PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

# MODELAGEM E PROVA DE SOLUÇÕES DE PROJETO PARA A RECONSTRUÇÃO DA ESTAÇÃO DE TRATAMENTO DE ÓLEO E ÁGUA

# MODELING AND PROVING OF DESIGN SOLUTIONS FOR THE RECONSTRUCTION OF TREATMENT FACILITY OF OIL AND WATER

# МОДЕЛИРОВАНИЕ И ОБОСНОВАНИЕ ПРОЕКТНЫХ РЕШЕНИЙ ПРИ РЕКОНСТРУКЦИИ ПЛОЩАДНОГО ОБЪЕКТА ПОДГОТОВКИ НЕФТИ И СТОЧНОЙ ВОДЫ

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## RESUMO

O problema de preparar produtos de petróleo de alta qualidade é que produz água para reutilização e injeção no reservatório em condições de capacidade limitada das instalações. Essa é uma questão relevante no setor de petróleo e gás. Assim, o objetivo desta pesquisa foi desenvolver uma abordagem para a justificativa das decisões de projeto durante a reconstrução da Unidade Preliminar de Descarga de Água. O artigo considera a questão da modelagem de soluções de projeto para a reconstrução da unidade preliminar de descarga de água (região de Perm) com uma unidade móvel. As principais tarefas industriais são reduzir o corte de água do produto e o volume de bombeamento de lastro na Unidade de Preparação de Óleo (OPU) para fornecer a qualidade da água de fundo para injeção na formação atendendo aos requisitos da norma industrial. A instalação móvel é um desenvolvimento inovador e possui todo o equipamento necessário para recriar o processo de produção da preparação de produtos de poço em uma escala de aproximadamente 1: 100. Os resultados da simulação do processo de produção do poço mostraram que pode ser alcançado 1% com aquecimento a 30°C na injeção dos desmulsificadores SNPH-4880, STH-9. O método complicado mostrou uma dependência funcional e estável dos indicadores de temperatura e qualidade do processo na presença de um desmulsificador. Durante os testes de bancada foram encontrados valores de indicadores tecnológicos que proporcionaram a redução do volume de bombeamento de lastro em uma média de 5-6%. Estudos de amostras de água da saída da unidade móvel mostraram os melhores resultados ao testar o STH-9. Os resultados obtidos são de grande importância prática, e o método e o equipamento móvel especial proposto no artigo podem ser usados em qualquer planta de produção de tratamento de óleo.

**Palavras-chave**: *refino de petróleo, refino de águas profundas, produção de poços, instalação móvel, emulsão de água e óleo.*

## ABSTRACT

The problem with preparing high-quality petroleum products is that it produces water for reuse and injection into the reservoir under conditions of limited facility capacity. This is a relevant issue in the oil and gas sector. Thus, the objective of this research was to develop an approach to justify project decisions during the reconstruction of the Preliminary Water Discharge Unit. The article considers the issue of modeling design solutions for the restoration of the preliminary water discharge unit (Perm region) with a mobile unit. The main industrial tasks are to reduce the water cut of the product and the volume of ballast pumping in the Oil Preparation Unit (OPU) to provide the quality of the background water for injection in the formation meeting the requirements of the industrial standard. The mobile installation is an innovative development and has all the necessary equipment to recreate the production process of the preparation of well products on a scale of approximately 1: 100. The results of the simulation of the well production process showed that it could be achieved 1 % with heating at 30°C in the injection of demulsifiers SNPH-4880, STH-9. The complicated method showed a functional and stable dependence on the temperature and quality indicators of the process in the presence of a demulsifier.




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During bench tests, values of technical indicators were found that reduced the volume of ballast pumping by an average of 5-6%. Studies of water samples from the outlet of the mobile unit showed the best results when testing the STH-9. The results obtained are of great practical importance, and the method and the special mobile equipment proposed in the article can be used in any oil treatment production plant.

**Keywords**: *oil refining, refining of bottom water, well production, mobile installation, water-oil emulsion*

## АННОТАЦИЯ

Проблема подготовки высокого качества нефтепродуктов заключается в том, что в процессе образуется попутно добываемой вода для повторной использования и закачки в пласт в условиях ограниченных производственных мощностях. Это актуальная проблема в нефтегазовой области. Таким образом, цель этого исследования состояла в том, чтобы разарботать подход для обоснования проектных решений по реконструкции установки предварительного сброса воды. В статье рассматривается вопрос моделирования проектных решений для восстановления работы установки предварительного сброса воды (Пермский край) с использованием мобильной установки. Основными производственными задачами являются снижение обводненности подготовленной продукции, уменьшение объема балластных перекачек на установке подготовке нефти (УПН), а также доведение качества подтоварной воды для закачки в пласт до требований отраслевого стандарта. Мобильная установка является инновационной разработкой и обладает всеми необходимым оборудованием для воссоздания производственного технологического процесса подготовки скважинной продукции в масштабе примерно 1:100. Результаты моделирования процесса подготовки скважинной продукции показали, что возможно достичь обводненность 1% при нагреве до 30°С в присутствии деэмульгаторов СНПХ-4880, СТХ-9. Комплексный метод на показазал устойчивую функциональную зависимость температуры процесса и показателей качества в присутствии деэмульгатора. В ходе стендовых испытаний установлены диапазоны технологических показателей, при которых снизился объем балластных перекачек, в среднем, на 5-6%. Исследования проб воды по выходу из мобильной установки показали наилучшие результаты при испытании СТХ-9. Полученные результаты имеют важное практическое значение, а предложенные в статье метод и специальное мобильное оборудование может быть использовано на любой производственной установке подготовки нефти.

