ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 11 , November 2021

To The Question of Destroying Multicomponent Dispersion Systems in Oil Production

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ABSTRACT: World oil production is going through a new stage of development associated with the completion of light oil reserves and the transition to active production of hard-to-recover oil reserves. This, in turn, dictates the development of new solutions for the construction of wells, the introduction of effective methods of stimulation of production with the provision of high final values of the oil recovery factor. As a result, the produced oil constantly undergoes changes in composition, and emulsion mixtures take the form of stable dispersed systems. The article presents a scheme for the preliminary processing of complex dispersed systems composed of complex-multiple emulsions that accompany oil production from hard-to-recover reserves. The proposed solution optimizes the cost of upgrading oil treatment units. It also provides a diagram of a unified oilfield technology with additional operational processes that reduce the environmental load on the environment.

KEY WORDS: hard-to-recover oil, complex dispersed systems, oil treatment, pretreatment scheme for complex multiple oil-water emulsion, oilfield technology.

I. INTRODUCTION

In modern conditions, with a constant increase in the share of oil production from fields with hard-to-recover reserves, there is a spontaneous increase in the share of complex dispersed systems formed as a result of continuously changing methods of oil production and the involvement of heavy fractions of peripheral and stagnant zones of the formation. At oil fields, the problem of accumulation of multicomponent dispersed systems in the form of a trap water-oil complex-multiple emulsion, which excludes the possibility of its destruction by coalescence of water globules, will increase.

The difficulties are mainly associated with the inability of the existing oil treatment plants (OTP) at the field to effectively destroy highly stable oil-water emulsions. To efficiently perform operations of degassing, dehydration and desalination of oil, continuous modernization is required, taking into account the applied method of oil production from complex reservoirs. If the issues of preliminary sampling of breakthrough gas and formation water during forced oil withdrawals are solved quite simply, for example, by additional installation of a high-performance gas separator and a preliminary water discharge unit at the feedstock inlet to the OTP, then the solution to dehydration of hard-to-break dispersed systems does not have an unambiguous solution.

II. RELEVANCE

Therefore, there is a need to control and regulate the properties of dispersed systems so that the oil-water emulsion pretreated with the maximum possible weakening of the armor shells around the emulsified water droplets and the removal of emulsion stabilizers from the interfacial surfaces is supplied to the oil treatment plant.

The search for new solutions to improve the efficiency of oil preparation requires a constant and systematic study of the properties of the produced oil and its emulsions in order to have a clear idea of the mechanism of formation, stabilization and the degree of stability of dispersed systems for further targeted regulation of their structural and mechanical properties.

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International Journal of Advanced Research in Science, Engineering and Technology
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III. TASKS TO BE SOLVED

The article discusses the thermochemical dehydration (TCD) of oil by the method of sludge, which is widely used at the OTP. From a practical point of view, the main criteria for TCD using the settling method, for emulsions of a simple structure and composition, are the dispersion of emulsions, the size of emulsified water globules in oil and the time of precipitation of water globules of various sizes in the oil layer.
The classics of priorities for TCDof oil at the OTP is reduced to the fulfillment of the following conditions:

- ensuring the enlargement of drops of emulsified water in the dispersed system oil - formation water to values of 200 microns in the bulk of 90% or more;
- maintaining the density difference between oil and formation water in acceptable intervals and adjusting the oil viscosity in a predetermined range by heating;
- mechanical weakening of the strength of the armor shells around the water droplets and the creation of favorable hydraulic conditions for the coalescence of water droplets;
- selection of an effective demulsifier and a method for dosing it into the emulsion, specifying the optimal settling time during delamination.

The classical methodology for the design of the OTP and the operating procedure provides for the receipt of averaged feedstock from the field (s) for preparation, consisting of oil, associated gas, formation water and their mixtures of a given property that does not change over time. However, in practice, especially when operating an oil production facility with hard-to-recover reserves, we are dealing with various cases of deviations from the design values of the composition and, especially, the properties of the feedstock supplied to the OTP.

