Part 2

WATER PROTECTION FROM DISCHARGES

2.3. Treatment of industrial and surface waste water from power companies

2.3.3. Treatment of surface waste water at power plants

2.3.3.1. Flotation treatment of surface waste water

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Installations, developed in a scientific research institute of power mechanical engineering of Bauman MSTU and JSC "GosNIIsintezbelok" for the treatment of oily waste water, including surface water, consist of a receiving lattice, a sand separator, a sedimentation reservoir, a flotation plant, coalescence, and sorption polishing filters.

Let's consider the proposed scheme of surface waste water treatment in more detail (fig. 2.29).

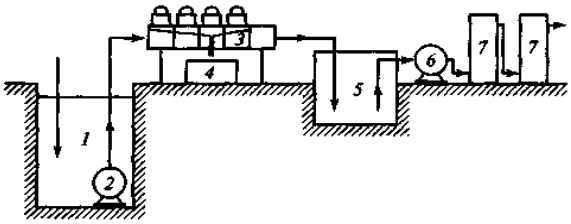

Рис. 2.29. Surface waste water treatment scheme

Surface waste water from an industrial area, passing through the lattice is collected in the sedimentation reservoir.

Waste water is pumped from the reservoir *1* with the pump *2* and is directed to the PMF-0,5 type pneumatic flotation machine *3* with the thin-layer clarification unit (fig. 2.23). In the above flotation machine extraction of fine drops of oil takes place when it flows upward together with air bubbles, appeared as a result of air dispersion aroused by air compressing through porous aerators, made from special rubber. Twelve aerators are installed in the floatation machine- three in each of the four chambers. In the additional fifth chamber of the flotation machine a thin-layer clarification unit for the final extraction of fine oil drops is installed. The treated waste water consequently passes all the above mentioned chambers, captured oil pollution is collected in the upper part of the treated water as a foam. Floating oil products together with air bubbles produce a foam layer that is removed by gravity into a foam collector *4* (supplied with the flotation machine). After settling of foam, which is a mixture of water and captured oil, decanted water is discharged into the sunk tank *5*. The purified liquid is disposed from the flotation machine by consequent passing the thin-layer clarification unit and the device for control of the required level of treated water in the floating machine and by gravity flows to the intermediate tank (collector) *5* with a work volume of not less than 3 m^3. Intermediate tank *5* is constructed from a monolithic or assembled reinforced concrete.

By means of the surface pump *6* preliminary treated water is directed for polishing to the sorption filters *7*. The first filter in the fluid direction has a combined load consisting of an expanded-clay layer (lower layer) and a layer of activated coal, and the second filter is fully loaded with activated coal. In these pressure filters coal with properties similar to the brand of coal AG-3 is used. This provides deep polishing of surface waste water to the residue oil products concentration of not more than 0.05 mg /liter. Taking into account the specifics of seasonal nature of the waste water treatment operation it is proposed not to regenerate the coal loading, and use it only for one season. It is expedient to utilize the spent loading by burning, for example, in the boiler or in a special furnace, where coal is used as fuel.

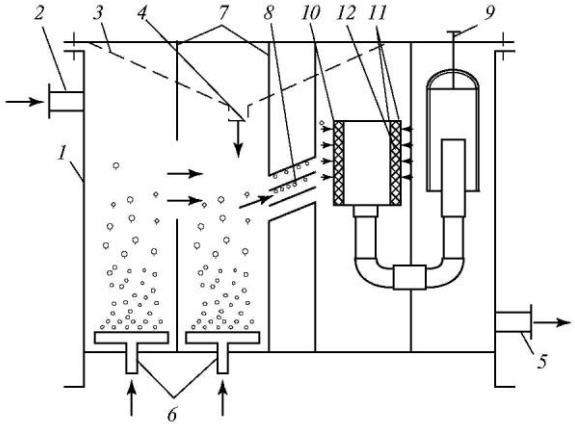

Fig. 2.30. Scheme of a flotation machine with a filtration element

Treated waste water with oil content less than 0.05 mg/l is allowed for discharge to the terrain or the nearby water reservoir.

