ENSURING ENVIRONMENTAL CONTROL DURING SOAPSTOCK PROCESSING IN THE ARCTIC CLIMATE

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Abstract. This article is a comprehensive analysis of the Arctic legislation of the Russian Federation in the context of the implementation of the main geopolitical and socio-economic interests of the country in the Arctic region. The relevance of the presented research is determined by the need for further development of international legal norms regulating various aspects of the development of the Arctic region, as well as domestic legislation that defines Russia's strategic interests in the Arctic zone and the competence of state authorities in the implementation of these interests, taking into account the basic principles and provisions of international public and private law and the Constitution of the Russian Federation.

1. Introduction
The aim of this investigation is to control the complex processing of soapstock by acid method with the possibility of obtaining commercial products capable of minimizing harmful environmental impact. The solution of these problems is vital, and this is approved in the priority directions of the development of science, technology and engineering in the Russian Federation (Presidential Decree of July 7, 2011, No. 899).

Traditionally, soapstock is considered to be a precipitate formed in the process of alkaline neutralization of vegetable oil and consisting of sodium salts of fatty acids, neutralized oil, phosphatides and their saponification products, unsaponifiable matters, pigments and moisture [GOST 21314−75].

The growth in the production of detergents, in some cases replacing soaps, has significantly reduced the market for consumption of soapstock and in the field of using fatty acids it has been replaced by tallol, a by-product of the paper industry. These changes have led to the introduction of high-temperature acid treatment of soapstock, that results in the production of fatty acids, which are used as a high-energy feed supplements or permits one to get a cleaner product for chemical manufacturing application [1-3].

2. Experimental procedure
The process of obtaining fatty acids includes the following stages [2]:

1. Deoxidation of basic, highly diluted (cut) soapstock with sulfuric acid in order to transform soaps into free fatty acids. The required dosage of acid varies depending on the amount of caustic soda used in the refining process, and is set at a level that allows a pH of 1.5-2.0 to be reached.
2. Hot breakdown of water emulsion of fatty acids and impurities when heated to 90 °C with vigorous mixing.

3. Division into three phases:
   - upper layer – the obtained fatty acids are resolved and transported to the warehouse;
   - the middle layer is emulsion of mixture of substances;
   - bottom layer – acid waste water [4-6].

To conduct the experiment and calculate the by-products per ton of fatty acids obtained, 38.8 tons of soapstock with total fat content of 35.4%, fatty acids of 31.4%, neutral fat of 4.0% were used. Acid water additive amounted to 18 tons, further processing required 1 ton of live steam, 1.552 tons of concentrated sulfuric acid. The total weight of the formed final mix is 59.352 tons, which comprises:

- 16 tons of fatty acids, that is 26.96 % by weight;
- the middle layer – 3.5 tons that is 5.88 % by weight;
- acid sewage is 39.86 tons, that is 67.16 % by weight.

On the basis of the data obtained it has been calculated that when one ton of fatty acids is produced, more than 2.7 tons of by-products are formed, which must be used to prevent environmental pollution.

According to [3, 4], separate collection and study physicochemical properties need to be applied for the most efficient use of process waste. The characteristics of the acid wastewater produced are shown in Table 1.

| Parameter                        | Value                     | Test method          |
|----------------------------------|---------------------------|----------------------|
| Appearance                       | Liquid of dark color with flocculent impurity | Visual method       |
| pH                               | 4                         | Litmus (pH) paper    |
| Total fat, %                     | 1                         | TS 10-04-02-80-91    |
| Water content, %                 | 90                        | Weight method        |
| Solid basis (dark-brown, porous substance), % | 9                          | Weight method        |
| Protein content in dry matter, % | 9.0-9.4                   | GOST 13496.4-93c     |

*TS stands for Technical specifications. A detailed description of technical requirements, usually with specific acceptance criteria, stated in terms suitable to form the basis for the actual design development and production processes of an item having the qualities specified in the operational characteristics.

*TS 10-04-02-80-91 Soapstock. Technical specifications.

*GOST 13496.4-93 Fodder, mixed fodder and animal feed raw stuff. Methods of nitrogen and crude protein determination

To neutralize acid water, an ammonium hydroxide solution 1 ml at a time was added to a sample weight of 100 ml with pH = 4. The pH level was monitored by litmus paper.

It has been found that it is sufficient to add 2 ml of ammonium hydroxide to the solution for neutralization. In this case, the pH of the solution is set at the borderline value of 7 units, the acidic and ammonia smell having disappeared, the color having changed to a darker one.