IV. METHODOLOGY

To eliminate the spontaneity of decisions and chaos in the actions of the OTP personnel in the current conditions of the transition to the production of hard-to-recover oil, aimed at improving the quality of oil, it is proposed to consider the option of a phased modernization of the oilfield technology in the design process, as geological and technical measures are introduced to intensify oil production.
To search for solutions to the problem of optimizing TCD of oilat the OTP in the conditions of production of complex oil dispersed systems from a complex reservoir, a systematic analysis of the literature data was carried out [2-8]. Which showed the following:
- an increase in the water cut of the produced oil with the formation of stable emulsions of high viscosity, which causes complications in downhole production and significantly reduces the throughput of collecting pipelines. This is the first reason for trapped oil accumulation;
- the involvement of stagnant and peripheral zones of the formation is accompanied by the growth of mechanical impurities and inclusions of solid asphalt-resinous substances in oil, which contributes to the strengthening of the armor shell around the water globules. This leads to the growth of a complex-multiple emulsion;
- oil production from thin rims of an oil and gas facility is accompanied by an intensive gas breakthrough to an oil producing well, which causes the growth of a finely dispersed emulsion system of oil with gas and formation water during their joint movement through pipes. This creates conditions for the formation of finely dispersed systems with the size of water droplets in a dispersion medium (oil) less than 10 microns in size;
- frequent workover of wells for the introduction of methods for stimulating oil production using special fluids, also create conditions for the growth of production of complex multiple emulsions.

V. ANALYSIS OF THE ACTUAL STATE

The performed analysis showed that the design and operation of a complex object - oil fields with hard-to-recover reserves or modernization of the development system for long-term developed deposits with low rates of the current oil recovery factor (ORF), due to objective factors, will require the development of additional operational processes to the existing oilfield technology aimed at preparation of a complex emulsion.
Before proceeding to the direct modeling of the processes that create conditions for the effective destruction of complex

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dispersed systems, before they are fed to the OTP, a procedure was developed related to the determination of the procedure for feeding the OWE to the OTP. Compliance with the order will create conditions for a sharp reduction in the accumulation of trapped oil and oil sludge during the preparation of oil for processing and will prevent the risks of failure in the operation of the OTP in conditions of production of complex oil and gas-water mixtures. And it is not difficult to be convinced of the high economic benefit that is associated with minimizing unforeseen costs during the operation of the oil facility as a whole.

The TCD method of water-in-oil emulsion stratification is performed under static conditions and is described by the Stokes formula. It is based on the principle of changing the potential energy of the position of water globules. The mechanism for changing the potential energy of the position of water globules in oil depends on the following parameters: oil viscosity, difference in density between oil and water, size of water particles dispersed in oil, and mechanical strength of armor shells around water droplets. An important provision for the success of the separation of the OWE into oil and water will be the preliminary provision of coalescence of emulsified water droplets to a size of 200 µm and more. This is clearly shown in Figure 1 for the calculated indicators of the dynamics of destruction of a monodisperse emulsion depending on the size of water globules, for a dispersion liquid (oil) with a viscosity of 10 cps in a gravity field. From Figure 1 it follows that the settling time for water particles (globules) less than 100 µm in size in a process tank with a water-oil emulsion of 4 meters in height takes more than 12 hours. From a practical point of view, this is not effective and therefore they resort to heating the OWE and the use of additives of chemical reagents, which facilitate the separation and enlargement of the size of the dispersed phase globules.

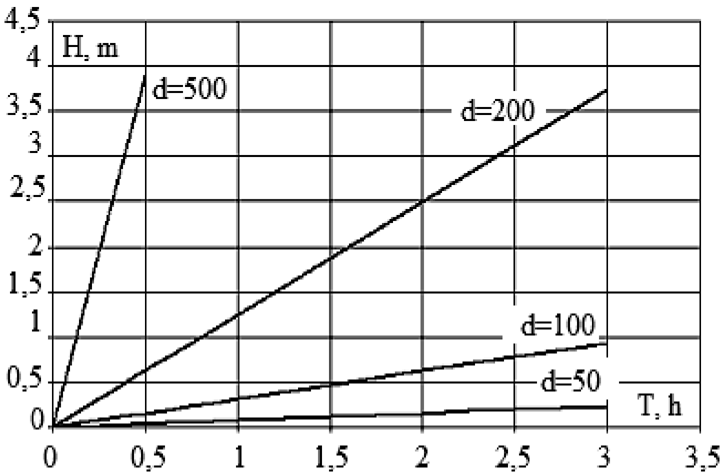

Figure 1. Graph for determining the time T of the destruction of the water-oil emulsion in the H layer depending on the size of water globules d (µm)

An important provision for the success of the separation of the OWE into oil and water will be the preliminary provision of coalescence of emulsified water droplets to a size of 200 µm and more.

