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Automatic industrial water treatment plant for the production of steam for boiler room JSC «Road construction materials», Karaganda

In the laboratory of Engineering Profile «Physicochemical Methods of Investigations» in the Karaganda State University named after Ye.A.Buketov scheme of water softening was developed, on the basis of which JSC «Road construction materials» manufactured by experienced industrial water treatment plant for boiler for production of steam. Research indicates that this installation successfully replace traditional water softeners and are promising for conducting water treatment in boiler rooms without hot separation of water.

Key words: steam, boiler room, chemical methods of water softening, hardness salts, industrial water treatment plant.

The application of hard water is unacceptable in some industries, for example in heat-and-power engineering, for example in boilers and heating devices is formed scum, which impairs heat transfer. Therefore the rigidity is one of the water quality parameters that must be controlled.

Special methods of water softening are applied in need of use of a water source with high hardness. The softening can be carried out by the transferring of hardness salts in soluble or coordination complex with the addition of chemical reagents, distilled water, ion exchange method, the electrolysis with the use of coagulants or flocculants.

The essence of chemical methods of water softening consists in the transffering of Ca^{2+} ions and Mg^{2+} in compounds with limited solubility: calcium carbonate $CaCO_3$ and magnesium hydroxide $Mg(OH)_2$. Criteria of a choice of a concrete method of solution purification are total hardness of crude (softened) water, the cost and availability of precipitation reagents, the use of coagulants and flocculants. When softening the water by salt precipitation, hardness salts is converted into next soluble compounds: calcium carbonate, magnesium hydroxide, trisubstituted phosphates.

Depending on the precipitator, ways of processing are called lime application, a codeswitching, phosphate coating. The main reason why to applied hard water, such much attention is paid to decrease in rigidity, mitigation, consists in ability of hydroxides, carbonates and hydrocarbonates of calcium and magnesium, double salts of these metals to form the slightly soluble compounds which are postponed on heat exchange surfaces, on walls of processing equipment and pipelines to put the forcing pumps out of operation. Water softening is much cheaper than:

– demineralization;
– regular cleaning or replacement of equipment;
– constant fuel consumption for the production of hot water, heat, steam.

The methods of its mitigation instrumental solutions and technological schemes are follow from the properties of salts causing the water hardness. The water filling boiler water treatment plant and being the head carrier is softened for 1–2 mEqu/l [1]. In the table 1 is showing qualitative classification of water by hardness.

Table 1

Qualitative classification of water by hardness

Water characteristics	Concentration Ca^{2+}, Mg^{2+}, mg-equ/l	Hardness of water ppm $CaCO_3$	German degrees of hardness dH (dGH)
Very soft water	0–1.4	0–70	0–4
Soft water	1.8–2.8	88–140	5–8
Water of medium hardness	3.2–4.2	158–210	9–12
Pretty hard water	4.6–6.3	228–315	13–18
Hard water	6.6–10.5	332–525	19–30
Very hard water	≥ 10.5	≥ 525	≥ 30

In the laboratory of Engineering Profile «Physicochemical Methods of Investigations» in the Karaganda state University named after Ye.A.Buketov scheme of water softening was developed, on the basis of which JSC «Road construction materials» manufactured by experienced industrial water treatment plant for boiler for production of steam.

Scheme water softening involves three processing method related to a single process line:

– the combined HEDPA (1-hydroxyethylene-1,1-diphosphonic acid);

– sodium silicate;

– electrolysis soluble aluminum electrodes.

The combined forms stable complexes with almost all cations, including cations of alkali and alkaline earth metals. Salt deposition on the surface of the heat exchanger leads to a significant waste of fuel and water resources. The use of chelating agents, dissolving scale, allows for periodic chemical cleaning of the equipment, and the addition of phosphate chelating agents inhibits salt deposition.

The unique ability of phosphate-based chelating agents to show the effect of substoichiometric allows through the introduction of micro-doses to avoid sludge formation even in supersaturated solutions.