**Ключевые слова:** *подготовка нефти, подготовка подтоварной воды, скважинная продукция, мобильная установка, водонефтяная эмульсия*

## 1. INTRODUCTION:

To refine oil and wastewater, there is a regular need for technologies and technical means to be used and to improve the quality of the final product up to the relevant standards, regulated by the state authorities and regulatory documentation of oil and gas companies. There is no detected strictly defined combination of methods and technologies in industry practice to bring the quality of products to the commercial standards or standards of a company within the terms of physical and chemical properties diversity and variable composition of the crude oil (Kokal, 2002). Therefore, there is a need for oil and gas companies to test the most appropriate and effective methods regarding the refining of oil and wastewater per each area facility. This question becomes particularly relevant as the current time technology of refining at the area facility in the short term will not be sufficient, which will require operational changes in the technological process (Kokal, Wingrove, 2000). Any change of procedure of the area facility requires a significant investment (time, administrative, finance) and, ultimately, might be technologically and economically feasible (Marquez-Silva, 1997). The results of laboratory modeling of the process regarding the refining are often turned to be estimated due to researching within the conditions to be different from the real (Tronov, 1977).

Increasing interest is received by mini- and micro-installations, the use of which is aimed at solving a specific problem within an industrial facility (Lekomtsev, Ilyushin, *et al*., 2018). Laboratory studies performed on model samples, when well production has complex compositions and properties, become uninformative (Ilyushin, Usenkov *et al*., 2017). The results of the studies often do not correlate with the actual situation in production (Tretyakov, Mazein, *et al*., 2017). The current trend in the refining of downhole products is minimizing the size of the equipment with an increase in their level of manufacturability (Bahadori, 2014), as well as the transition from laboratory research to field tests (Li, Wengerter, *et al*., 2016). This opinion proves the need to create a site (testing ground) for testing modern scientific methods and technologies and adapting theoretical studies to the existing practice (Lekomtsev, Ilyushin, 2016). The way out is the creation of mobile units (The Canadian Association of Petroleum Producers, 2014).

A disadvantage of the known studies is the lack of a systematic approach and the corresponding technology for carrying out bench (field) testing of techniques for improving the quality of the preparation of tank oil and water for injection into the reservoir. Based on the Scientific-educational Centre for Geology and the Development of Oil and Gas Fields of the Perm National Research Polytechnic University, there is a unit created allowing to simulate different technological modes onto the current facility of refining without affecting the primary process (Tretyakov, Usenkov, *et al*., 2016).

The principle of the unit is the destruction of Water-Oil Emulsion (WOE) by traditional and new technologies that are available at industrial facilities (Rzayev, Rasulov, 2013). Modern ideas about the stability of water-oil emulsions are concentrated in the theory of Deryagin-Landau-Fairway-Overbek (DLFO theory) (Deryagin, 1986). According to the method, the formation of structural-mechanical protective layers at the interphase boundaries is decisive importance in ensuring the stability of a WOE (Salager, 1990). Resistant layers can resist deformation and destruction and can “heal” defects arising from the contact of particles of the dispersed phase (the wedging effect of the Rebinder). Three stages determine the staging of the process of destruction of a WOE. For each stage, it is used technologies that are characterized by different efficiency and manufacturability (Zhang, 2010). The main ones are the use of chemical reagents, coalescing nozzles, magnetic, electric, and acoustic impact (Wallau, Schlawitschek *et al*., 2016), heating (Schubert, Brandner, 2001), centrifugation and sedimentation with specific equipment and materials (Wang, 2016).

The developed unit has all the necessary equipment to recreate the production process of refining well products on a scale of approximately 1: 100. Due to this, in real-time, it is possible to assess the current and future possibilities of the refining facility when changing volume and composition crude oil production. It has the potential to allow to predict the product quality for several years ahead in the future.

The main practical value of the unit is the approbation of projects for the modernization of industrial plants and the rationale for investment costs for the purchase of equipment and the construction of additional facilities. The article considers the issue of assessing design solutions for the reconstruction of a Preliminary Water Discharging Unit (PWDU) using a developed mobile unit in the Perm region (Russia). The aim of technological reconstruction of the area facility was the bringing of oil quality to the conformity of group 3 under Russian Government Standard requirements (GOST 51858-2002) regarding the content of water to reduce ballast pumpings up to Oil Preparing Unit (OPU) and to improve the quality of produced water (SSP – 15 mg/L; oil products – 15 mg/L).

The target of field treatment of crude oil is to reduce the resistance of WOE, to their disintegration, and to degrade the SSP and oil ratio within the wastewater (Tumanyan, 2000). To disintegrate the WOEs, the most important aspect is the process of Armoured Shells (AS) removing of Emulsified Water Droplets (EWDs) and the separation of oil and water into separate phases (Nebogina, 2010). WOE stability is a critical factor regarding the disintegration of oil and water mixture and characterizes the ability not to be exfoliated for oil and water within a time specified. The factors greatly influence a drop AS stability (kinetic and aggregative) within the emulsion as following: coagulation and fragmentation of drops within a turbulent flow; disperse composition; physical and chemical properties of natural emulsifiers forming armored shells; the double emulsion layer presence on EWDs; the temperature of miscible liquids (oil and water); specific consumption of demulsifier; the pH of the reservoir water emulsified (Sakhabutdinov, Kosmacheva et al., 2007). Also, one of the methods of water refining is electrocoagulation. Electrocoagulation is a progressive technological direction for getting rid of water from polluting substances by cleaning it in an electrolyzer with soluble electrodes. When an aqueous solution is found under the influence of a constant electric field, coarse impurities are destroyed, colloidal contaminants are aggregated, which stimulates the process of phase separation and water purification. The method of electrocoagulation of water shows excellent results in the refining of industrial water from finely dispersed organic monomers and polymers, emulsions, and refined products. It is useful in ridding water solutions of excess phosphates and chromates (Tetreault, 2003).

