Technologies and installations for treatment the waste water from the Romanian power plants

STANCA GRIGORE[1], TEODORESCU FLORIN[1], STANCA ANGELA[2], SERBANESCU AGNES[2], BOLMA AURELIA[2], CRACIUNOIU MARIANA[1], FLORESCU MARGARETA[3]
[1]Unconventional Technologies Applicative Research Department (DTPC)
Mechanical Engineering and Research Institute – ICTCM SA
041303 Oltenitei 103, Sector 4, Bucharest, ROMANIA
[2]Environment and Ecotechnology Department
Energy Research and Modernizing Institute –ICEMENERG
032414 Energeticienilor Blvd 8, sector 3, Bucharest, ROMANIA
[3]Management Department
Academy of Economic Studies –ASE,
010374 Piata Romana 6, sector 1, Bucharest
ROMANIA

Abstract: - The waste waters from the Romanian power plants mainly result from the water treatment stations and partially from the continuous blow-down from steam boilers, from the liquid ash removal/slag removal, the hydrotechnical circuits, the boiler chemical cleaning, air reheaters, the blow-down from the cooling systems, the gravitational separators of oil. Taking into consideration the legislation in force, the physico-chemical indices that could surpass the admissible limits are: pH, suspended matters, chlorides, sulphates, organic compounds, oil products. The discharge requirements impose the treatment of the waste waters resulting from the power station. This paper presents a modern technology for the treatment of the sludge resulted from the blow-down of pre-treatment decanters. It also presents the laboratory experiments for the treatment of the wastewater resulting from the softening process.

Key-Words: - Treatment, sludge, wastewater, power plants, softening process, decanters

1 Sludge dewatering technology

The waste waters from the Romanian power plants mainly result from the water treatment stations and partially from the continuous blow-down from steam boilers, from the liquid ash removal/slag removal, the hydrotechnical circuits, the boiler chemical cleaning, air reheaters, the blow-down from the cooling systems, the gravitational separators of oil.

In agreement with the fuel used (power plants with or without ash dump), the power plant location and the sewage system configuration, the wastewater is discharged in:

- the slag and ash dump;
- the rivers;
- the lakes;
- directly to the town sewage system.

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The discharge requirements impose the treatment of the waste waters resulting from the power station.

This paper presents a modern technology for the treatment of the sludge resulted from the blow-down of pretreatment decanters. It also presents the laboratory experiments for the treatment of the wastewater resulting from the softening process.

The sludge treatment and discharge is analyzed from the following points of view:

- treating or processing the sludge in such a manner as to change it into a form suitable for disposal;
- recuperation of water from wastes;
- the discharge of waste in such a manner as not to disturb environment.

The moisture, as well as the great volume of the sludge, presupposes important expenses for discharge and transportation, and at the same time great areas for storing.

1.1 Sludge classification

The characterization of sludge is of great importance in choosing the method of treatment as

well as the performances of the equipment used in the process.
The composition of the sludge depends on the nature of the water initial polluant and the treatment methods: physical, physico-chemical and biological.
Considering the level of the suspended matter in the raw water and the treatment methods, the sludges can be:
- very hydrofile sludges, presenting a great proportion of metal hydroxides (Fe, Al), reaching about 60% of the dry matter content for the low content suspended matter rivers;
- sludges in which the content of organic matter can surpass 30% in the case of still waters and with a metallic hydroxide content between 20-30%, in the case of average loaded rivers;
- sludges with hydrophobia tendencies in case of high floaded rivers and those with a content of clay suspended matters, in which the content of metallic hydroxides is 15-20%;
- sludges resulting from the pretreatment process, with a content of 50-55% $CaCO_3$, 20-30% metallic hydroxides and 10-20% organic matters.

1.2 Factors that characterize the sludges
The factors that characterize the nature of the sludges are:
- solids concentration;
- moisture;
- volatile matter content;
- mineral matter content.

The behavior of a sludge during the dewatering process is characterized by factors which are:
- the specific resistance of sludge determined at 0,5 bar. This determination allows the approximated evaluation of the capacity of an industrial vacuum filter. It also allows the determination of the optimal reagents dosage on the pressing filter;
- the compressibility index ("s"), that varies between 0 and 1. For uncompressible precipitates formed by hard particles, reluctant at deformation (s=0). For the very compressible precipitates formed by soft particles, s=1.

