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Решение проблем высокотемпературной сернистой коррозии на установках первичной переработки нефти

В статье рассматривается влияние природных серосодержащих соединений нефти на коррозионное состояние оборудования. Описано, что основной причиной резкого повышения коррозионной агрессивности нефти в последние годы является применение на стадиях добычи и транспортировки нефти реагентов для связывания сероводорода и меркаптанов. Предложены пути решения проблемы высокотемпературной сернистой коррозии на установках первичной переработки с учетом локализации проблемных зон.

Ключевые слова: нефть, сероводород, меркаптаны, формальдегид, высокотемпературная сероводородная коррозия.

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Solving Problems of High Temperature Sulfur Corrosion
at Crude Oil Processing Units

This article reveals the influence of natural sulfur containing oil compounds on corrosion condition of equipment. It is described that the main reason of rapid increase of oil corrosion aggressiveness recently is application of reagents at the stage of oil extraction and transportation to bind hydrogen sulfide and mercaptans. Several solutions are suggested to solve the problem of high temperature sulfur corrosion on crude oil processing units with account of problematic zones isolation.

Key words: oil, hydrogen sulfide, mercaptans, formaldehyde, high temperature hydrogen sulfide corrosion.

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Гидродемеркаптанализация — оптимальный способ получения реактивного топлива. Сравнение с гидроочисткой и окислительной демеркаптанализацией

Проведен комплексный анализ и сравнение существующих технологий получения реактивных топлив: гидроочистки, гидродемеркаптанализации и окислительной демеркаптанализации. Показано преимущество гидродемеркаптанализации по большинству показателей. Этот процесс является простым, надежным, эффективным и позволит в короткие сроки увеличить выпуск реактивного топлива.

Ключевые слова: реактивное топливо ТС-1, сернистые соединения, содержание общей серы, содержание меркаптановой серы, гидроочистка, гидродемеркаптанализация, окислительная демеркаптанализация.

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Hydrodemercaptanization – Optimal Method to Receive Jet Fuel.

Comparison with Hydrotreatment and Oxidizing Demercaptanization

Complex analysis has been performed together with comparison of existing technologies to produce jet fuel: hydrotreatment, hydrodemercaptanization and oxidizing demercaptanization. Advantage of hydrodemercaptanization is revealed as per majority of indicators. This process is simple, reliable, effective and will allow to increase jet fuel production in short time frames.

Key words: *TS-1 jet fuel, sulfur compounds, total sulfur content, mercaptan sulfur content, hydrotreatment, hydrodemercaptanization, oxidizing demercaptanization.*

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Идеальная модель фракционного распределения сырья установки депарафинизации

Проведен комплексный анализ свойств узких фракций гидроочищенного дизельного топлива и дизельного топлива гидрокрекинга для оценки применимости в качестве сырья установки изодепарафинизации на платиновом катализаторе. Составлена идеальная модель фракционного распределения сырья установки депарафинизации. Показано, что свыше половины традиционного сырья установок депарафинизации является балластом процесса, который надо выделить и направить в товарное зимнее дизельное топливо помимо реактора. Показано, что наиболее благоприятным сырьем депарафинизации является тяжелая часть дизельного топлива гидрокрекинга.

Ключевые слова: *зимнее дизельное топливо, депарафинизация, фракционное распределение, идеальная модель, комплексный анализ, гидроочистка, гидрокрекинг, АВТ.*

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Ideal Model of Fractional Feed Separation of Dewaxing Unit

Complex analysis of close fractions properties of hydrotreated diesel fuel and hydrocracking diesel fuel has been made to evaluate application as a feed of isodewaxing unit on platinum catalyst. The ideal model of feed fractional

separation of dewaxing unit feed has been made. It is revealed that more than half of traditional feed of dewaxing units is ballast of the process, which it is required to identify and direct to marketable winter diesel fuel apart from reactor. It is revealed that the most convenient dewaxing feed is heavy part of hydrocracking diesel fuel.

Key words: winter diesel fuel, dewaxing, fractional separation, ideal model, complex analysis, hydrotreatment, hydrocracking, atmospheric vacuum pipestill.

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Ноль процентов светлых в мазуте. Иллюзия или разумная перспектива?

Выход светлых продуктов на установках АВТ предлагается повышать за счет утяжеления 95%-ной точки выкипания дизельного топлива с 360 °С (требования ГОСТ) до 365 °С. Далее фракционный состав облегчается за счет гидрирования ароматических соединений в тяжелой части дизельного топлива при гидроочистке. Опытный пробег подтвердил правильность теоретических разработок.

Ключевые слова: содержание светлых в мазуте, выход светлых, предельная температура фильтруемости, атмосферно-вакуумная трубчатка, гидроочистка, дизельное топливо, гидрирование.