Flotation machines of this type have been implemented at various enterprises, and therefore their technological schemes of waste water treatment differ from that described above in some cases. Plants for waste water treatment, with a flotation machine shown in fig. 2.23, are implemented at various power plants.

A considerable improvement of a floating machine PMF-0.5 is a floating machine with a filtering element (fig. 2.30). It consists of a casing, which is divided by screens into chambers with aerators installed at the bottom. In the last (in water flow direction) chambers a thin-layer clarification unit and a device for controlling of the waste water level are installed. At the outer side of the casing inlet and output pipes are installed, at the lateral of the casing- channels for captured pollution drainage. A distinctive feature of the flotation machine is an additional intermediate chamber installed between the thin-layer clarification unit and the level control device. A filtration element is installed in this chamber designed as two empty cylinders with perforated surfaces with special loading located between them. The test researches determined that an optimal range of perforated surface living section is within 10 ... 25% of the total area. It was found that when the living-section is less than 10% improvement of the efficiency of the waste water treatment is not achieved, and when it is more than 25% treatment effect remains without any change.

Loading is made of the adsorption material such as activated coal, sipron, vizopron, megasorb, etc.

A flotation machine with a filtration element for the waste water treatment (Fig. 2.30) consists of the casing *1*

with an inlet pipe for initial water feed, a foam channel *3* and an output pipe for pollution withdrawal in a form of foam *4*, an output pipe *5* for treated water output are installed at the outer side. Disc aerators *6* used for gas (air) supply and also immersed partitions *7*, the thin-layer clarification unit *8*, the device for liquid level control *9* and filtration element including casing *10* with perforated inner and outer surfaces *11*, and filtration loading between them *12* are installed inside the casing.

An operation principle of the flotation machine for the waste water treatment is as follows. The initial waste water is fed through the pipe 2 and further to the bottom of the machine 1 to the aeration zone, created by the disc aerators 6, which are generators of gas bubbles (air). When water is moving in the aeration zone hydrophobic contaminants contact with the bubbles, stick with them and form complexes (particle - bubble). Flotation complexes formed - particles of contaminants and air bubbles - rise up, forming a foam layer, which is by gravity or by force is discharged from the machine through the foam outlet channel *3* and *4* to a sludge collector. Purified water from the aeration zone is taken away passing the thin-layer clarification unit *8*. Flotation complexes caught in between shelf space, quickly reach the top shelf due to the small distance between the shelves (10 to 150 mm). Flotation complexes adhered to the top shelf stick together (coalesce) into larger aggregates, arousing large buoyancy and rapid floating of these complexes to the upper foam layer. The purified liquid passed between shelf spaces gets to the filtration zone, where a filtration element of the adsorption type is installed. Flotation complexes adhered at the outer perforated surface 11 of the filtration element coalesce with each other similar as in the thin-layer clarificator. The filtration element is filled with a special material *12*, capturing suspension pollutions. Further, purified water passes through the liquid level control device *9* and is derived from the body of the flotation machine through the output pipe *5*. Waste water cleaning efficiency in the described flotation machine is 98 ... 99.5%, the concentration of hydrophobic contaminants in the purified fluid is within 0.05 to 0.5 mg/l. Such efficiency is considerably higher than in the known flotation machines, where residual concentration of hydrophobic contaminants makes usually 2 ... 4 mg /liter.

Advanced units of flotation equipment including PFM-0,5 were takes as a basis in various designs of reconstruction of the existing technological units and newly constructed treatment facilities in the process of waste water cleaning from oil products, in particular in power industry, for example Yuzhnaya and Pervomayskaya HTPP of JSC "Lenenergo" and Ust-Ilimskaya hydro power plant of JSC «Irkutskenergo".

Implementation of the developed technical solutions at Ust-Ilimskaya hydro power plant included development of a technological part of the working design of local treatment facilities (LTF) for surface runoff and treatment facilities of car wash of a motor transport shop; manufacture of equipment based on our documentation, supervision of equipment erection, start-up and putting of treatment facilities into permanent operation.

Ust-Ilimskaya hydro power plant refers to objects with relatively well-solved environmental problems. However, treatment of surface runoff in the motor transport workshop (MTW) was provided only in the horizontal settling tank, failing to provide normative values of main controllable indicators: for oil (there should be no more than 0.05 mg/l) and suspended substances (no more than background concentrations +0.75, where concentration of suspended solids in the creek Simah, falling into the Angara river is taken as the background).

