
- TPP No12 "Mosenergo" JSC
- Nizhnekamskaya TPP No 2
- TPP "Siddirgach" (Bangladesh)

Installation of water treatment unit is being completed at Kaliningadskaya TPP No2, Ryazansky oil plant, Dzerjinsky thermal power plant, Stavropol SRPP.

Together with domestic companies foreign engineering companies specializing in water treatment are represented at the Russian market. For example, in recent years, the following companies are successfully implementing counter-current technologies at thermal power plants and other power industrial enterprises:

- Chriva (Germany)- "Acron", Novgorod the Great; "Kuibyshevazot", Talyatty; "Severstal" Cherepovec, "Azot", Bereznyaki
- "Wabag" (Germany)-"Kuybyshevazok", Tolyatty
- YIT (Finnland)- Leningrad Thermal Power plant No5, Kirish SRPP.

The operation experience has shown that UpCore in comparison with the parallel-current technology yields the following:

- Improvement of water quality
- Reduction of quantity of equipment (filters, pumps, tanks), fittings, pipelines by 2…3 times.
- Reduction of chemical reagents consumption (acid, alkaline, salt) for water treatment needs by 1.5…3.0 times
- Reduction of water consumption for water treatment own needs and accordingly waste water discharge by 2…6 times.

Other advantages are noted [26—28]:

- Possibility of implementation of Russian equipment (parallel flow exchangers FIPa I)
- Simplicity of design and installation of internal (top and bottom) collector-radial type drainage-distribution units with polypropylene caps (KSH, Germany) and possibility of manufacture of the distribution units at Russian works
- Absence of rigid requirements to presence of suspended particles in the feed water entering counter-current ion exchangers
- Elimination of dependence of treated water quality on change in production of ion exchangers, i.e. wide range of water treatment productivity.

At the same time at a number of power plants decrease of ion exchange performance was observed with worsening of quality of pre-treated water caused by progressive contamination of anion resins with organic substances [1].

The Amberpack technology of Rohm and Haas also provides a drainage system at the top of the ion-exchanger. Regeneration is performed downward and treated water is fed upwards. The ion-exchangers are almost completely loaded with ion-exchange resins, yielding elimination of mixing of ion-exchange resin layers during operation and providing high quality of treated water requiring low reagent consumption used for regeneration of the filtering loading. Upward flow of treated water substantially reduces hydraulic resistance of the loaded ion-exchange resins due to the effect of the "converted" layer and allows operation at higher speeds. Backwashing in the exchanger itself is not provided in the Amperpack technology. For backwashing and washing from ion-exchange small fractions a part of loading is hydrolically transported to the special tank and after processing is returned to the exchanger. Implementation of the Amberpack technology requires substitution of commonly used ion-exchange reins by "Amberjet and Amberlit RF" resins, specially developed for such technology and having high consistency and small dispersion in granulometric compound.

Completely automatic water treatment with Amberpack process at the TPP-1 of "Mosenergo" SC was sufficiently operating for a while. Then characteristics went down mainly caused by anion resin contamination by organic substances. The reason for that was insufficient operation of pretreatment based on direct flow coagulation. Clarified water quality in respect to suspended substances is provide by efficient operation of five-layer clarifies, loaded with silica sand and antracide of 2,5 m total layer high, but such pretreatment actually does not remove organic substances [1].

Bayer Schwebebet process is performed in ion exchangers similar to those designed for the UpCore process described above, but with the opposite direction of flows: regeneration downward, water treatment- upward. The basic disadvantage is the requirement to keep elevated treated water flow rate to prevent precipitation of ion exchange resin layer and its mixing. Besides, the technology is sensitive to the quality of the feed water. At a completely automatic NPO "Azot" "(Talyatty) water treatment based on Schwebebed process, operation characteristics went down shortly due to contamination of cationic exchange resins with slurry from the pretreatment operated extremely insufficient [1].

Thus a certain positive experience of industrial implementation of counter-current ion-exchange demineralization based on different technologies is obtained in our county. All technologies have similar technical-economic characteristics and allow substantial reduction of consumption of water for own-needs and reagents for regeneration of ion-exchangers. Therefore they provide reduction of waste water discharge and total content of mineral substances in them. A number of equipment required and volume of ion-exchange resins are decreased.

At the same time investigations showed necessity in substantial improvement of water pretreatment in respect to residue concentration of suspended particles, cilicate and organic substances, supersaturation of clarified water with scaling compounds in lime-treatment process. Technologies, when water treatment is performed upward are especially sensitive to these parameters.

The problem of regeneration waste water utilization remains. Though sulphuric acid and caustic soda consumption for regeneration of ion-exchange resins reduces averagely by 1,5…2,0 times, sodium sulfate appearing in ion exchange resins 1,5…2 times exceeds total quantity of mineral compounds, removed from water during demineralization.