E3S Web of Conferences **216**, 01083 (2020) https://doi.org/10.1051/e3sconf/202021601083
RSES 2020

Research on technological unit of wastewater disposal after regeneration of H-cation exchange filters

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AnnotationTechnological installation of waste water disposalafter washing of H-cation filters is quite promising idea of avoiding penalties and reuse of waste water in cycle of thermal power plants (TPP). The development of this unit is based on reactions that occur when mixing several TPP water treatment plant wastes, namely, neutralization and exchange-type reactions. As neutralizing reagent, the sludge of the water treatment plant is used, which consists of $CaCO_3$ by 80%. This method reduces the concentration of sulphate-containing components in wastewater to a standard level, and also provides neutral wastewater without the use of additional purchase reagents.

1 Introduction

The ecological problem today is the main problem of mankind. Therefore, over the last 10 years the Ministry of Ecology has significantly strengthened the norms for emissions and discharges of pollutants from industrial enterprises. In addition to flue gas emissions and heat energy, the TPP discharges wastewater that do not comply with the standards established by the sanitary supervision. The most difficult and expensive is the disposal of wastewater after H - cation filters regeneration, since the waters are acid waste regeneration solutions (AWRS) with a significant excess of sulphate-containing components. The concentration of sulphate-containing components is about 2-10 g/dm^3 depending on the water treatment plant (WTP), and the maximum permissible concentration (MPC) is not more than 1 g / dm^3. In addition to AWRS, slurry waters and salt-waste regeneration solutions (SWRS) are formed at the water treatment plant during the ion exchange processes, which are also not reused in the plant cycle. The problem of wastewater disposal exists at all plants where ion-exchange water treatment system is still being maintained. Therefore, the development of a technological installation, which allows the complex disposal of the WTP wastes, is very relevant.

2 Theoretical part

The work is based on a technology that allows the disposal of the AWRS using other wastes of the TPP's WTP. On the pre-treatment of the WTP, which is carried out by the method of liming, coagulation with iron salts, as solid waste, carbonate sludge is formed. Its composition is determined by the natural water component composition and is approximately the same for the TPPs of the middle strip of the Russian Federation. Dry-treated sludge consists of approximately 80% of calcium carbonate ($CaCO_3$), 15% of magnesium hydroxide ($Mg(OH)_2$), 2% of iron hydroxide, the rest of it is other impurities (SiO_2, organic substances, etc.). That is, the WTP slurry is an alkaline calcium-containing reagent [1], [7], [8].

At some thermal power plants, slurry wateris sent to a press-filter and in semi-dehydrated condition stored on the territory of the station. To date, there is no cost-effective technology for the water treatment sludge reuse to produce secondary valuable components. Although the TPP has a large amount of slurry, as waste from the WTP.

AWRS are acidic (pH ≈ 2 units) waters with a significant overestimation of the sulfate ions from normalized indicators for wastewater. Thus, the wastewater treatment plant will be based on the neutralization of acid sulfate water by WTP sludge. As a result of the reaction, a white sediment is formed - calcium sulfate, that is, an excess of sulfate-ions will be bound by calcium ions. The industrial experiment with slurry waters revealed that, along with the appearance of white sediment, there is also a decrease in total rigidity, sulphates and dry residue, which indicates the formation of gypsum. In addition, there is a regular decrease in the content of silicates, as well as a decrease in permanganate oxidability. It can be explained by the presence of iron hydroxide and magnesium compounds in carbonate sludge of the pretreatment coagulant, which are active to silicates and organic substances [1], [5], [6].

Using the WTP slurry, it is possible to clean the wastewater after the H-cation filters regeneration from sulphate-containing components, thereby reducing penalties for discharge with unnormalized values.

The technological scheme can be represented in the following form, figure 1. When neutralizing with slurry waters, the AWRS passes into the neutral region, most of the sulphates are deposited at the moment when the water

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pH has not reached the neutral value. Further pre-deposition can be carried out with the help of the SWRS, which are a solution of calcium chloride and are the wastewater of Na-cation filters. Thus, the initial raw materials of this plant are: the AWRS and SWRS.

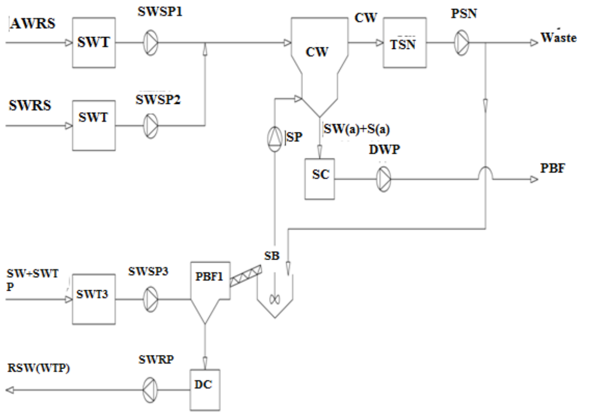

Fig. 1. Technological scheme of the wastewater disposal unit after H-cation exchange filters
AWRS -acid waste regeneration solutions; SWRS -salt-waste regeneration solutions; SW+SWTP - slurry water and sludge from the WTP; RSW (WTP) - return of slurry water from the WTP; CW - clarified water; SW (G) + S (G) - slurry water and sludge (gypsum); SWT – slurry water tank; SWSP – slurry water supply pump; PBF – press belt filter; DC– drainage cell; SWRP – slurry water return pump; SB – slurry basin; SP – slurry pump; C – clarifier; SC – slurry cell; DWP – drainage water pump; TSN - tank for self needs; PSN - pump for self needs.