I. Design and operation principle of LTF of motor transport shop at Ust-Ilimskaya hydro power plant

LTF scheme includes a sedimentation reservoir , which is also a receiving reservoir, two flotation machines PFM-0,5, a reservoir to collect the captured oil products, four pressure filters, loaded with activated coal of brand AG-3 and intermediate tank with a bottom pump KR250A1 (fig. 2.31).

According to the design the unit can operate in two modes: manual and automatic. Automatic mode is used during normal every day operation of the equipment, and manual- in the emergency cases when automatic mode is impossible.

During rains surface waste water is collected from the surface of the MTS and is piped to the sedimentation reservoir. When the level in the sedimentation reservoir reaches a maximum value, the float *401* (hereinafter – reference numbers of equipment accepted at LTF of Ust-Ilimskaya hydro power plant are used), floats up and drives the pump *301* which pumps the cleaned water through the flotation machine into the intermediate tank *102* and the compressor *305*, which begins to blow air in flotation machine *201*. When the water level in the sedimentation reservoir is reduced to a minimum value, the float falls down and turns off the pump and the compressor.

After passing the main treatment in the sedimentation reservoir and the flotation machine waste water is collected in the intermediate tank *102*. The pumps *303* and *304* installed un the intermediate tank, are equipped with float switches *403* and *404*, which also automatically drive pumps and pump water through sorption filters when the level is at its maximum and then stop pumps when level reaches its minimum level. Cleaned water after filters is discharged to the terrain. When rain water volume increases and the pump fails to pump the total water flow, the level reaches the second critical level, the standby pump turns on by its own float switch and pumps water through a parallel treatment line. Similarly, there is a second backup pump in the reservoir *102*, for which the second critical level is provided.

During emergency situations involving automation failure, operation of the unit is carried out manually. At the same time during absence of rains repair of damages and elimination of emergency situation consequences should be carried out.

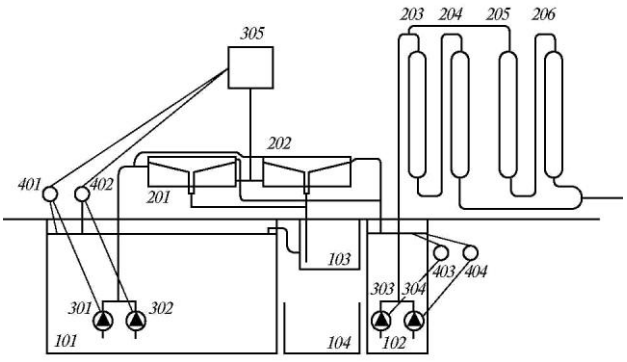

Fig. 2.31. Principal scheme of surface water treatment facilities at motor transport plant of Ust-Ilimskaya HPP

The separation reservoir consists of three parts. In the first part averaging and clarification of wastewater takes

place. In this part the bottom pump KR250A1is installed, which controls the supply of waste water into flotation. The second part of the tank is not used. The third part is used to release treated wastewater into the creek Simah.

The sedimentation reservoir has the following dimensions, m:

Length 12,82
Width 3,0
Height 4,26

The sedimentation reservoir was earlier used as a main construction for surface waste water treatment of a MTS of Ust-Ilym hydro power plant.

Waste water from a sedimentation tank is directed into the flotation units of PFM-0,5 (2 machines.) for treatment against oil products.

Technical characteristics of PFM 0,5

Number of chambers 4
Overall dimensions of the chamber, mm:
length 500
width 1000
height 1000
Unit air flow rate, $m^3/(m^2 \cdot min)$ 1,2

According to the Sanitary-Epidemiological conclusion No 77.01.03.485.P.34421.11.2 dated 11/27/02 residual concentration of oil products in the treated water does not exceed 0.05 mg/l when flotation machine PFM-0,5 together with a polishing filter is used for the waste water treatment.

From the intermediate reservoir fluid previously purified is pumped by means of a bottom pump for additional treatment to the polishing filters with coal load (active coal of AG-3 brand produced by JSC "Sorbent", Perm, Russia).

