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MAINTENANCE OF OPENED RESERVOIRS OF OIL PUMPING STATIONS OF MAIN OIL PIPELINES

Nowadays, practically at all oil pumping stations of JSC "Transneft", opened reservoirs (OR) and basins for oil disposal from waste water treatment plants, emergency spills, sediments removed from reservoirs and oil with all inclusions from scraper chambers are included in the technologic chain of the production processes. Similar installations exist at the enterprises of oil production and oil processing as well. Thus, by the end of 1997, approximately 2 ml. tons of contaminated oil was accumulated in OR, sumps and all kinds of basins at the enterprises of oil production and oil transport of Bashkortostan and Tatarstan, which practically makes up an annual level of the production of such countries as Hungary and Austria. Such ponds and basins are situated in the location area of main units of the pumping stations and residential settlements, which may involve unpredictable situations, hazardous for man. A condition and variety of the surroundings, health and quality of life of the population in the vicinities of main oil pipeline units as well as fire safety of forests and settlements depend on volumes of emissions to the environment, quality of waste waters removed after waste water treatment plants, industrial wastes utilization technology.

A development of production processes, an introduction of new technologies of work shall allow to reduce their quantity in a great degree, and in some cases, to exclude them from the operation completely. A complex approach to the solution of these problems, providing with an increase in maintenance reliability, natural resources preservation, and decreases of a contamination level is one of the priority tasks of JSC "Transneft" and its subdivisions. The selection of a treatment technology and further re-cultivation of soils in each concrete case shall secure a return to the circulation of a considerable quantity of the additional oil, soils for the application as agricultural lands, stable and safety maintenance of flow process systems of the main transport of oil and oil products.

The main tasks in solution of problems of the maintenance of opened vessels are as follows:

1. The analysis of a condition and structure of opened reservoirs, existing at oil pumping stations in operation and its influence on the surrounding units.
2. The study of physical-chemical properties of oil products, existing in opened reservoirs.
3. The elaboration of flow processes and the selection of technical means for oil product removal out of opened reservoirs.
4. The choice of methods of oil sludge utilization, water and ground treatment out of oily contamination in condition of oil pumping stations (OPS) and refineries (NPZ).

In the course of research works, over 20 opened basins were examined at oil pumping stations in operation. Based on the examinations carried out at the existing opened basins, the analysis was made of reasons of the emergence and condition of these opened basins. Summary parameters, situational location schemes, typical general view are given. The examinations carried out, allowed estimating the necessity of each concrete pond really in the overall flow process chain of oil pumping station (OPS), as well as ecological and technical genetic hazard made by it.

It is shown that ponds, a functioning of which shall be made in future as well, require to be provided with the technology of operation, securing a rapid removal and utilization of oil fraction, and treatment and drainage of water accumulated in due time.

The data are given according to researches of physical and chemical properties of oil products in opened basins. A complexity of opened basin structure, a heterogeneity and variety of the fractional composition of samples, taken from 11 various regions are pointed out. A wide range of variation based on the comparison of received physical and chemical results is detected: density, viscosity, water content, sediments, asphalt-tarred (pitch) materials, paraffins and etc.

The products analyzed are divided into groups as per consumption properties and delivery terms.

On completion, having defined criteria of the approach, an attempt based on real researches of opened basins and a laboratory study of oil product properties is made to elaborate a classification system of opened basins functioning per main indications, among which the following are outlined: oil product properties, a functional purpose, dimensions and forms, age and etc.

A stress is made to the importance of the definition of the physical and chemical structure of oil products, existing in opened basins to select technologies of oil product removal and utilization during the treatment and liquidation of ponds.

Fulfilled research works of oil products allowed to underline the following: the main parameter, defining a possibility of the efficient removal of oil products out of opened basins is the viscosity and density, which depend on temperature essentially, therefore, the most important task is the definition of both the current oil product temperature and a subsequent one due to the environmental temperature alteration.