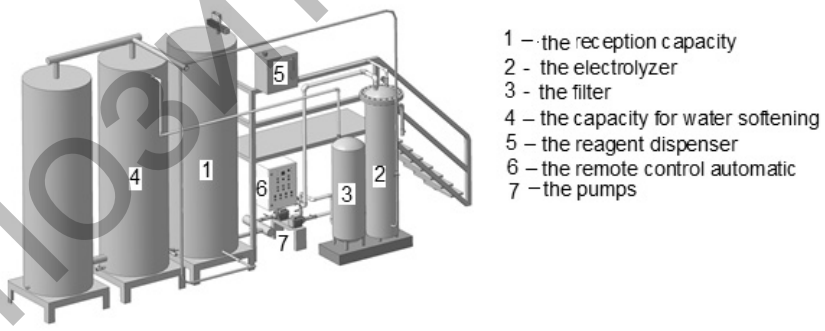
Sodium silicate also softens water by binding cations Ca^{2+} and Mg^{2+} in the insoluble silicates.

The alkali metal silicates at a concentration of 10–25 mg/l — effective high-temperature corrosion inhibitors, regardless of the thickness in the internal metal surface of the heating layer of rust build a solid, dense, but quite thin (20 μm) protective layer.

Electrolyze. Currently, the most effective water purification methods are electrochemical. In contrast to purely chemical, physical and mechanical range, improve electrochemical methods water quality parameters most widely. Method of electrochemical treatment of water by processing the package parallel soluble electrodes (electrocoagulation method) is widely used for waste water, industrial and natural waters, including drinking water [2].

Experimental part

This causes various technical results: an increase in the degree of water purification from impurities, suspended particles, water disinfection, improvement of its chemical properties and other. Treatment of water in stagnant mode (static conditions) allows in a single volume all kinds of electrocoagulation processes: polarization, electrochemical, hydrodynamic and concentration of coagulation. All three ways were united in a single technological cycle for increase capacity, reduce reagent consumption and electricity. On the picture is showing automatic industrial water treatment plant scheme:



Picture. Automatic industrial water treatment plant scheme

Water treatment plant belongs to the group of electrochemical water purifiers and consists of:

– tank heated and bubbling source water dispenser reagent No. 1 (complexone);

– flotation cell containing the cell with the electrode system of soluble aluminum electrodes, bubbling, with dispenser reagent No. 2 (sodium silicate);

– filter cleaning softened water (porous granules);

– tank storage of the treated water;

– the automatic control system of technological cycle.

In the JSC «Road construction materials for boiler feed water for steam production the water from two sources wells and wells in the storage reservoir was used. Water from the two sources was investigated on quality indicators, also for comparison was investigated water resulting from the operation of the plant.

Data source and softened water from well (Table 2, 3).

Qualitative indicators of source water

pH — 6.79; Color — no color; Odour — odourless; Sediment — no sediment

Hardness of water, mg-equ/dm^3 general 6.50
carbonate 3.60
permanent 2.90

Solids content, mg/dm^3 617

The amount of mineral substances, mg/dm^3 727

In the table 2 is showing the ionic composition of the source water:

Table 2

The Ionic composition of the source water

Cations	mg	mg-equ	% mg-equ	Anions	mg	mg-equ	% mg-equ
Na^+	90	3.91	38	Cl^-	77	2.16	21
K^+	1.0	0,03	0	SO_4^{2-}	216	4.50	43
Ca^{2+}	86	4.30	41	HCO_3^-	220	3.60	34
Mg^{2+}	27	2.20	21	NO_3^-	10,5	0.17	2
NH_4^+	0.50			NO_2^-	0.03		
Total		10.44	100	CO_3^{2-}		<3.0	
				Total		10,43	100

Qualitative indicators of softened water after the processing in the unit

pH — 9.4; Color — no color; Odour — odourless; Sediment — no sediment

Hardness of water, mg-equ/dm^3 general 3.60
carbonate 3.60
permanent 0.00

Solids content, mg/dm^3 820

The amount of mineral substances, mg/dm^3 904

In the table 3 is showing the ionic composition of softened water after the processing in the unit:

Table 3

The ionic composition of softened water after the processing in the unit

Cations	mg	mg-equ	% mg-equ	Anions	mg	mg-equ	% mg-equ
Na^+	350	15.22	81	Cl^-	126	3.55	19
K^+	1	0,03	0	SO_4^{2-}	192	4.00	21
Ca^{2+}	45	2.25	12	HCO_3^-	165	2.70	15
Mg^{2+}	16	1.35	7	NO_3^-	7.4	0.12	1
NH_4^+	1.00	0.06		NO_2^-	0.45		
Total		18.91	100	CO_3^{2-}	24	68.2	44
				Total		18.57	100

Data source and softened water from the water-conduit well (Table 4, 5).