In order to determine the effectiveness of TCD in the destruction of complex multiple OWEs formed in oil production from difficult-to-build reservoirs, special studies were carried out in comparison with the traditional method. In particular, the impact on dehydration and desalination of complex water-oil emulsions in the presence of reaction products (mechanical impurities, asphalt-resin-paraffin particles) formed during well workovers and measures to stimulate oil flow to the well is considered. The materials of such studies were reviewed and summarized in [1]. Where the ineffectiveness of direct TCD of complex multiple emulsions is shown. Since the mechanical observance of the technological regulations at the OTP under these conditions will be ineffective, energy- and resource-intensive and will cause a deterioration in the quality of the oil being prepared. That is, in order to weaken and destroy the armor shells around the water droplets, pre-treatment of complex-multiple emulsions is needed before they are fed to the OTP. It is also important to observe the developed procedure and sequence of actions when feeding complex multiple emulsions to the OTP.

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VI. SEARCH RESULTS

For this, a schematic diagram of feedstock supply to the OTP, the main stream of the OWE and an additionally processed complex-multiple emulsion was developed, which was built into a single oilfield technology (Figure 2). In Figure 2, the unified oilfield technology includes: a classic OTP, a scheme for supplying and processing a complex-multiple dispersed system (water-oil mixtures), an installation for preliminary discharge of formation water and extraction of associated gas, a system for utilizing low-pressure gas to obtain electric and thermal energy using ORC technology, pyrolysis shop for the processing of oil sludge and secondary hydrocarbons.

Let us consider in detail the proposed scheme for processing and supplying complex multiple emulsions to the OTP.

The sequence of additional processing of complex dispersed systems, including complex-multiple oil-water emulsions (OWE), is as follows. After accumulation, a complex multiple OWE from DT-2 is pumped through the distribution device under the layer of formation water in the receiving water reservoir No. 1 of the WTS, with subsequent collection in the drainage tank DT-1. This technique creates conditions for maximum contact of emulsified water globules contained in a complex emulsion with formation water. This achieves the removal of mechanical impurities and emulsion stabilizers from the surfaces of the armor shells of water droplets dispersed in a complex OWE, and also the phase inversion occurs, which has a positive effect on the enlargement of the droplets.

The second phase of complex OWEtreatment includes the impact on the armor layers (shell) around the emulsified water globules.

The destruction and weakening of the armor layer is carried out by pumping the emulsion from DT-1 through the HM where the demulsifier, flocculant and hot fresh water are injected. This creates conditions for hydrodynamic instability for the existence of complex-multiple OWEs.

The third phase involves the removal of emulsion stabilizers into the aqueous phase and the coarsening of emulsified water droplets to a size of more than 200 μm. To do this, the most destroyed oil-water emulsion, converted into an unstable mixture of hydrocarbons with formation water, is fed to the intake of DG and IPWDGS for combining the main feed stream with the oil-water emulsion and feeding it to the OTP.