1.3 Sludge treatment stages
The treatment of sludges includes six stages:
- thickening;
- stabilization (anaerobic digestion of sewage sludge);
- conditioning (physical, chemical);
- dewatering;
- drying and incinerating;

disposal or utilization

1.3.1 Sludge thickening
The capital cost of any sludge treatment process, is largely influenced by the quality of sludge to be handled. There are great economic advantages if the sludge can be thickened and hence the volume diminished as much as possible of such thickening are the flow characteristics of the sludge.

1.3.2 Sludge conditioning
Sludge conditioning is necessary in order to improve the function of the dewatering equipments. Sludge conditioning realizes the brake down of the colloidal stability and the growth of the particles.
There are physical conditioning methods but most frequent methods are the chemical ones, using inorganic chemicals and polyelectrolytes.

1.3.2.1 Physical conditioning method
By physical conditioning methods the sludge is frozen or heated. The sludge conditioning by heating represents the most efficient methods for reducing the particles hydrofilies.
The growth of the temperature of the sludge produces irreversible changes in their physical structure, especially if this contained a large proportion of organic and colloidal compounds.
The conditioning of the sludge is made at 150-200 ^{0}C, the time varying between 30-60 minutes, function of the type of sludge and the wished rate of filterability.

1.3.2.2 Chemical conditioning
Researches have found that the addition of chemical reagents (conditioning) to sludge resulted in increased rates of sludge dewatering, decreased sludge volumes, and reduced equipment costs.
Chemical conditioning of sludges involves use of inorganic chemicals and use of polyelectrolytes.
In addition to organic polyelectrolytes inorganic conditioning agents have been considered as aids to gravity dewatering. Examples are ferric chloride to aid dewatering of alum sludge and lime or fly ash for coagulant sludges. The mechanism by which such conditioning agents function are not entirely clear, but they may improve floc rigidity or increase the specific gravity of sludge particles. Because many of these same inorganic chemical are used in coagulation processes, it is reasonable to expect analogies between the modes of particle destabilization and sludge conditioning for these processes.

1.3.2.3 Chemical conditioning by poly-electrolytes

Initially, most of the chemical conditioning reagents used were inorganic salts, but now high molecular weight organic polyelectrolytes have been used either independently or in conjunction with the inorganic materials.

In general, polyelectrolytes are long chain, high molecular weight organic polymer that contains ionizable sites along the chain. They may be weak or strong acids, bases, or polyampholytes, and the ionizable groups may be grouped evenly or randomly or placed in blocks.

Two possible mechanisms could control the functioning of polyelectrolytes as sludge conditioners: charge neutralization and interparticle bridging.

1.3.3 Sludge dewatering techniques

Sludge dewatering could be made on sand beds, where the process occurs by two mechanisms: gravity drainage through the sludge cake and sand-filter and air drying from surface cake by evaporation.

Also there are various dewatering systems: centrifugation, vacuum filtration, pressure filtration, belt filter pressing.

The sludge dewatering using sand-drying beds represents a less competitive solution than the mechanical dewatering filters.

1.4 The characteristic equipments for a sludge dewatering installation

A dewatering installation of the sludge resulted from the raw water pretreatment technologies includes, function of the basic dewatering filter, the following equipments placed in a technical room:

- sludge pump, which takes over the sludge from the storage reservoirs or from homogeneous reservoirs and feeds the sludge conditioning tank;
- the automatic polyelectrolyte solution preparation station, which realizes the total dissolution of the polyelectrolyte used for the sludge conditioning;
- polyelectrolyte solution dosing pump;
- conditioning tank, a vertical tank in which the sludge is conditioned with the polyelectrolyte solution. The tank has a variable speed mixer for the improvement of the process. The volume of the tank ensures sufficient time of the dewatering filter with sludge. In case of using a centrifugal decanter as dewatering equipment, the conditioning tank is not necessary;
- dewatering filter (centrifuge decanter, vacuum filter, pressure filter, belt filter press);
- belt conveyor for the cake evacuation.