AWRS is collected in SWT - 1, and SWRS is collected in SWT - 2, then pumps SWSP 1 and 2, respectively, are transferred to the clarifier. To facilitate the clarifier tying, it is possible to mix them directly at the clarifier entrance. The ratio between the AWRS and the SWRS will depend on the initial content of sulfate ions in the original solution, but the main calculation should be conducted on the chemical reactions that occur during neutralization and exchange-type reactions [1], [9], [10].

Reactions when neutralizing the AWRS by slurry components (formulas 1.2):

$$CaCO_3+H_2SO_4=CaSO_4\downarrow+H_2O+CO_2\uparrow \ (1)$$

$$Mg(OH)_2+H_2SO_4=MgSO_4+2H_2 \ (2)$$

The exchange reaction will be based on the following principle (formula 3)

$$CaC_2+Na_2SO_4=CaSO_4\downarrow+2NaCl (3)$$

Slurry waters from WTP accumulate in SWT - 3 and pump SWSP - 3 are fed to PBF - 1. Partial sludge dewatering takes place on the belt filter press. At the outlet we get more dehydrated sludge and partially purified slurry waters, which accumulate in the dayand then are fed by the pump SWSP further to the WTP.

Partially dehydrated slurry in the SB is mixed with clarified water and then is fed by the pump SP into the clarifier reaction zone. The residence time of the wastewater mixture in the clarifier is approximately 30 minutes. In order for the reaction to be as complete as possible, the interaction time can be increased Clarified water with a reduced content of sulfates and sludge water, which accumulate in the conical bottom of the clarifier, leave the clarifier.

Slurry water (G) is largely calcium and magnesium sulfate, and also includes components of unreacted carbonate sludge. Sludge waters are in large excess at TPPs, so they can be dosed into clarifier in 2–3 times. Sludge water (G) accumulates in the sludge cell and is pumped by a DWP pump to PBF – 2.PBF - 2 allows maximum dehydration of gypsum sludge water. Since most of the materials used in construction consist of gypsum and carbonates, further prospects for the use of gypsum sludge are possible in the construction industry.

The clarified water with a reduced content of sulfate ions accumulates in the TSN and by the PSN pump is discharged as wastewater. The effectiveness of this method depends directly on the properly configured mode map of the installation in industrial conditions. This method is extremely sensitive to the component composition of wastewater, as well as to the hydrogen indicator. Proper operation will minimize sulphate-containing components in wastewater.

3 Conclusion

The technological unit presented in this work, will significantly reduce sulfate-containing components in the TPPs wastewater to normalized values. This allows the reuse of purified water in the station cycle, as well as to avoid penalties.

The work was carried out with the financial state support of young Russian scientists - candidates and doctors of sciences under the President of the Russian Federation (Competition - MK-2020). Application No. MK-424.2020.5. Agreement No. 075-15-2020-170 of 10 March 2020.

Literature

1.A.Vlasova, N.Chichirova, A. Chichirov, A. Filimonova, S. Vlasov,Water Ecol.,**2**, 3–17, (2017).
2. A. Gromoglasov, *Water preparation: Processes and devices.*(Moscow,Energoatomizdat, 1990).
3. I. Evgeniev, N. Chichirov,Izvestia of higher educational institutions. Energy problems,**9-10**, 96, (2001).
4. I.Zakirov, A. Korolev, N. Chichirova, A. Chichirov, S.Vlasov, S.Paimin, Izvestia of higher educational institutions. Energy problems,**11-12**, 55–60, (2013).
5. N. Chichirova, A. Chichirov, S. Vlasov, Russian Federation, patent,**133122**, 2013.
6. N.Chichirova, A. Chichirov, S.Vlasov, Russian Federation, patent,**133526**, 2013.
7. S. Kutsenko, J. Khruleva,Russian Federation, patent **2448054**, 2010.
8. V. Popik, V. Zamansky, Yu.Pavilainen, M. Trubitsyn, A. Fedotov, A. Bogdanov, P. Sidorov, Russian Federation, patent**2010013**, 1994.
9. Yu.Shamraeva, L. Pavlukhin, V. Yurkova, E. Pavlova, USSR, patent,**1330078**, 1987.
10. V. Nazarov, Yu. Smirnov, M. Nazarov, Russian Federation, patent, **2355647**, 2009.