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Zero Percent of Light Products in Mazut. Illusion or Reasonable Perspective?

Yield of light products on atmospheric vacuum pipestill units is suggested to increase by means of making more heavy 95% boiling point of diesel fuel from 360°C (GOST requirements) to 365°C. Then fraction composition is getting lighter due to hydrogenating of aromatic compounds in heavy part of diesel fuel during hydrotreating. Test run confirmed the correctness of theoretical insights.

Key words: content of light products in mazut, yield of light products, limit filtering temperature, atmospheric vacuum pipestill, hydrotreating, diesel fuel, hydrogenating.

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Опыт эксплуатации блока по удалению сероводорода из мазута

Описан опыт разработки и эксплуатации уникальной установки удаления сероводорода из мазута в токе азота. При разработке процесса решены не имеющие аналогов задачи: определена температура начала

разложения сернистых соединений, создана лабораторная установка, подобраны контактные устройства, обеспечивающие массообмен при рабочей вязкости жидкости 80–200 сСт. Правильность технических решений подтверждает многолетняя успешная эксплуатация объекта.

Ключевые слова: мазут, сероводород, азот, вязкость.

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Operation Experience of Hydrogen Sulfide and Mazut Elimination Section

Here is described the development and operation experience of unique unit where hydrogen sulfide is removed from mazut in nitrogen flow. During thus process development the following unparalleled tasks have been solved: initial temperature of sulfur compounds decomposition have been determined, the laboratory have been built, contact devices have been selected, which ensure weight exchange at liquid operating viscosity 80–200 cSt. The correctness of technical solutions is confirmed by many years of unit successful operation.

Key words: mazut, hydrogen sulfide, nitrogen, viscosity.

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Получение арктического дизельного топлива с температурой применения до минус 65°C в ПАО «Славнефть-ЯНОС»

Министерством обороны Российской Федерации был разработан уникальный стандарт для арктического дизельного топлива, который подразумевает достижение низкотемпературных показателей топлива ниже –65°C без использования присадок. Благодаря высокой технологичности производства, в период с 2017 по 2020 г. в ПАО «Славнефть-ЯНОС» в ходе ряда опытно-промышленных пробегов были наработаны опытная и опытно-промышленная партия арктического дизельного топлива для Министерства обороны Российской Федерации. Данное топливо поставлено на производство.

Ключевые слова: Арктика, дизельное топливо, раздельная переработка дизельного топлива, изодепарафинизация, опытно-промышленный пробег, низкотемпературные свойства.

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Production of Arctic Diesel Fuel with Application Temperature

up to minus 65°C at Slavneft-YANOS PJSC

Ministry of Defense of the Russian Federation has developed unique standard for arctic diesel fuel which assumes achievement of low temperature indicators of fuel below minus 65°C without use of additives. Thanks to high production technology during the period 2016–2020 Slavneft-YANOS PJSC during several test-industrial runs has produced test and test-industrial consignments of arctic diesel fuel for Ministry of Defense of the Russian Federation. This fuel is now put into production line.

Key words: *arctic, diesel fuel, separate diesel fuel processing, isodewaxing, test-industrial run, low temperature properties.*

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Разработка технологии и особенности производства высокоокисленного

кровельного битума марки БНК 115/15

В ПАО «Славнефть-ЯНОС» разработан и производится высокоокисленный кровельный битум марки БНК 115/15, не имеющий аналогов в России. Отличительной особенностью кровельного битума БНК 115/15 является его высокая температура размягчения (110–119°C) при сохранении хорошей пластичности.

Интервал глубины проникания иглы при 25°C составляет 10–25 0,1 мм. Битум востребован у производителей современных кровельных материалов. Рассмотрены особенности технологии его производства.

Ключевые слова: *кровельные материалы, высокоокисленный битум, оптимизация технологии.*

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Development of Technology and Production Features

of High Oxidized Roofing Bitumen of Grade BNK 115/15

Slavneft-YANOS PJSC has developed and produced high oxidized roofing bitumen of unparalleled in Russia grade BNK 115/15. The distinctive characteristic of roofing bitumen BNK 115/15 is its high softening point (110-119°C)

while preserving good elasticity. Interval of needle penetration depth at 25°C is 10-25 0.1 mm. Bitumen is demanded at manufacturers of roofing materials. Its production technology features have been reviewed.