The technological scheme of a sludge dewatering installation is presented in fig. no. 1.

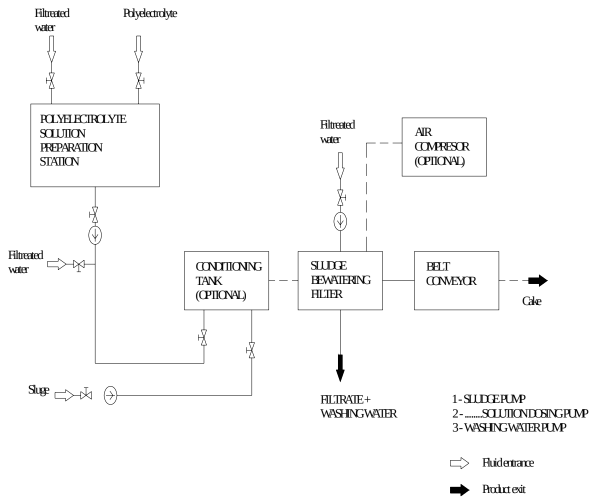

Fig. 1 Technological scheme for the sludge dewatering installation

1.5 Conclusion

The laboratory and the industrial tests made in Bucharest-West power plant with a NOXON centrifuge decanter led to the following conclusions:

- the sludge conditioning with polyelectrolytes is necessary before dewatering, resulting in a significant improvement of phases characteristics obtained from this process and a process efficiency increase;
- the liquid phase resulting from the process has the following characteristics:
- suspended matter under 40 mg/l;
- pH: 8,0-9,0;
- “p” alkalinity, ionic silica contents are comparable with those of the pretreated water;
- the iron content is about 4 time greater than that of the raw water;
- the total hardness content has comparable values than that of the raw water;
- the solid phase resulting from the process presented a content of drying substances of 46,8%;
- the polyelectrolytes dose used in the industrial test was between 1-1,5 kg/t dried substances.

2 Technology for the treatment of the used waters resulting from the softening process

In most of the cases, the power plants located in towns also supply the heat carrier for the district heating networks. From the water softening technological process great amounts of wastewater with a high salinity are obtained. This water is directly discharged into the sewage system of the town.

The high salinity of these waters, as a result of the calcium, magnesium and natrium chlorides presence in the water, inhibits the biological treatment process in the town water treatment stations.

The limits set for chlorides and fixed residue at their discharge into the sewage system (300 mg/l, 1200 mg/l, respectively) are very difficult to observe, because not all the power plants have homogenization-dilution basins (tanks), or enough water for dilution.

At present the only way to diminish wastewater salinity, to be discharged within the allowable limits is dilution, requires great volumes of water. At the same time wastewater homogenization basins (tanks) are also necessary to eliminate peak concentrations.

There are two variants for the treatment of highly salted used waters, namely:

a) The chemical treatments to remove total hardness of water and treated water re-utilization as a regeneration solution;

b) Salt removal from wastewater by making it passes through reverse-osmosis filters and treated water reutilization as technological process water.

These treatment variants are used both for the environmental problems solving, by considerably diminishing the discharged wastewater amounts to the indices allowed by legislation and the diminishing of the costs of the technological process water and of the regeneration reagents of the Na-cationic filters.

2.1 Laboratory tests

Chemical treatment tests of the wastewater resulting from the Na-cationic filters have been carried out in the lab in order to obtain treated water that can be reutilized for subsequent regenerations.

The lab tests were performed in order to attain two goals (objectives):

- the establishment of the optimum conditions for calcium and magnesium hardness precipitation and for correcting the sodium chloride concentration in the resulting waters, to the concentration necessary for the Na-cationic filters regeneration;
- verification of the treated wastewater influence on the process of their reutilization for the Na-cationic filters regeneration.

The reactive agents used for settling were sodium carbonate and sodium hydroxide.

The parameters envisaged for the optimum precipitation condition of calcium and magnesium hardness were:

a) the utilized precipitation reactive agents;
b) the dose of reactive agents operating;
c) working temperature;
d) settling down time;

The tests have been carried out under mechanical stirring conditions for 15 min (60 rotations/ min). Then the samples were left to settle for an hour. After this time, analyses of the supernatant water were performed.

