Deasphaltizing of High-Viscosity Oil at the Field

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Abstract. Considering the processes of oil treatment, transportation and refining of very high-viscosity index (VHVI) oil as a single technological process, the article proposes a variant of optimal technology for recovery and treatment of VHVI oil with minimizing energy and operating costs along the whole process chain, obtaining additional products, and the reduction of ecological risks. In connection with this, it is proposed to build a single ecologically safety pay zone, inside of which there are production wellheads of directional wells and all technological facilities for the production and treatment of VHVI oil, including a modular heat power plant for thermal-steam formation treatment and power generation. In addition, it is proposed to divide production fluid into asphaltum containing 95-97% of metals and "synthetic" oil, which will exclude major pipeline transport of VHVI oil, allocate the production of bitumen and metals in a separate production and reduce negative impact on the environment along the whole process chain.

1. Introduction

In the total reserves of hydrocarbon, the share of VHVI oil is constantly increasing [1] and currently accounts for 82% of the world's oil reserves. In the Melekess Basin, running through the territory of the Samara Region, Tatarstan and Bashkortostan, there are 45% of the Russian VHVI oil reserves [2], which contain on average 850 grams of vanadium [3] per ton of oil and other metals [4]. Since vanadium is not extracted from VHVI oil during its extraction [3], its losses in recent years have exceeded the extraction volume [2]. With the introduction of the process scheme proposed by the authors, the extraction of only vanadium in Russia will increase by 100%.

Since VHVI oil is characterized by high value of destiny and viscosity, high content of asphalt pitches, high concentration of metals and sulfides, increased cocking behavior [4,5,6], application of traditional technologies of recovery, treatment, transportation and refining of VHVI oil leads to high product costs and consequently to the need for preferential taxation [7,8,9]. In addition, VHVI oil differs so much in composition and properties [7], so the development of universal technologies seems to be an unattainable task.

The most effective methods of recovery of VHVI oil are thermal methods [10,11,12,6]. Using the example of a hypothetical field (Tab.1), we consider the differences between the standard and proposed variants for recovering VHVI oil using heat injection method, namely the thermal-steam formation treatment.
Table 1. Initial data of a hypothetical field.

| Description                                      | Value        |
|--------------------------------------------------|--------------|
| OOIP (original oil in place), mil. tons          | 23.7         |
| Initial recoverable reserves of oil, mil. tons   | 5.2 (oil recovery index = 21.9%) |
| Initial recoverable reserves of oil with multihole wells, mil. tons | 10.3 (oil recovery index = 43.5%) |
| Extension of field, km                           | 4x6          |

Usually the development of VHVI deposits by drilling a large number of producing wells, while the higher the viscosity of oil, the more the drilling density is greater [7,13]. For the development of the field using vertical and directional wells using the thermal-steam formation treatment [14], it is necessary to drill from 520 to 550 wells at a distance of 200 m from each other (Fig. 1) and place them on 22-25 multiple well platform (Fig. 2). This will lead to the formation of an infield network of roads with a hard ground covering with a total length of up to 30 km, construction of an infield oil-gathering system and high-pressure steam pipelines with a length of up to 30 km.

Figure 1. Number of vertical wells in the field.

Figure 2. Placing of manufacturing areas and communications.

To gathering and transport VHVI oil recover from the well, a local well pad is constructed at each pad of the bush, consists of:

1. GMS - Group Metering Station, which gathering production fluid and measurement of well yields;
2. pipe system, which gathering production fluid from wellhead to GMS;
3. VM – valve manifold, distributing steam from the steam generator to each of the wells;
4. steam injection system from VM to wellhead
5. supply system - geophone receiver point (TP 36/6) from the main power supply lines and the cable electrical network from the transformer to the wellhead;
6. pipe heating of water-oil emulsion in conditions of oil production at low temperatures [14].

Transportation of produced VHVI oil from the well pad to the primary processing facility of oil, gas and water is complicated, both by the formation of "plugs" from asphaltene deposits, and by ruptures of pipelines due to external and internal corrosion of metals [15,16]. In this regards, a lot of investments are needed, both for the field facility construction of recovering of VHVI oil and communications, and for their servicing and maintenance in working order.

Consider next the proposed variant using directional multihole wells with a length of 500 to 1500 m, where production is carried out by cyclic injection of steam into different parts of the bench with a temperature of about 150 °C produced at the heat power plant, while the total number of wells is reduced to 110 (Fig. 3).
Figure 3. Project directional multihole well.