Qualitative indicators of source water

pH — 6.6; Color — no color; Odour — odourless; Sediment — no sediment

Hardness of water, mg-equ/dm^2 general 14.36
carbonate 3.80
permanent 10.56

Solids content, mg/dm^3 923

The amount of mineral substances, mg/dm^3 1231

In the table 4 is showing the Ionic composition of the source water:

Table 4

The Ionic composition of the source water

Cations	mg	mg-equ	% mg-equ	Anions	mg	mg-equ	% mg-equ
Na^+	132	5.74	38	Cl^-	103	2.9	21
K^+	1.0	0.03	0	SO_4^{2-}	805	16.76	43
Ca^{2+}	255	12.73	41	HCO_3^-	232	3.8	34
Mg^{2+}	66	5.43	21	NO_3^-	29.1	0.47	2
NH_4^+	0.50	0.01	0	NO_2^-	0.03	0	0
Total		23.94	100	CO_3^{2-}	<3.0		
				Total		23.93	100

Qualitative indicators of softened water after the processing in the unit

pH — 8.7; Color — no color; Odour — odourless; Sediment — no sediment

Hardness of water, mg-equ/dm^3 general 6.96

carbonate 3.80

permanent 3.16

Solids content, mg/dm^3 925

The amount of mineral substances, mg/dm^3 1507

In the table 5 is showing the Ionic composition of softened water after the processing in the unit.

Table 5

The Ionic composition of softened water after the processing in the unit

Cations	mg	mg-equ	% mg-equ	Anions	Mg	mg-equ	% mg-equ
Na^+	390	18.5	68.7	Cl^-	125	3,88	14.4
K^+	1.0	0.03	0.1	SO_4^{2-}	576	17.03	63.3
Ca^{2+}	145	7.2	26.7	HCO_3^-	298	5.72	21.3
Mg^{2+}	25	1.2	4.5	NO_3^-	25.6	0.26	1.0
NH_4^+	0,0			NO_2^-	0.0		
Total		26.93	100	CO_3^{2-}	<3.0		
				Total		26,89	100

In the water treatment pilot plant it happen the following physico-chemical changes:

– almost completely disappears constant component of water hardness, due to the transition in the sediment part of the anions;

– the pH increases towards alkalinity;

– the carbonates become bicarbonate;

– the cations Ca^{2+} and Mg^{2+} is replaced by Na^+ cations.

Obtained after processing in the installation of water:

– hard become soft;

– alkaline;

– colorless;

– odorless;

– no sediment;

– boils without scale;

– suitable for use in steam boilers.

Research indicates that this installation successfully replace traditional water softeners and are promising for conducting water treatment in boiler rooms without hot separation of water.

References

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Қарағанды қ. «Дорстройматериалы» АҚ бу жасауға арналған қазан үшін автоматты өндірістік су дайындау қондырғысы

Е.А.Бөкетов атындағы ҚарМУ физика-механикалық зертханасында суды жұмсарту схемасы жасалды, оның негізінде «Дорстройматериалы» АҚ бу өндірісі бойынша қазанға арналған тәжірибелі өндірістік су дайындау қондырғысын жасап шығарды. Жүргізілген зерттеулер нәтижесінде осындай қондырғылар су жұмсартудың дәстүрлі үлгісін табысты алмастыратыны және қазандарда ыстық су бөлусіз суды дайындауды жүргізу үшін келешегі бар екені анықталды.

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Автоматическая промышленная установка водоподготовки для котельной по производству пара АО «Дорстройматериалы» г. Караганды

В ЛИП «ФХМИ» КарГУ им. Е.А.Букетова была разработана схема умягчения воды, на основании которой в АО «Дорстройматериалы» изготовили опытную промышленную установку водоподготовки для котельной по производству пара. В результате проведенных исследований было установлено, что подобные установки с успехом заменяют традиционные схемы умягчения воды и являются перспективными для ведения водоподготовки в котельных без горячего водоразбора.