In practice, acid water is neutralized with caustic soda (due to its cheapness compared to other reagents) and sent to the plant-wide sewage system. This leads to additional workload in the operation of treatment facilities and does not bring additional economic profit [7-9].

Based on the experiment, we draw certain conclusions: per 1000 liters of acid water at pH = 4-5, the flow rate of ammonium hydroxide is 10-15 liters. Acid removal takes place with the separation of ammonium sulfate (nitrogen fertilizer, retail price of dry matter is 33 rubles per 1 kg.).

The properties of the resulted middle layer are shown in Table 2. This middle layer was called «ASHER» by our corporate business partner «EZIP». Based on the data in Table 2, we assume that «ASHER» can be used as a lubricant for drilling muds.
3. Results and discussion

We have identified the influence of the «ASHER» lubricant on the friction factor of the simulated drilling mud.

The lubricating efficiency of the drilling fluid is indirectly defined by the friction and sliding factor at a preset contact stress.

To determine the lubricity of the drilling fluid (according to API (American Petroleum Institute) standard for determination of the friction factor), the laboratory used a Baroid friction machine (USA). Determination of the friction factor was performed at a load of 150 psi and a rotary speed of 60 rpm.

In order to control the properties of clay drilling mud the lubricating additive «ASHER» 0.5% and 1% by weight was introduced while stirring in the laboratory mixer into 300 g of simulated drilling mud. The mixing time (period) was 30 minutes.

Simulated drilling mud was prepared on the basis of PBMB brand bentonite clay powder manufactured by OAO Ilsky Plant «Utyazhelitel» (OJSC). Three litres of water were measured and poured into the desiccator. 240 g of PBMB grade clay powder was added with stirring on a slow-speed mixer (n = 1000 rpm). It was being mixed for 2.5 hours, then closed tightly with a lid and left to disperse for 18 hours, after that it was being mixed for 1 hour [10, 11].

The following coefficients were identified:

- friction factor of simulated clay drilling mud with a density of 1.07 g/ml (without a lubricant additive);
- friction factor of simulated drilling mud with 0.5% by wt «ASHER»;
- friction factor of simulated mud with 1% be wt «ASHER».

The friction factor was first determined with making use of distilled water (the standard value of the friction factor for a friction machine is variable from 0.33 to 0.37). In this paper, \( F_{frH2O} = 0.37 \).

The lubricating ability of the simulated drilling mud with the addition of 0.5% and 1% by wt «ASHER» lubricant additive measurement results are demonstrated in Table 3.

Technological parameters of «ASHER» are presented in Table 4.
Table 3. Testing the lubricating properties of the simulated drilling mud and drilling mud with the addition of 0.5% and 1% by wt «ASHER» lubricant additive.

| Load, pi (pounds per inch, lb/in) | Value Ffr | Simulated drilling mud | Simulated drilling mud + 0.5% «ASHER» | Simulated drilling mud + 1% «ASHER» |
|----------------------------------|-----------|------------------------|----------------------------------------|-----------------------------------|
| 0                                | 0.0       | 0.0                    | 0.0                                    |                                   |
| 25                               | 9.0       | 3.0                    | 2.0                                    |                                   |
| 50                               | 17.0      | 8.0                    | 12.0                                   |                                   |
| 75                               | 27.0      | 10.0                   | 21.0                                   |                                   |
| 100                              | 37.0      | 10.5                   | 23.0 (indicator range widely)           |                                   |
| 125                              | 48.0      | 11.0                   | 18.0                                   |                                   |
| 150                              | >50       | 13.0                   | 22.0                                   |                                   |
| 175                              | -         | 14.0                   | 22.5 (indicator range widely from 0 to 33 and back) | |
| 200                              | -         | 20.0                   | 24.0                                   |                                   |
| 225                              | -         | 24.0                   | 27.0                                   |                                   |
| 250                              | -         | 26.5                   | 26.0                                   |                                   |
| 275                              | -         | 25.5                   | 25.5 (indicator range widely from 0 to 33 and back) | |
| 300                              | -         | 25.5                   | 26.0                                   |                                   |
| 325                              | -         | 25.5                   | 29.0                                   |                                   |
| 350                              | -         | 27.5                   | We stopped measurements since the indicator had gone off-scale over 50 |
| 375                              | -         | 26.6                   | -                                      |                                   |
| 400                              | -         | 26.5                   | -                                      |                                   |

Table 4. Definition of technological parameters of simulated drilling mud and drilling mud with «ASHER» additive.