The purpose of this work was to develop an approach to the justification of design decisions during the reconstruction of the Preliminary Water Discharging Unit and select the necessary equipment to reduce the water content of products refined. Also, it is aimed to decrease the number of ballast pumpings onto OPU, as well as bringing the quality of the produced water to be injected into the formation up to the requirements of Industrial Standard (IS-39-225-88).

During the research and pilot tests, the following tasks were solved:

- the confirmation of the technological scheme of the facility;
- the determination of temperature mode of refining;
- the selection of reagent-demulsifier from the number of recommended ones due to the results of laboratory tests.

## 2. MATERIALS AND METHODS:

### 2.1. The description of the mobile unit

The mobile well production preparing unit (MU) provides a core technology for oil refining (regarding the Russian government standard GOST 51858-2002): demulsification (dehydration), desalting, purification from mechanical impurities, oil stabilization (hot separation). According to this standard, oil is divided into three groups depending on the value of this parameter. Refining of wastewater used for flooding oil fields (regarding the Industrial Standard IS 39-225-88) – removal of oil products and Solid Suspended Particles (SSP). Due to mobility, the unit allows executing the refining of oil and water onto the well cluster sites with their low capacity of the product pumped without capital construction and arrangement of the area facility (Figures 1a and 1b). The mobile well production preparing unit technical characteristics are represented in Table 1. The PWDU existing and technological design schemes are shown in Figures 2a and 2b.

Under the technological project scheme of refining, the products shall come into the BE-2 container, which is used as a two/three-phase separator with its possibility of separating and discharging of formation water. From BE-2, the liquid separated from the gas under the pressure of 0.2-0.25 MPa is supplied to the pump intake of inner pumping P-1,2, which pumps the pressure up to 0.45 MPa, and feed the fluid into the heating block, consisting of two heaters H-1,2, which provides the liquid heating up to 40-45 ºC. The heated flow past the heaters is fed to the OG-1 oil sumps, 2, where the thermochemical process of oil dehydrating at a pressure of 0.3 MPa is performed. The dehydrated oil with its water content of up to 3 % is supplied into the BE-3 buffer tank. From BE-3 via the pump of oil external transporting through the oil metering unit, it is periodically pumped out onto the OPU. The gas separated in the process is sent to the gas turbine unit and is used as an energy source for heating the incoming raw materials. The content of sulfur-containing volatile compounds is low; therefore, associated petroleum gas is used without preliminary treatment.

Under the current scheme, the mobile unit was connected prior to the BE-2 serving as a buffer-degasser (E-1 in the MU). The modeling of piping the heaters was implemented by the heating system consisting of a heat exchanger, the H-4 pump, and the E-4 tank with the heaters. The E-5 horizontal type unit was consistent with the oil-settling tanks OG-1, 2. The products from the E-5 output were supplied into the drainage system. Within the field activities onto the mobile well production preparing unit prior to the maintenance, the demulsifier was brought into. To keep the experiment pure, the feeding of the demulsifier at the facility was not executed.

The properties of oil feeding into the PWDU are represented in table 2. Crude oil has an average viscosity, high gas factor, and is highly asphaltenic (Vyatkin, Kochnev, *et al*., 2017).

### 2.2. The calibration and testing of the mobile unit

The calibration of the mobile unit prior conducting the simulation was to define the operating parameters (flow, pressure, temperature) under which the quality parameters (water content within the oil, chlorinated salts, mechanical impurities) of the mobile well production preparing unit output product and the refining facility were corresponding. The mobile unit performed the calibration mode past a series of experiments with regard to compliance of well products time spent within technological devices while ensuring the performance indicators as following (Table 3).

The water content at the outfeed of the bench (MU) and field installations is equal to 2%. The indicators of formation water quality have their differences, and the SSP content past the stand is above the field data, the oil content in water is lower than within the field facility. This fact indicates the high velocity of water discharging and capturing a more significant number of solid particles within the flow. The consumption rate at the time of the recording mode exceeded the estimated per 53%. The increased content of oil products in the water at the outfeed from the production facility in comparison with the bench data is associated with the process temperature, which at the time of the experiment differed per 3 °C.

When increasing the flow rate of oil up to 0.76 $m^3$/h (corresponds to 88 $m^3$/h at the PWDU), the water content is risen sharply at the outfeed up to 18%, and the water quality worsens: SSP – 76 mg/l; oil products – 159 mg/L. Thus, the mobile well production preparing unit calculated mode fully describes the technological process of the PWDU.

#### 2.3. The experimental-industrial testing

The modeling of advanced technological scheme past establishing a calibration mode of operation was performed under the rates calculated below.

The consumption of oil within the mobile well production preparing unit when testing is selected based on the equil time of treatment into operating volumes of OG-1, 2 at the PWDU and the E-5 tank installed on Mobile Unit:

$$Q_{MWPPU} = Q_{\mathrm{PWDU}} \frac{\frac{L_{liq\ E-1}}{\mathrm{d_{E-1}}} \mathrm{V_{E-5}}}{\mathrm{V_{OG-1\ perf}} + \mathrm{V_{OG-2\ perf}}} = 0.22 \frac{m^3}{h} \quad \text{(Eq. 1)}$$

Where $V_{nom\ E-1}$ – the E-5 nominal volume – 1.6 $m^3$; $L_{liq\ E-1}$ – the liquid level – 740 mm; $d_{E-1}$ – the E-5 diametre – 800 mm; $V_{OG-1\ perf}$, $V_{OG-2\ perf}$ – the operating volumes of OG-1, 2 – 100 $m^3$, $Q_{PWDU}$ – the pumping of oil from PWDU – 720 $m^3$/day or 30 $m^3$/h; daily water injection under the PWDU – 200-220 $m^3$/day 8.3-9.2 $m^3$/h; the ratio of oil pumping out/water pumping out – 27.8-30.6%.

