formulas and nomograms based on the values of specific refraction, density and molecular weight. The results of determining the structural-group composition of vacuum gas oil are shown in Table 2.

Table 2

Results of calculation of the structural-group composition of vacuum gas oil

Group composition, wt.%	Feed		Product	
	№1	№2	№1	№2
Content of carbon in aromatic structures	23,022	22,448	15,813	17,322
Content of carbon in naphthenic structures	17,569	18,247	22,877	20,907
Content of carbon in paraffinic structures	59,409	59,305	61,310	61,771
Number of aromatic rings	0,937	0,912	0,748	0,790
Number of naphthenic rings	0,983	1,008	1,540	1,372
Total number of rings	1,92	1,92	2,288	2,162

From the obtained results that the number of rings in the vacuum gas oil is 1,92 wt. %, the carbon content in the paraffin and naphthenic structures is 59,305-59,409 wt. % and 17,569-18,247 wt. %, respectively. As a result of hydrotreatment, the composition of vacuum gas oil changes towards an increase in the carbon content in alkane (61,310-61,771 wt. %) and cycloalkane structures (20,907-22,887 wt. %), the proportion of carbon in aromatic structures decreases, which is associated with the reactions of saturation of olefins and benzene rings with hydrogen. The average number of arene rings in the fraction decreases, while the average number of naphthenic rings, on the contrary, increases.

The obtained data will be used in the development of a mathematical model that will allow choosing the optimal process parameters and deepening the vacuum gas oil hydrotreatment.

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HIGH-VISCOSITY OIL EXTRACTION USING DOWNHOLE STEAM GENERATOR

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Nowadays, there is a problem of field development, the operation of which is impossible using the existing methods and equipment. Such fields are called shale or hard-to-recover fields. Traditional oil reserves are lowering, therefore, the need for the development of technologies, allowing to extract the hard-to-recover oil is gradually increasing [1].

The Krasnoyarsk Territory, for instance, has a huge number of oil fields, some of which are related to the general group – Vankor cluster. This cluster consists of 4 fields – Vankorskoe, Suzunskoe, Tagulskoe and Lodochnoe. The geological structure of them is very similar, but the Tagulskoye field in terms of the physical and chemical composition of oil is different.

Viscosity is the most important technological characteristic that determines the mobility of oil in layer conditions, which has a significant impact on the methods of oil production. The question of high-viscosity oil extraction at the Tagulskoe field remains open today: effective methods and technologies have not been determined for the extraction of such oil; solutions for uninterrupted production of hard-to-recover oil have not been implemented. An analytical review of modern scientific and technical literature and an analysis of existing methods for the production of high viscosity oil made it possible to draw a conclusion about the relevance of the problem under consideration [2].

The purpose of this work is to develop equipment that allows to extract high viscosity oil more efficiently, environmentally safely and cost-effectively, as well as to think over the ways of using this equipment in the production process.

The oil of the largest reservoir – the Tagulskoe field, belongs to the category of hard-to-recover reserves. The average value of the dynamic viscosity reaches 202,1 *mPa·s*. It is not possible to produce such oil using standard methods while maintaining the profitability of the field development. Therefore, we consider the possibility of creating a steam generator unit, which principle of operation will be based on heating water with further evaporation (Fig.1).

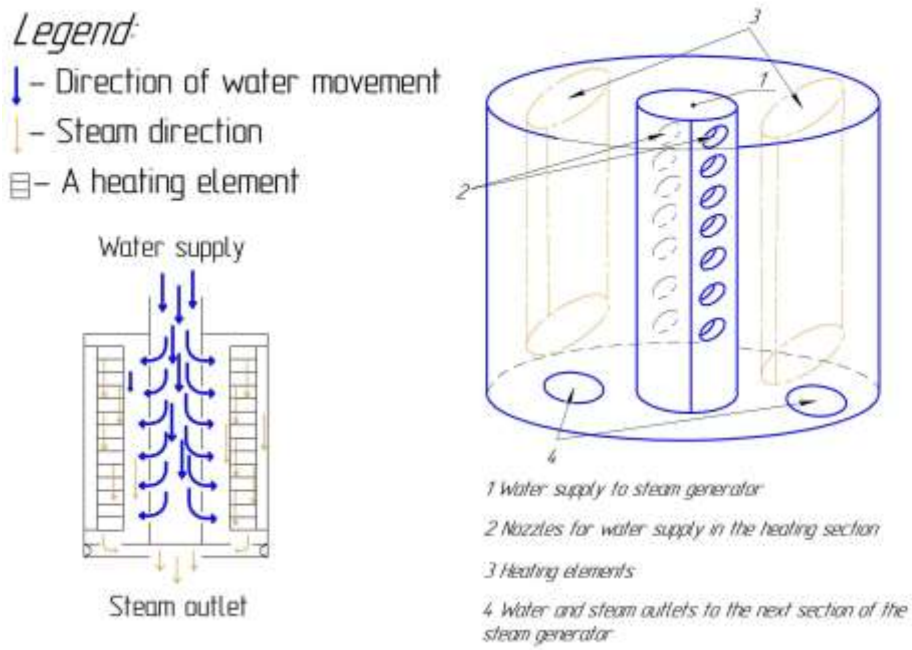

Fig. Downhole steam generator model

Under high pressure, steam and water are supplied from the unit to the reservoir for subsequent heating. The technological design of the unit will depend on the required amount of steam for heating the formation.

Water is supplied to the unit by pumping device that deliver water from the water treatment plant. In the same way, water can be extracted from a water well.

The operation of the unit is combined with a high-temperature electric submersible pump or a compressor gas lift. It is possible to use the unit in an injection well to heat water in a reservoir. This unit can be used in steam assisted gravity drainage development of reservoirs with high-viscosity oils.

Advantages of the downhole steam generator unit:

- the possibility to extract oil with high-capacity pumps;
- growth in the oil recovery factor;
- non-use of expensive ground equipment in comparison with other existing methods;
- no heat loss in the wellbore (steam generation occurs at the bottom hole);
- exclusion of rock thawing and casing collapse under the influence of rock pressure.

In laboratory conditions we plan to study the dependence of the viscosity of oil from any field at different temperatures. We will consider the dependence of the viscosity of oil at different temperatures, select a well and determine the flow rate in a horizontal well (using U.P. Borisov's formula) [3]:

$$Q = \frac{2\pi \cdot k \cdot h}{\mu} \cdot \frac{\Delta P}{\left(\ln\left(\frac{4R_k}{L}\right) + \frac{h}{L} \cdot \ln\left(\frac{h}{2\pi \cdot r_c}\right) \right)},$$

where Q − well flow rate, m^3/day, k − reservoir permeability, m^2, h − effective reservoir thickness, m., μ − formation fluid viscosity, Pa·s., ΔP − differential pressure between the boundary of the supply circuit and the borehole wall, Pa., R_k − circle radius, m., L − horizontal well length, m., r_c − well radius, m.

Well flow rate allows to substantiate the technological efficiency of the introduction of the new equipment.

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