A similar task is possible to be solved with the application of mathematical models, allowing making prognosis of the oil product temperature for that period of time, when works of product's removal are to be carried out. The oil product condition prognosis allows changing parameters of equipment operation in due time, and as the result, reduces expenses essentially for works fulfillment. Besides this, it shall provide with a trustworthy choice and the installation of heating elements, which will secure favorable conditions of oil product's pumping out of opened basins regarding both the technical and economic parts.

A model is elaborated, allowing making prognosis of oil product changing in time, depending on the outside conditions alteration.

From the beginning, the task of heat spreading in opened reservoirs is examined, provided a product is to be heated from the surface at the expense of the environmental medium without an artificial heating.

A heat spreading process in ponds – accumulators during a natural heating of the product via the surface with a reasonable for practice exactness may be described by one-measured heat conductivity equation. Since a range of temperature alteration is not wide in the examined task, the thermal-physical coefficients, included in equations,

describing the heating process, may be considered, not depending on the temperature. A thermal field may be described mathematically in the mentioned conditions as follows:

$$c(y)\rho(y)\frac{\partial T(y,t)}{\partial t} = \frac{\partial}{\partial y}(\lambda(y)\frac{\partial T(y,t)}{\partial y}), t \in (0, t^*], \quad y \in (o, H), \quad (1)$$

$$T(y, 0) = T_0(y), \quad y \in [0, H], \quad (2)$$

$$\lambda(y)\frac{\partial T(y,t)}{\partial y}\Big|_{y=H} = \alpha(T_{BH}(t) - T(H,t)), \quad (3)$$

$$-\lambda(y)\frac{\partial T(y,t)}{\partial y}\Big|_{y=0} = 0 \quad , \quad (4)$$

Where T(y,t) - temperature in point y at the meeting moment t (^{0}C);

C (y)>0- specific heat capacity (J/kg·degree);

$\rho(y) > 0$ - Density of heated medium (kg/m3);

$\lambda(y) > 0$ - Heat conductivity coefficient (J/(day·m·degree));

$\alpha > 0$ - Heat exchange coefficient (J/(day·m^2·degree));

$\mathbf{T_{ext}(t)}$ - environment temperature (^{0}C).

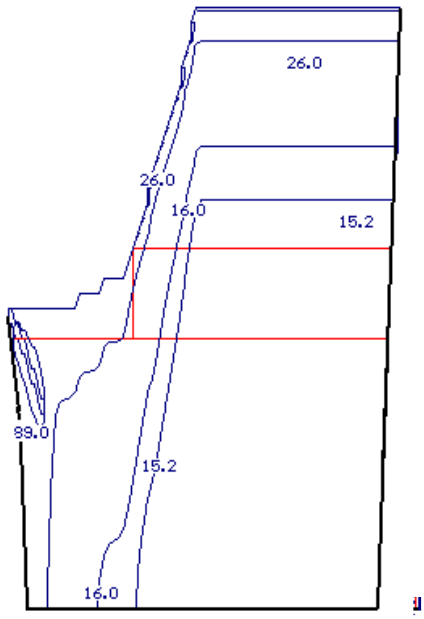
The heated temperature consists of several layers. In each layer thermal and physical coefficients c(y), p(y), λ(y) are constant, but in different layers they adopt various meanings.

A product's heating is made by an external source $T_{ext}(t)$ as per Newton's law, that is reflected mathematically in the marginal requirement (2.3). The marginal requirement (2.4) means an ideal thermal insulation in point y=0.

T A S K. To find function T(y,t), y∈[O,H],t∈[0,t*], that is a decision of the equations system (2.1)-(2.4) and description of temperature distribution in a basin – accumulator.

The mathematical description of thermal processes in basins-accumulators is carried out on the basis of non-linear differential equations of particular derivatives of parabolic type with non-linear marginal requirements. A method of end differences is proposed for the application in this paper as the method for decision of such tasks. Firstly, a calculation is carried out provided an artificial heating of the product is applied. Then, a temperature field of the basin – accumulator is investigated, taking into account a natural heating of the product from the surface at the expense of the environment and an artificial heating of the product at one of the shores by means of internal thermal sources.