The technology for the treatment of the wastewater resulting from Na-cationic filter regeneration was developed on the basis of the results obtained during the testing of the water samples taken from the thermal power plants.

2.2 The principle of the technology utilized to treat the used water resulting from the softening process

The technology aims at eliminating calcium and magnesium hardness by a chemical precipitation process, the restoring of the concentration of sodium chloride as a regeneration reactive agent, and reutilization of the solution for a new regeneration.

The basic reactions that take place are the following:

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$$

$$MgCl_2 + 2NaOH \rightarrow Mg(OH)_2 \downarrow + 2NaCl$$

The wastewaters resulting from the backwash, regeneration reagents dosing and slow rinse operations (about 70 m^3 since the beginning of the slow rinse operation) are collected in a treatment reactor and homogenized.

Total hardness, calcium hardness and magnesium hardness are determined.

In the reactor the used water is warmed up to 30-35 ^{0}C by steam intake.

Determined amounts of sodium carbonate and sodium hydroxide are dosed. In the reactor the solution is mixed for 15 minutes, then the stirring and the steam are stopped and it is left to set for 60 minutes for settling.

The efficiency of precipitation is checked by total hardness analyses .

After the sludge settles, it is discharged into the existing sludge tanks. The clear supernatant is discharged through pumping into a tank for pH correction. The automatic dosing of hydrochloric acid performs the pH correction up to 8,0-8,4. After the pH correction, the treated used water is discharged into a buffer tank, which is used for the following purposes:

- sodium chloride dissolution in the salt cell and preparation of the concentrated salt solution (up to 20-25%);
- backwashing of the Na-cationic filters;
- dilution water for the sodium chloride (up to 10%) preparation;
- counter-flow water during the regenerant dosing.

The schematic diagram of the wastewater installation resulting from the softening process is presented in fig. no. 2.

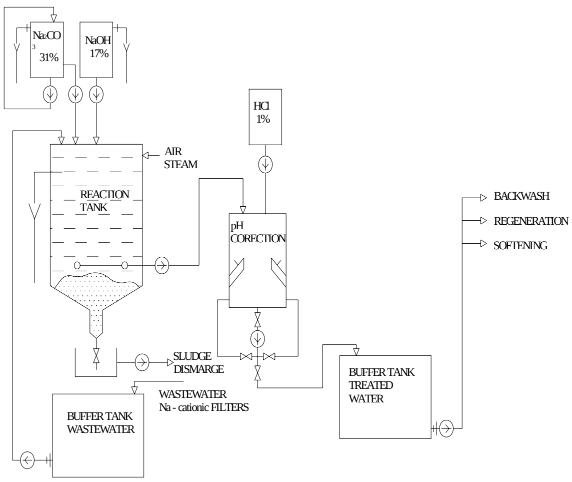

Fig. 2 Principle scheme of the wastewater treatment installation

3 Conclusions

The laboratory tests established:

- the optimum conditions for the calcium and magnesium hardness precipitation (reactive agents and their doses , operating temperature, settling time);
- the optimum physico-chemical indices of the treated wastewater (pH, "p" alkalinity, total hardness and carbonic hardness), necessary for the re-utilization of the treated water for the subsequent regenerations of the Na-cationic filters. The insurance of these indices prevents the diminishing of the useful capacities of ionic exchanges, under the conditions of the treated water reutilization as a regenerative solution;
- the technology for the wastewater treatment in order to reuse it as a regenerative agent.

The advantages of applying this technology are the following:

- full reutilization of the treated wastewater in the process of backwashing and as a regeneration solution in the Na-cationic filters;
- a great diminishing in the volume of the waste water discharged from a of power plant that produces softened water for the district heating networks;
- environmental pollution diminishing through the reduction of the discharged waters with a high salt content;
- diminishing of corrosion in the wastewater transport pipes, by reducing the waste waters chloride content ;
- diminishing of the power plant costs by recovering the regenerative agents of the Na-cationic filters;
- reducing the power plant costs by diminishing the technological process water consumption and the costs for the volume and quality of the discharged water.

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