| Parameter | Unit of measure | Indicator value of the simulated drilling mud | Indicator value of the simulated drilling mud + 0.5% by wt «ASHER» | Indicator value of the simulated drilling mud + 1% by wt «ASHER» |
|-----------|----------------|-----------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------|
| Density, ρ | g/ml           | 1.07                                          | 1.07                                                             | 1.07                                                             |
| pH        |                | 9.26                                          | 8.75                                                             | 8.21                                                             |

To measure the rheological parameters, a VSN-3 rotational viscometer was used. Making use of viscometer, the scale readings were measured at 600 rpm (φ600), at 300 rpm (φ300) and 0.2 rpm (φ0.2) during the structure hardening time of 1 min and 10 min.

Then calculations were performed using the formulae:

- effective viscosity \( \eta_{ef} \) was calculated by the formula \( mPa\times s \)
  \[
  \eta_{ef} = A \cdot \phi I,
  \]
  \( (1) \)

where A is the constant of the viscometer VSN -3 (given in the certificate);\( \phi I \) – VSN-3 viscometer scale reading.

- plastic viscosity \( \eta_{pl} \) (mPa\times s) was calculated using the formula
\[ \eta_{pl} = \phi_{600} - \phi_{300}, \]  

(2)

where \( \phi_{600} \) is the instrument reading at 600 rpm; \( \phi_{300} \) – instrument reading at 300 rpm.

- the dynamic shear stress \( \tau \), expressed in Pascals (Pa), was calculated by the formula

\[ \tau = (\phi_{300} - \eta_{pl}) \times 0.48, \]  

(3)

where \( \phi_{300} \) is the instrument reading at 300 rpm; \( \eta_{pl} \) – plastic viscosity; 0.48 – conversion factor pound/100 feet, expressed in Pa.

- static shear stress (SSS\textsubscript{1,10}), Pa, during hardening was calculated by the formula

\[ SSS_{1,10} = A \times \phi_{1.10}, \]  

(4)

where 1.10 – static shear stress in 1 and 10 minutes, Pa; \( A \) – error rate (given in the instrument certificate); \( \phi_{1.10} \) – the twisting angle measured after 1 and 10 minutes at rest, deg.

The results of measurements of the structural and rheological parameters of the simulation drilling mud and drilling mud with «ASHER» addition are shown in Table 5.

| Parameter | Unit of measure | Indicator value of the simulated drilling mud | Indicator value of the simulated drilling mud +0.5 % by wt «ASHER» | Indicator value of the simulated drilling mud +1 % by wt «ASHER» |
|-----------|----------------|--------------------------------------------|-------------------------------------------------|---------------------------------------------------|
| Viscometerscale reading, \( \phi_{600/300} \) | deg | 69/48 | 68/48 | 60/43 |
| Effective viscosity, \( \eta_{ef} \) | mPa\times s | 17.5 | 16.9 | 15.2 |
| Plastic viscosity \( \eta_{pl} \) | mPa\times s | 10.5 | 10.0 | 8.5 |
| Yield point, \( \tau_{0} \) | Pa | 4.05 | 4.19 | 3.9 |
| Viscometer scale reading \( \phi_{0.2} \) during the 1 min. period of hardening | deg | 21 | 20 | 12 |
| Viscometer scale reading \( \phi_{0.2} \) during the period of hardening 10 min. | deg | 25 | 23 | 18 |
| Static shear stress during the 1 min. period of hardening, SSS 1 | Pa | 3.5 | 3.3 | 2.0 |
| Static shear stress during the 10 min. period of hardening, SSS 10 | Pa | 4.2 | 3.8 | 3.02 |

4. Conclusion

Data available from the experiments made it possible to state that when 1% by wt «ASHER» lubricant is added to the simulated drilling mud, it results in:

- decrease of pH by 1 unit;
- significant reduction of structural-rheological parameters;
- reduction of clay drilling mud friction factor by 56%.

Addition of 0.5 % by wt «ASHER» lubricant to the simulated drilling mud results in:

- decrease of pH by 0.5 units;
- minor change of structural-rheological parameters;
- reduction of friction factor of clay drilling mud by 74%.

Hence it appears that in order to effectively reduce the friction factor, 0.5% by weight of «ASHER» must be added to the drilling fluid without disrupting the structure of the fluid.

Thus, the complex processing of soapstock by the acid method makes it possible to obtain not only the main product (fatty acids), but also «ASHER», lubricants, fertilizers and other marketable products. These studies will help to prevent pollution and provide a cost-effective benefit from their implementation[12-15].
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