The temperature distribution in the basin after 20 days from the beginning of the heating is given in Fig.1.



Temperature rang: 15… 26 ^{0}C

ISO-lines of the same temperatures after 20 days from the beginning of heating

Fig.1.

Based on the proposed models and algorithms of the calculation, a package of the applied programs is worked up, permitting to define at any arbitrary moment of time a value of the product's temperature at any point and get a graphic presentation of the temperature distribution field in all investigated object.

An efficiency of the artificial heating application is proven by calculated experiments in order to improve requirements of a product selection.

A possibility of the elaborated package application of the applied programs is defined for specific opened basins-accumulators when choosing a flow process and equipment for oil product removal.

Different reasons and stages of the opened reservoirs' formation, inhomogeneous physical and chemical composition of its oil products cause the necessity of the application of various flexible methods and technologies of oil and oil products removal and disposal.

Based on the analysis of the condition of opened basins and the simulation of possible temperature effects, the P & I diagrams of oil and oil products removal were elaborated. In order to remove a mobile part of the oil product, flow process diagrams were elaborated, the central chain of which are skimmer – units FOILEX TDS-200, Elastec TDS-118, WP-1-30 and others, then, the application conditions, operation modes and specific design features were presented. To protect working parts of the pumping equipment, screen filters were used at the inlet and outlet of the pressurized line.

While handling opened basins, requirements are displayed when the application of simple technologies with the usage of a minimum set of the equipment and processes

are not sufficient. Therefore, the necessity of the combined technology application with the usage of artificial heating and more universal equipment is arisen.

With the purpose of the development of technologies concerning to opened basins, containing viscous oil products, a description of more complicated diagrams is given with the application of a larger set of the equipment, places of location and modes of artificial heating.

An example of the similar scheme is shown in Fig.2.

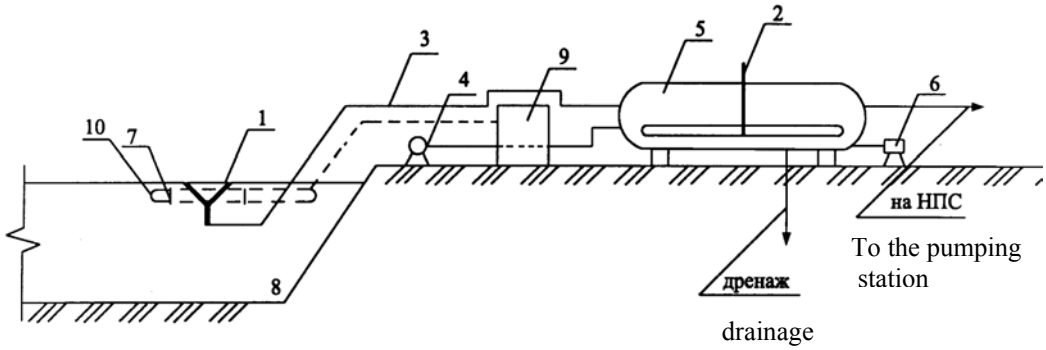


Fig.2 Flow process for viscous oil products

1-In-take arrangement; 2-Electrical heater ГТЦ; 3 - Pipeline for oil product pumping; 4 - Vacuum pump BBH1; 5 - Vessel for oil product; 6 – Compressor; 7 - Level Control System; 8 - Emergency basin; 9 - MSU (mobile steam unit); 10 - Oil product heating coil.