To ensure the time of degassing of products input into the Mobile Unit, corresponding to a PWDU, the working volume of the E-1 should be:

$$\mathrm{V_{E-1}} = \mathrm{V_{BE-2\ nom}} \frac{\mathrm{L_{liq}}}{\mathrm{L_{nom}}} \frac{Q_{MU}}{Q_{PWDU}} = 0.82\ m^3 \quad \text{(Eq. 2)}$$

Where $L_{liq}$ – the fluid level within the BE-2 – 1.9 m, $L_{nom}$ – the nominal level within the BE-2 – 3.4 m. The fluid level in E-1 will be:

$$\mathrm{L_{liq\ E-1}} = \mathrm{L_{nom\ E-1}} \frac{\mathrm{V_{E-1}}}{\mathrm{V_{nom\ E-1}}} = 0.94\ m \quad \text{(Eq. 3)}$$

The consumption of water within the mobile well production preparing unit is regulated regarding the interface level in the E-5 at around 280-350 mm and, on average, $Q_{MU\ (v)}$= 0,076 $m^3$/h, which is 30% of the pumping volume of oil.

When conducting the field tests, the technological standards met the calculated values accordingly. Before the pilot tests on a mobile unit for model samples of emulsions, demulsifiers were selected. The most effective were brand demulsifier SNPH-4880, SNH-4114, STH-9 with the consumption of 70 g/ton. Demulsifiers showed the highest rate of emulsion separation; therefore, they were selected for field tests. Within the modeling process, it was succeeded to heat the products up to 30 °C in connection with the frequency of fluid intake because of the presence of the cork of the pumping mode till the PWDU and high velocity of the liquid phase flowing under images.

## 3. RESULTS AND DISCUSSION:

The results of the process modelling on refining of well production show that under the existing volumes of crude oil feeding, the refined oil pumping to the OPU and time and sediment term, it was enabled to reduce the water content u to 1% when heated to 30 °C in the presence of demulsifiers SNPH-4880, STH-9 (Figures 3 and 4).

The quality of oil refining onto the PWDU under the current scheme is not regulated and the water content at the outfeed of the installation varies from 2 to 10%. The proportion of the fluid fed at the OPU is 8.6%. The reducing and maintaining the water content up to 3% will decrease the daily volume of ballast pumping more than 40 $m^3$.

The studies of water samples at the mobile well production preparing unit output have shown their best results within the testing of the STH-9. It is clear from Figures 3 and 4 that the synergistic effect of heating and chemical reagent supplying is decreased under the process temperature increasing. This is due to the high emulsion stability and the strength of armored shells of small droplets within the dispersed phase, requiring higher energy to perform its disintegrating (Zlobin, 2015). Besides, the size of the particles remaining in suspension under the flow temperature increased is not involved in the process of sedimentation and put away with water flow. The limitations on the effectiveness of thermo-chemical and gravitational processes of water refining are estimated at up to 45 °C for the given conditions (Figures 3 and 4). The bench tests, together with the results of sewage samples analysis, represent stable, functional dependence of the process temperature and the quality parameters under the action of the demulsifier. They are ensuring the temperature of the refining process up to 37-40 °C evidences the fulfillment of the industrial standard requirements regarding the SSP and oil content within produced water.

In this field research, the similarity method is used to study the effect of destruction WOE and application study results to the real industry (Yemelyanov et al., 2019). This section discusses the technique of modeling crude oil refining with a developed mobile unit.

## 4. CONCLUSIONS:

Thus, within the course of bench tests regarding the modeling of the refining process at the pilot mobile unit, the effectiveness of the PWDU designed technological scheme has been approved. According to the results of the studies conducted, it is possible to conclude the following:

1. The new product developed – mobile well production preparing unit – is industrially applicable and has shown its high convergence of scalable technology.
2. The proposed approach regarding the transition from the laboratory modelling to the field testing within a facility real conditions allows to increase the reliability of the results obtained and to justify the design decisions.
3. The ranges of technological parameters onto an area facility are set, under which it is possible to reduce the volume of ballast pumping an average of 5-6%.

The dependence of the wastewater quality indicators is set, based on the design scheme of an area facility depending on the process temperature and the demulsifier brand. The calculated boundaries per the heating temperature of the well production in the range of 37-40 °C to meet the requirements for commercial water quality up to the requirements of industry standards have been defined.


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## 6. REFERENCES:


1. Bahadori A., Hazardous Area Classification in Petroleum and Chemical Plants. A Guide to Mitigating Risk, 2014.
2. Deryagin B.V. The Theory of Stability of Colloids and Thin Films. Moscow: Science, 1986, 368 p.
3. Ilyushin P.Yu., Usenkov A.V., Tretyakov O.V., Lekomtsev A.V., Mazein I.I, Khasanov R.F, Gorbushin A.V., Durbazhev A.Y., (2016). Unit for pretreatment of production fluid: pat. 2616466 Russian Federation no. 2016114262; appl. 12.04.16; publ. 17.04.17. Bull. no. 11.
4. Kokal S. Crude oil emulsions: A state-of-art review, SPE Paper 77497, 2002 SPE Annual Technical Conference and Exhibition, San Antonio, TX, USA, September 29-October 2.
5. Kokal S., Wingrove M., (2000). Emulsion Separation Index: From Laboratory to Field Case Studies. Presented at the SPE Annual Technical Conference and Exhibition, Dallas, Texas, 1-4 October. SPE-63165-MS. http://dx.doi.org/10.2118/63165-MS.
6. Lekomtsev A.V., Ilyushin P. Yu., Martyshev D.A., (2018). Experience of introduction of intensification device on the mobile plant for preparation of oil well product. Chemical and Petroleum Engineering, Volume 54, Issue 3–4: 213-218. https://doi.org/10.1007/s10556-018-0465-4
7. Lekomtsev A.V., Ilyushin P.Yu., Shishkin D.A., (2016). Cluster technology of preparation and injection of produced water into the reservoir using a pipe phase divider. Exposition Oil & Gas 7: 85-88.
8. Li Y.a, Wengerter M.b, Gerken I.a, Nieder H.c, Scholl S.b, Brandner J.J.a. Development of an efficient emulsification process using miniaturized process engineering equipment. Chemical Engineering Research and Design. Volume 108, 1 April 2016, Pages 23-29
9. Marquez-Silva R.L., Key S., Marino J. et al., (1997). Chemical Dehydration: Correlations between Crude Oil, Associated Water and Demulsifier Characteristics, in Real Systems.

Presented at the International Symposium on Oilfield Chemistry, Houston, Texas, 18-21 February. SPE-37271-MS. https://doi.org/10.2118/37271-MS.

10. Nebogina N. A., Prozorova, I. V., Savinykh, Yu. V., Yudina, N. V. (2010). The influence of natural surfactants on the stabilization of oil-water emulsions. *Petroleum Chemistry*, vol. 50, 2: 158-163.
11. Rzayev V. G., Rasulov S. R., Abasova I. A., Ragimova S. N., (2013). The Modelling of Nanotechnological Processes of Formation and Disintegration of Oil Emulsions.The Equipment and Technologies for Oil and Gas Industry 5: 54-58.
12. Sakhabutdinov R. Z., Kosmacheva T. F., Gubaydulin F. R., Tatyanina O. S., (2007). The Causes of Water-Oil Emulsions Stability Increasing. Oil Industry 1: 74-77.
13. Salager J.L. The Fundamental Basis for the Action of a Chemical Dehydrant: Influence of Physical and Chemical Formulation on the Stability of an Emulsion. Intl. Chemical Engineering 30 (1): 103.1990.
14. Schubert K., Brandner J., Fichtner M., Linder G., Schygulla U., Wenka A. Microstructure devices for applications in thermal and chemical process engineering. Microscale Thermophysical Engineering, 5 (1) (2001), pp. 17-39
15. Small, Portable Oil & Gas Production Facilities: Recommended Solutions for Design and Operation. SAFETY GUIDE, The Canadian Association of Petroleum Producers (CAPP), July 2014.
16. Tetreault, A. Electrocoagulation Process for Wastewater Treatment. Sydney NSW: 1-29. 2003.
17. Tretyakov O. V., Mazein I. I., Usenkov A. V., Lekomtsev, V. A., Ilyushin, P. Yu., (2017). The Development and Implementation of a Mobile Unit for Preparation of Well Products. Oil & Gas Exhibition 2: 80-82.
18. Tretyakov O.V, Usenkov A.V, Lekomtsev A.V, Ilyushin P.Yu., Galkin S.V., (2016). Results of pilot tests of mobile unit for well production treatment. Oil Industry 12: 131-135.
19. Tronov V.P., 1977. Oil treatment. Moscow: Science.
20. Tumanyan B. P., (2000). The Scientific and Applied Aspects of the Theory of Petroleum Disperse Systems. – M.: Technology.
21. Vyatkin K.A., Kochnev A.A., Lekomtsev A.V., (2017). Evaluation of oil viscosity expansion and property investigation of oil-water emulsion in Perm region. Exposition Oil & Gas 2: 89-93.
22. Wallau W., Schlawitschek C., Arellano-Garcia H. Electric Field Driven Separation of Oil-Water Mixtures: Model Development and Experimental Verification. Industrial and Engineering Chemistry Research. Volume 55, Issue 16, 27 April 2016, Pages 4585-4598
23. Wang Z. Rapid and efficient separation of oil from oil-in water emulsions using a janus cotton fabric. Industrial and Engineering Chemistry Research. Volume 55, Issue 16, 27 April 2016, Pages 4585-4598.
24. Yemelyanov, V. A., Yemelyanova, N. Y., Nedelkin, A. A., Glebov, N. B., & Tyapkin, D. A. (2019). Information system to determine the transported liquid iron weight. Paper presented at the Proceedings of the 2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2019, 377-380. doi:10.1109/EIConRus.2019.8656693
25. Zhang L.-M. Desing, experiment and practical application of high voltage electrostatic coalesce. Gaodianya Jishu. High Voltage Engineering.Volume 36, Issue 7, July 2010, Pages 1797-1802.
26. Zlobin A. A., (2015). The Experimental Studies of the Processes of Aggregation and Self-Assembly of Nanoparticles within the Oil Disperse Systems. The Bulletin of Perm National Research Polytechnic University. Geology. Oil and Gas Treatment, 2015, V. 14, No. 15: 57-72.