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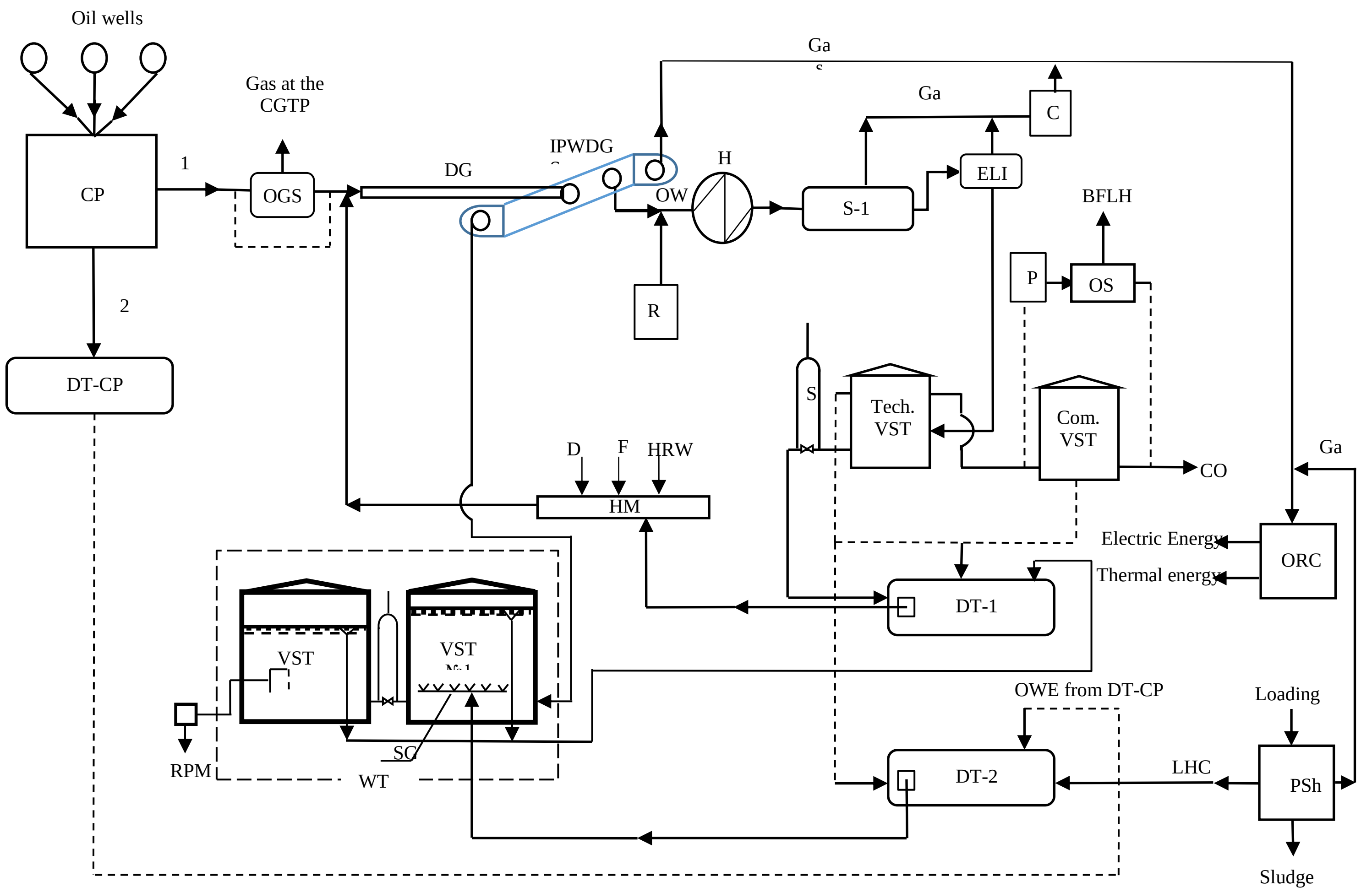

1 – main stream OWE; 2 – flow of complex dispersed systems; CP – collection point; OGS – oil and gas separator; CGTP – complex gas treatment plant; DG-droplet generator; IPWDGS –installation of preliminary water discharge and gas sampling; OWE –oil-water emulsion; HO – heating oven; RU – reagent farm unit; S-1 – separator; ELI – end ladder installation; C – compressor; VST–vertical steel tank; P – pump; OSU – oil stabilization unit; CO – commercial oil; BFLH – broad fraction of light hydrocarbons; S – siphon; DT-1,2 – drainage tanks; WTF – water treatment units; RPM–reservoir pressure maintenance; SG–Switchgear; HM–hydrodynamic mixer; DM –demulsifier; F-flocculant; HRW-hot rinse water; PSh – pyrolysis shop; LHC – liquid hydrocarbons; ORC – organic Rankine cycle.

Figure 2. Schematic diagram of feedstock supply to the OTP, the main stream of the OWE and additionally processed complex-multiple emulsion (a variant of unified oilfield technology)

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VII. CONCLUSION

- Oil production from hard-to-recover reserves is accompanied by the growth of complex emulsions entering the oil treatment unit.
- The use of the classical TCD method for the destruction of complex dispersed systems is energy and resource intensive and leads to additional losses of hydrocarbons.

VIII. RECOMMENDATIONS

For the development of an oil field with hard-to-recover reserves, the stage of designing the surface facilities of the field should be carried out simultaneously with the design of the underground part, which will ensure the development of a decision on the use of the most accessible oilfield technology that meets the decisions made acceptable throughout the entire life cycle of the project.
When switching to the preparation of complex-multiple emulsions, the classical method of TCD of oil needs to be modernized by embedding a scheme for the preliminary treatment of such dispersed systems.
In the case of forced oil withdrawal from the reservoir, it is proposed to carry out the development of the oilfield technology according to the scheme shown in Figure 2.

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ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 11 , November 2021

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