Further, approaches to difficult-treated basins of large dimensions with a considerable content of the bottom sediment are examined. It is pointed out, that identical tasks are typical for both opened basins with “old” oil products, with a miserable content of fresh oils as well as for opened basins, used in a chain of waste water treatment plants of refineries. According to the proposed diagram, the oil product, including floating formations and the bottom’s part, was handled and mixed before its delivery to the in-take arrangement. The diagram’s central link is special submergible mixers FLYGHT, mounted on a floating device (pontoon). The operation according to such a scheme shall allow to transport floating oil products and bottom’s sediments to the place of the in-take via a directed influence on the relief of sediments and heavy oil sludge. The collected oil product undergoes the treatment and de-watering in the macerator, hydrocyclone and settling basin with fazes of separation level. Fig.3.

At the final stage of the treatment of opened reservoirs it became known, that a bottom oil sludge and water remain there after removal of main oil product and the treatment of ground pond’s bottom is a big problem.

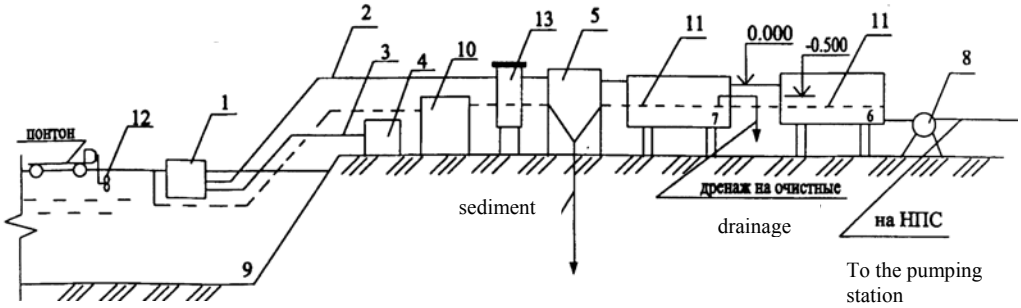


Fig.3. Flow process with the application of the submerged mixers

1.-In-take arrangement; 2.-Pressurized hose for oil product pumping; 3.-Electrical cable or oil-tracing line for heating; 4.-Power unit; 5.- Hydrocyclone; 6. - Oil product collection vessel; 7. - Settling basin with fazes separation level; 8. - Pump for commercial oil product; 9. - Emergency basin; 10. - Mobile steam unit or boiler; 11.-Oil product heating coil; 12 - Mixer assisting oil product movement toward the skimmer; 13 - Macerator NBI-200.

The questions examined in this direction showed that that the bottom's oil sludge might be in some cases as a raw material for receiving specific oil products and constructional materials.

The important problem when treating opened reservoirs is water drainage. Water-treatment procedure is obligatory in all cases. The results of the fulfilled researches point at a possibility to achieve a higher degree of the treatment in conditions of OPS. For this reason it is necessary to use high effective chemicals. A wide series of reagents of CIBA (Allied Colloids) was tested. The results of laboratory and industrial tests showed, that the application of correctly selected reagents allow to use a potential of waste water treatment units of OPS as much as possible for both for the treatment of waste waters and for the treatment of oil sludge in centrifuges. A flow process diagram, including a chain of shelf settler – turbo-flotator, is proposed for the treatment of wastewater of sludge accumulators. The shelf settler serves for the purpose of sediment of a big sized dispersion suspension, solids and for catching of floating oil products.

The shelf settler functions flooded at the atmospheric pressure. The level control system secures a required degree of filling of the basin and removal of the oil products caught. Water, after the preliminary treatment in the settler, comes to the flotation stage.

Turboflotators GFS are flotators of an impeller type, which means, the initiation process of flotation is achieved by means of the rotating impeller. Waste waters subject to the treatment, go via four working chambers in turn. The formation of air bubbles in the working chambers occur due to air suction by the rotating impeller and its subsequent dispersion via the system of perforated ring sheets fixed rigidly on the housing.

The automatic level water control, due to flow rate fluctuations, is made by the control and operation system, connected with quieting – the last chamber of the unit.

Qualitative results, received at the outlet, meet the existing norms with a reserve per removal to the installations of bio-chemical treatment.