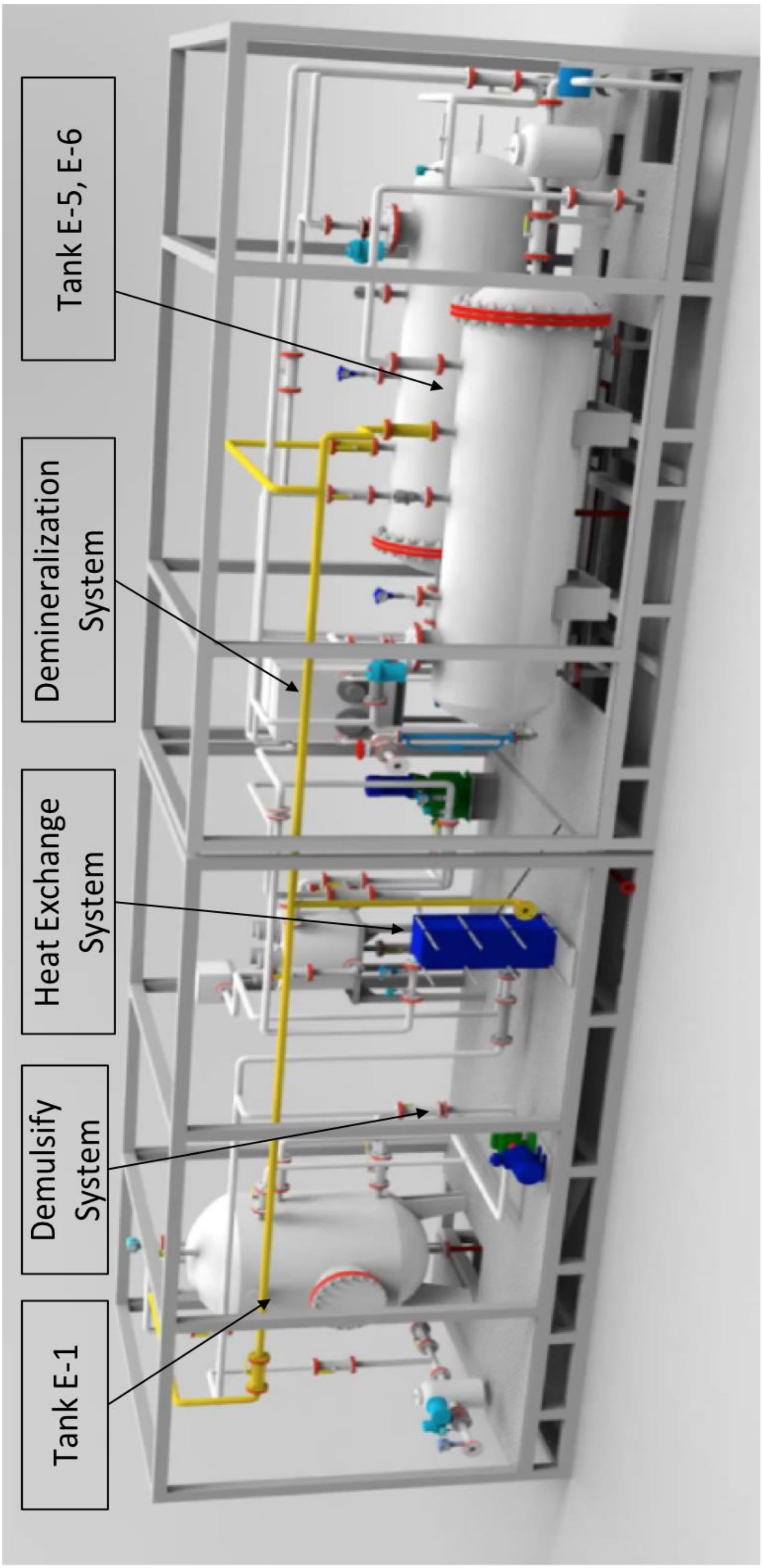


***Figure 1a.*** *View of Mobile Unit - Inside view*

***Figure 1b.*** *View of Mobile Unit - Outside view*

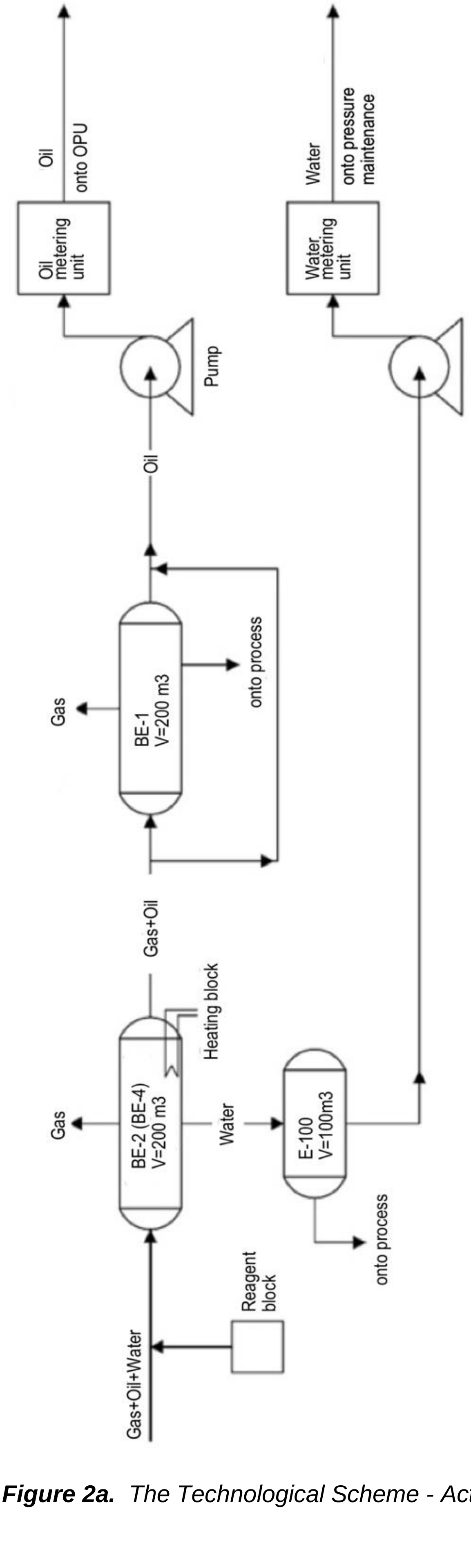


***Figure 2a.*** *The Technological Scheme - Acting*

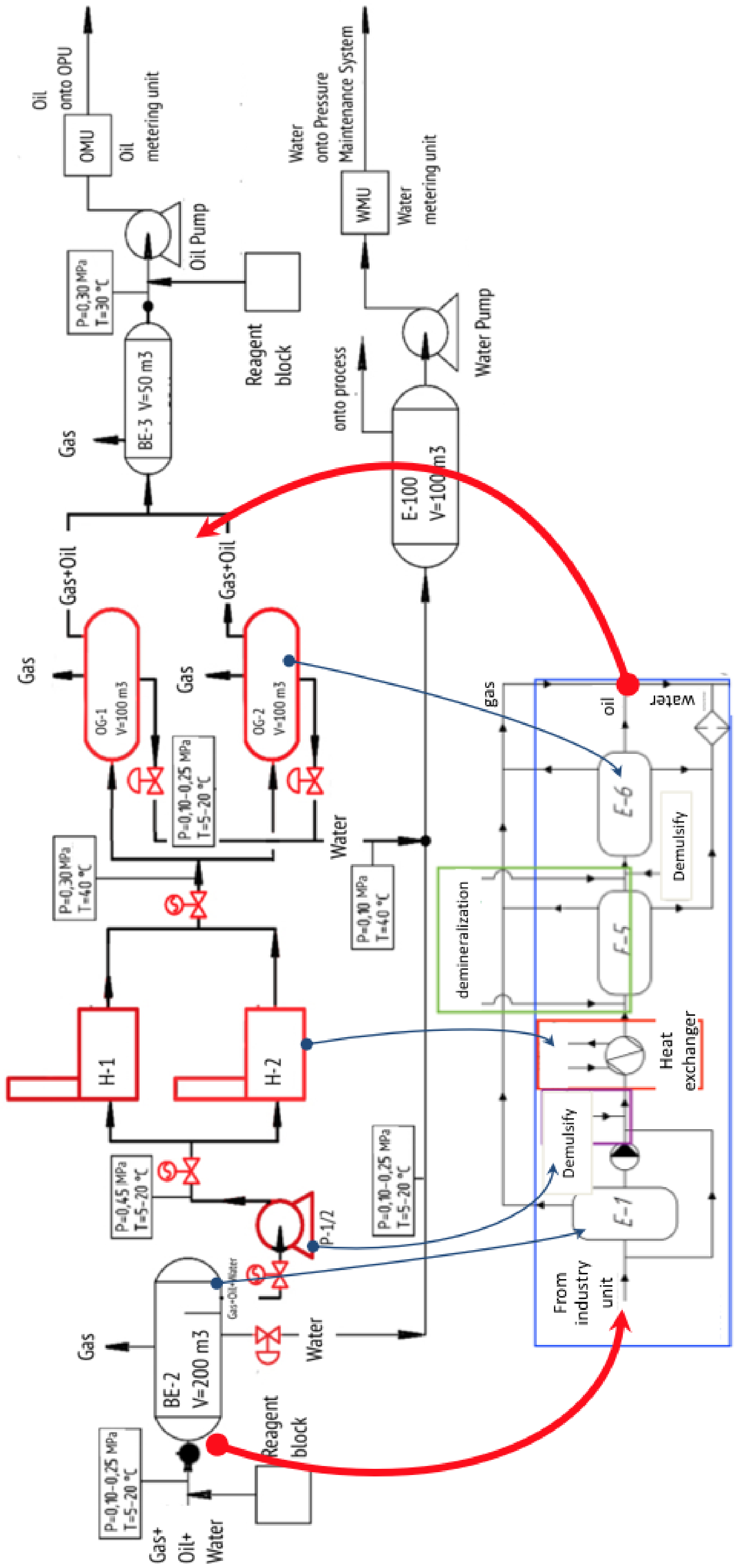


***Figure 2b.*** *The Technological Scheme - Project with junction point of Mobile Unit*

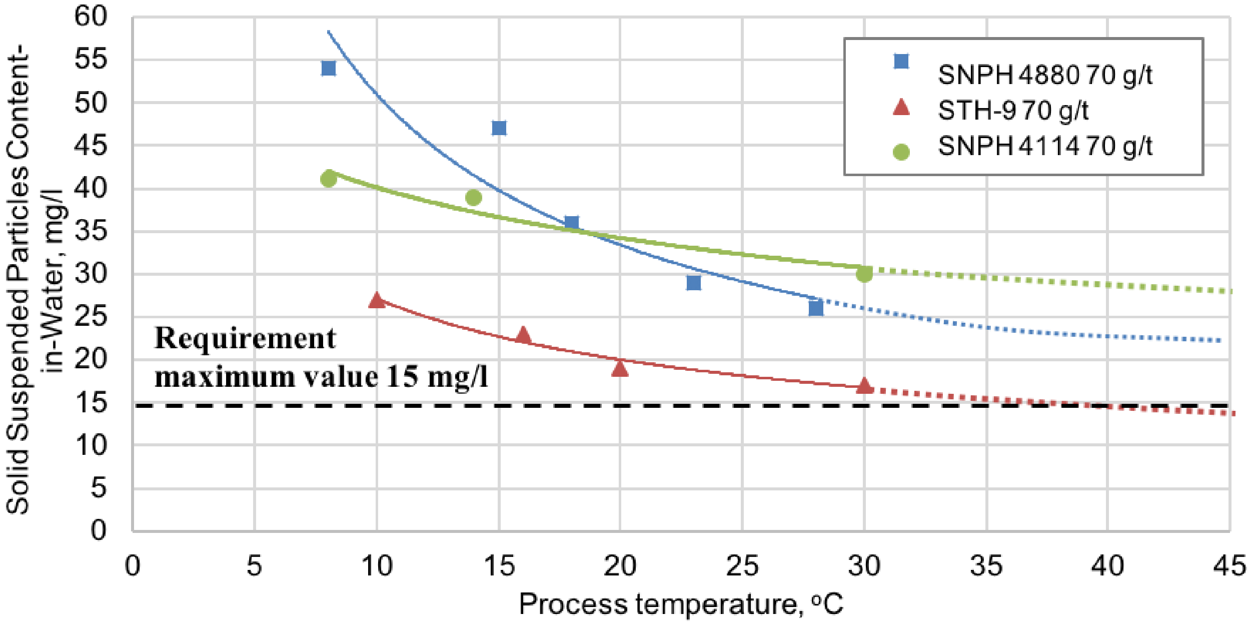


***Figure 3.*** *The results of wastewater testing on the solid suspended particles content under the testing of demulsifiers.*

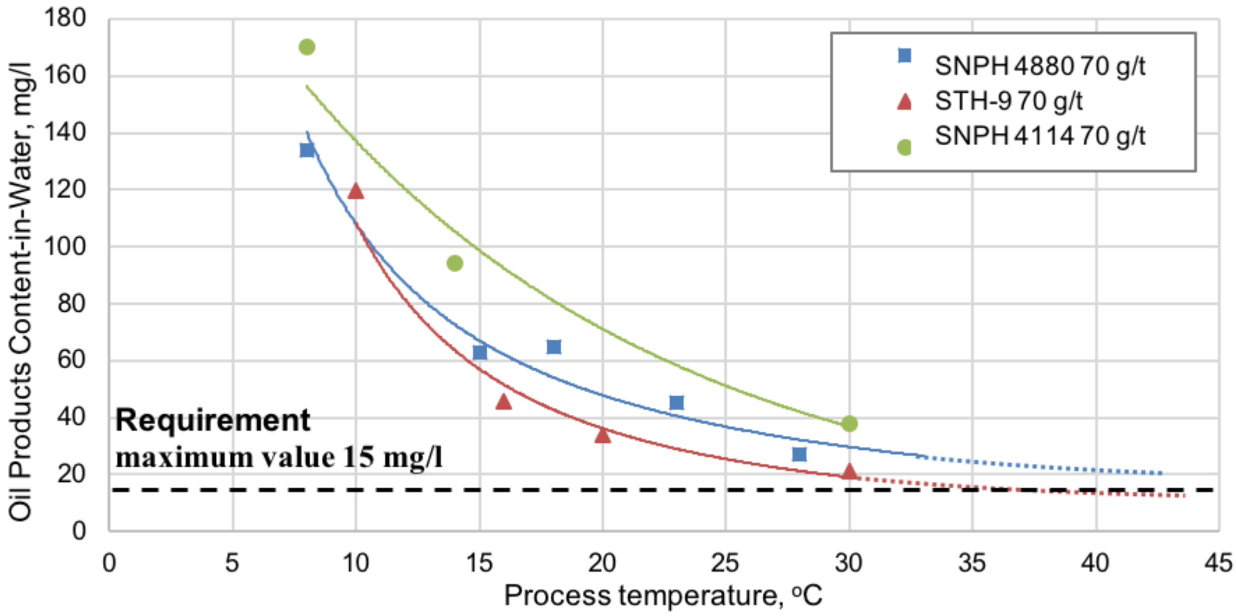


***Figure 4.*** *The results of wastewater testing on the oil products content under the testing of demulsifiers*

***Table 1.*** *The MU Technical Characteristics*

| Name | Units | Value |