It is proposed to combine multihole wells to the super well pads to reduce the number of an infield equipment and communications. The most optimal position of super well pads is shown in (Fig.4).

Figure 4. Placing of manufacturing area and communications for the project development version.

In the proposed variant, a single field production project site (SFPPS) of oil is located in the center of the field, which includes:

- recovery and steam-injection wells with infield extraction facilities of oil placing along the perimeter of a SFPPS;
- deasphalting unit of VHVI oil;
- deasphalting treatment unit for transportation to refineries;
- mini oil refinery plant (MRP), where solvent and fuel are produced for the modular heat power plant;
- a multifunctional power generating plant fueled by associated surface products (oil-well gas, black strap, possibly hydrogen disulfide);

In connection with the excess heat and superheated water in the power generation at the block heat power plant, the implementation of systemic steam-heat treatment in large volumes becomes cost-effective. Also, it is obvious that using a system of multihole wells reduces adverse environmental effect.
(Tab.2) presents the comparative characteristics of recovery technique using vertical and directional wells and the recovery technique using multihole wells.

**Table 2.** Comparative analysis of the standard and project variants for the development of the VHVI oil deposit.

|                          | Standard project | Project SFPPS |
|--------------------------|------------------|---------------|
| Number of wells, pcs     | 520-550          | 110           |
| Zone, ha                 | 195-211          | 395,0         |
| Infield network of roads with a hard ground covering, km | 25,0          | 7,5           |
| Infield oil gathering pipelines, km | 25,0          | 7,5           |
| Infield steam-, water-driven pipeline, km | 25,0          | 7,5           |
| Infield power supply lines 6,0 KW, km | 29,0          | 9,2           |
| Infield equipment in (VM, GMS, et al), number | 22-25          | 5             |

Thus, the method proposed in this article for the development of VHVI oil fields is more effective than the methods currently used.

In addition, at the first stage of treatment, fluid production is proposed to be divided into "synthetic" oil and asphalt. Most likely, the most effective method of deasphalting in this development method will be centrifugal separation [17], which will separate 95-97% of the metals contained in VHVI oil. In addition, in the process of centrifugal separation, water will be separated along with asphaltenes, which will lead to the exclusion from the standard technological process of oil treatment in the field of preliminary water removal unit. This will lead to the construction of specialized plants for the production of high-quality asphalt-bitumen products and metals. The profitability of the bitumen plant will be determined by the presence of several VHVI oil fields within a radius of 100-150 km (Fig.5) [18], where asphalt is proposed to be delivered by road tank cars.

"Synthetic" oil (deasphalted oil) passes the standard treatment process for further transfer pipeline transportation to the refinery (Fig.6). Part of the treated oil refines at the mini oil refinery plant (electric desalter and dehydrator) in sufficient quantity to compensate for solvent losses, and oil refining residue is used to provide the field with fuel [9].

![Figure 6. Technical plan for treatment of VHVI oil.](image)

To implement this project, it is proposed to develop and redress table 2 -Types of oil GOST R 51858-2002 "Oil. General technical conditions" for the content of asphaltenes in commercial oil [19], which will lead to the need to reduce the content of asphaltenes to 1%(point 4, Tab.3) when processing oil in the field [20].
Thus, the advantages of the oil recovery method with the directional multi hole wells and the SFPPS project with the separation of production fluid into "synthetic" oil and asphaltum are:

- reduction of numbers of wells;
- reduction of numbers of equipment and infield communications;
- regulation of the quality of oil sent to oil refineries;
- the possibility of independent power supply due to associated surface products and primary processing of a part of "synthetic" oil.
- reduction of the formation of asphaltene deposits in pipelines and equipment along the whole process chain treatment - transport – refining;
- reduction in the scope of works for the clean up of pipelines and equipment;
- reduction of waste burial of oil slime;
- reduction of costs for payment for negative impact on the environment;
- reduction of refinery costs related to the deactivation of expensive catalysts and high-temperature corrosion of equipment;
- significant reduction of environmentally harmful emissions into the environment during the use of refined products;
- allocation of high-quality bitumen and asphalt production to self-production;
- extraction of 95-97% of strategic metals (V, Ni) from VHVI oil and an increase in vanadium production by 100% compared to volumes currently recovered[8].

2. Conclusion
The proposed project of field development of the VHVI oil with the recovery of associated surface products will ensure the required profitability of the VHVI oil production and increase the resource potential of the Russian Federation in rare and rare-earth metals.
3. References

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