A similar scheme may be used as the first chain in the system of wastewater treatment plants of OPS and oil bases in case of the reconstruction of mechanical wastewater treatment plants. To the indisputable advantages of the scheme the

following may be referred: compactness, a wide range of typical measures as per flow rate, treatment efficiency, simplicity of the maintenance, not requiring constant personnel's control, hermetically execution and execution on the surface.

Further, versions of chemical and biological contaminated soil recultivation are examined as well as the application of thermal treatment of severely contaminated sediments.

In most cases, this method uses a specially treated calcium oxide (quicklime) as a main reagent.

When slaking lime, an energy is released in the form of heat in the process of hydration, and calcium hydro-oxide is received as the result (slake lime):

$$CaO + H_2O = Ca(OH)_2 + \text{energy}. \quad (5)$$

When mixing a reagent with a contaminated material, water-free components (for ex. oil) are selectively absorbing between particles of calcium oxide treated. Water, existing in the contaminated material, after some time, starts to react with calcium oxide, forming fine powder-like calcium hydro-oxide, that is approved by the equation above.

The contaminated substance is surrounded with a capsule from particles of calcium hydro-oxide. Since hydrophobia agent is preserved, calcium hydro-oxide continues to push away water and remains resistant to leaching:

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O. \quad (6)$$

It is shown that the application of the known DSR technology allows receiving powder-like hydrophobia's materials with high geo-mechanical results when requirements for passing carbonization reactions are observed. Meanwhile, this technology does not limit a positive effect of biocenosis on grounds treated with quicklime.

A mobile incinerator Vulcanus secures the thermal treatment with the purpose of making material non-hazardous. The Vulcanus incinerator consists of a container with a lowering and regulating roof and a ventilator equipped with a diesel drive. Air, pushed by the ventilator, goes through the fire grate hearth via fire in the chamber as well as on top, through air-blowers in the roof towards the fire, which causes flame turbulence, provides with a high temperature and as the result, a full burning of the residuals charged in the incinerator.

Optimal conditions for burning are achieved by regulation of:

- Air valves
- Guiding bars, which allow changing an inclination angle of the roof.

The Vulcanus unit may be used both for applications in case of emergency at linear part of pipelines for thermal destruction sorbents and soil contaminated with oil, as well as for cleaning works at basins and reservoir parks.

There are two main models: Vulcanus-400 and Vulcanus-1000, where figures mean a volume of a charged material in kg/hour.

The integral advantages of Vulcanus are as follows:

- Autonomy and mobility
- Converting utilized products non-hazardous as much as possible.
- Minimizing of the contamination of the environment made by emissions.

Due to a high content of oil and oil products in residuals, removed from a bottom's part of opened sludge accumulators and basins up to 65-70%, there is a possibility to maintain rather a high temperature of approx. 1300-1500 C deg. in the incineration chamber, which in its turn favors the best burning with the formation of slag and ash at the end. From the other hand, high temperatures exclude a possibility of the formation of hazardous dioxin combinations.

CONCLUSION

Based on the fulfilled research works, the fact of the existence of the opened reservoirs in the system of oil transport and storage is examined, their purpose and influence on the surrounding objects. Physical and chemical properties of oil products, existing in the opened reservoirs were considered.

The mathematical model of heat spreading process in opened reservoirs is elaborated and the method of temperature field calculation is proposed both at a natural heating of the product and an artificial one by means of external heating sources. A complete set of the applied programs is worked up, allowing to define at any moment of time the value of the product in any point and to get a graphic representation of the temperature field distribution in all examined object. The application of the package of the applied programs allows to chose the technology and the equipment for removal of the product out of the opened reservoirs.

A series of flow processes and diagrams was elaborated. They were tested and, then, they showed its efficiency at specific objects. Schemes of the treatment of wastewater were proposed with the usage of chemical reagents at hermetically closed units as well as oil sludge separation at OPS' conditions. The selection of chemical and biological and thermal methods was proved for treatment and utilization of the contaminated ground by oil products.

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