|---|---|---|
| The unit productivity | $m^3/h$ | 0.1…2 |
| The pressure in the connection point | MPa | 0.015…1.0 |
| The temperature of fluid pumped | ºC | +5…+70 |
| The water content | % | 1…99 |
| The power consumption | kW | 80 |
| The unit overall dimensions<br>length<br>width<br>height | mm | <br>12000<br>3000<br>3300 |
| Net weight | kg | 13000 |

***Table 2.*** *The Properties of Oil*

| Parameters | Value |
|---|---|
| Degassed Oil Density, $kg/m^3$ | 901 |
| Oil Viscosity within the Reservoirs, MPa·s | 18.96 |
| Content, % wt. | |
| Paraffin | 6.84 |
| Resins and Asphaltenes | 19.04 |
| Sulfur | 2.2 |
| Gas Content, $m^3/t$ | 43 |
| Saturation Pressure, MPa | 11.48 |

***Table 3.*** *The Calibration Mode of Production Refining onto Mobile Unit and Industrial Unit*

| The Norm of the Technological Mode | Mobile Unit | Industrial Unit |
|---|---|---|
| Volume of Fluid under Dehydration, $m^3$ | 0.676 | 78 |
| Refining Period, h | 2.6 | |
| Temperature, °C | 13 | 10 |
| Pressure, $kgs/cm^2$ | 1.2 | 1.2 |
| Liquid Consumption Rate, $m^3/h$ | 0.26 | 30 |
| Consumption (Discharge) of Water $m^3/h$ | 0.116 | 9.2 |
| Ratio of Pumping Oil/Pumping Water, % | 44.6 | 30.6 |
| **Analytical Control** | | |
| Water Content (in oil), % | 2 | 2 |
| The Content of SSP (in water), mg/l | 51 | 21 |
| Oil Products Content (in water), mg/l | 24.6 | 59 |