Pressure filters are designed for polishing of waste water from oil and suspended solids to regulatory targets set for the discharge of treated wastewater into surface fishery type water objects (for oil of 0.05 mg/l of suspended solids + 0.75 to the background - the concentration of suspended solids in creek Simah).

Technical characteristics of the pressure filter:

Working volume, m^3	0,15
Dimensions of a working chamber. m:	
diameter	0,5
height	0,8
Loading.....	Activated coal of Ag-3 brand (as for design)
Load mass for one filter, kg	80

Cleaned water after the filter through the water flow gage is discharged to the creek Simaha.

II. Test of operation ability and the technological effect of LTF

LTF operation ability tests were performed in three stages.

At the first stage testes were conducted at the existing equipment without any special preparation. The technological LTF operation efficiency data are presented in Table. 2.7 (line 1). It has been established, that concentration of the oil products decreased from 10.5 mg/l at the entrance (in the sedimentation reservoir) to 0.15 mg/l at the exit (after filters).

To organize the LTF in accordance with the design a series of necessary measures was carried out, including the substitution of the filter loading by active coal of AG-3 brand from the new received parcel of JSC «Sorbent» (Perm). After that tests were continued (second stage). Results of the second stage tests are presented in Table. 2.27 (lines 2-6). The analysis of data presented in the Table. 2.27 shows that substitution of filter loading improved the quality of treated waste water.

The results obtained satisfy the regulation requirements for the quality of treated waste water discharged into the fishery water sources.

III. Final tests of LTF

For the final assessment of the LTF operation efficiency final tests were carried out with determination of oil product and suspended particle concentrations at the entrance of LTF (in the reservoir) and at the exit (after filter). The sample characteristics are as follows:

Place of sampling — Ust-Ilymskaya hydro power plant local treatment facilities;

Data and time of sampling — 1.07.2005 ., sampling beginning — 10 h 45 min, sampling performed each 10 min;

Protocol of sampling № 7;

Document regulating sampling and sampling assessment, — GOST R 51592—2000 «Water. General requirements to sampling».

Results of final tests are provided in table. 2.8.

Final test results indicate that as for regulated water quality indicators (oil products and suspended particles maximum concentration limit is respectively 0.05 mg/l and the background concentration in the creek Simaha +0.75) the values of the achieved concentrations do not exceed the established maximum concentration limits. Similar results were obtained for other power plants.

Table 2.7. Results of in-situ tests of LTF operation for waste water treatment from oil products

Sample	Date	Oil concentration, mg/l in treated waste water				Comments
		Sedimentation reservoir	Inlet chamber of the flotation machine	Outlet chamber of the flotation machine	After filters	
1	16.06.05	10,5	–	–	0,15	Old filter loading New loading
2	21.06.2005	–	0,79	0,54	0,07	The same
3	22.06.2005	9,14	–	–	0,02	»
4	23.06.2005	3,53	–	–	0,06	»
5	23.06.2005.*	3,52	–	–	0,052	»
6	24.06.2005 **	1,42	–	–	0,019	

*The measurements performed by Ust-Ilymskaya multi-regional department of analyses and monitoring of the environment.

** The measurements performed by the laboratory of Ust-Ilymskaya water supply system

Table 2.8. Results of final tests of LTF for the surface waste water

Ingredient	Regulation document	Measurement results*, mg/dm^3		Accuracy of the measurement results**, mg/dm^3		Comments
		Sedimentation reservoir	After filters	Sedimentation reservoir	After filters	
Suspended particles	PNDF 14.1:2.110—97	114,6 120,1 112,4 116,6 117,8	11,3 11,1 11,2 10,8 10,5	For all 10,0	For all 2,0	Standard + 0,75 to the background
Oil products	PNDF 14:1:2:4.128—98 Issue 2002 г.	4,99 1,48 1,42 1,49 1,16	0,02 0,02 0,03 0,04 0,02	1,25 0,37 0,36 0,37 0,29	0,01 0,01 0,015 0,02 0,02	

*Results are calculated as arithmetic mean of the two parallel measurements

** The stated accuracy is obtained in the laboratory and is guaranteed by results of measurement accuracy control.