Key words: *roofing materials, high oxidized bitumen, optimization of technology.*

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Nitration of Petroleum Asphaltenes with Concentrated Nitric Acid under Various Conditions

The regularities of the reaction of nitration of tar asphaltenes with concentrated nitric acid have been studied under various quantitative, temperature and time conditions. According to IR spectroscopy data, nitration occurs to the greatest rate when asphaltenes are exposed to a 50-fold excess of 64% nitric acid at a temperature of 60°C for 4 hours. Nitration process is accompanied by oxidation reactions, which result in the formation of nitrate, phenolic, carbonyl, sulfoxide groups. The method of mass spectrometry determined a tendency towards a decrease in the number-average and weight-average molecular weights of the nitration products in comparison with the initial asphaltenes. The EPR method revealed a decrease in the content of stable free radicals and vanadyl complexes in the products of the nitration reaction.

Key words: asphaltenes, nitration, nitroasphaltenes, spectral coefficients, molecular weight, stable free radicals, vanadyl complexes

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New Intelligent Model of Cuttings Logging Based on Grey Clustering

With the deepening of exploration and development, the lithology of the drilling strata becomes more complex. Using the digital technology for processing the data obtained by the cuttings logging helps to provide accurate lithological data and evaluate clamping of the formation interface. However, the existing logging digitization technology relies on element logging and is restricted by the large error of the cuttings logging instrument, the disunity of multi-source data, and the poor pertinence of data. In this paper, we propose an intelligent identification model of the cuttings logging based on grey clustering analysis. First, the grey prediction method is used for processing the in-depth instrument data, and then the extended Kalman filter is used to standardize and unify the multi-instrument data. Finally, the identification model based on the grey clustering method is applied to identify the cuttings. The results of the simulation analysis and field application show that the identification model proposed in this paper can accurately identify the rock strata. Compared with the traditional methods, the accuracy of the proposed has been greatly improved. The field applications show that the model provides important theoretical support for the development of rock-cutting digital technology.

Keywords: cuttings logging; unified standardization of multi-source data; extended Kalman filter; grey clustering analysis; grey prediction.

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Fracture Network Simulation and Mechanical Characteristics Analysis of Glutenite

Hydraulic fracturing technology has become an effective technical method of developing tight oil reservoirs, such as an oilfield in Mahu, China. However, numerical simulation of the actual fracture seam network remains problematic. In this paper, we have simulated hydraulic fractures in the Urho Group of the Mahu target layer and analyzed the characterization of the rock mechanics parameters. The results show that Young's modulus of the Wuerhe domain ranges between 18 and 58.5 GPa, with an average of 32.4 Gpa, the Poisson's ratio is between 0.21 and 0.38, with an average of 0.31, the brittleness index is between 21.0 and 89.0, with an average of 44.3, and the hydraulic fracturing can form a multi-branch crack modification. The designed direction of horizontal wells in the area is north-south, and the horizontal stress difference is between 4.2 and 9.8 MPa, which facilitates easy fracturing of the reservoir and reforming of a complex seam network. Simulation of the artificial seam network helps to optimize the reasonable parameters of fracturing and the development parameters of horizontal wells in the Mahu 1 well area.

Keywords: sewing mesh simulation, brittleness, hydraulic fracturing, numerical analysis.

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Influence of Sensitive Parameters on Pressure Wave Velocity of Gas Drilling Fluid

In this paper, the authors have simulated pressure wave propagation in a closed system, considering the virtual mass force on the interphase border, the viscous shear force, the slippage velocity, and the narrow drag conditions. Based on the gas-liquid momentum conservation and mass conservation principles, the two-fluid model is established. To solve the model, considering the small disturbance principle and ignoring the second-order items, the basic equations are converted into vector form, and the final equation of velocity is obtained. The model is solved by the software program. The results show that with increase in porosity and decrease in the system pressure, temperature, and density of the liquid phase, the pressure wave propagation velocity decreases. With decrease in the low-frequency angular frequency, the slip velocity, and other factors that can slow down the gas-liquid exchange rate, the pressure wave velocity also decreases. With increase in the incompressibility of the gas-drilling fluid system and decrease in the interphase exchange time, the pressure wave propagation velocity increases. When the pressure wave frequency is low, the wave velocity is restricted mainly by the mechanical characteristics of the phase and the mechanism of thermodynamic balance.

Keywords: virtual mass force; void fraction; pressure wave velocity; two-phase system; angular frequency.

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Research on Development Effect Standard of Polymer Flooding Well Group Based on EnKF Method

Due to the different sedimentary environment, development and oil generation conditions of the target reservoirs of polymer flooding, the reservoir physical parameters of polymer flooding blocks are quite different, there is a large difference in the extent of enhanced oil recovery between different polymer flooding well groups, and it is difficult to track development and adjust evaluation. In order to formulate adjustment standards for polymer flooding phases, it is necessary to formulate phase recovery rate standard curves for different types of polymer flooding well groups. This paper analyzes the dynamic and static data of the polymer flooding block to determine the sensitivity of each factor that affects the well group classification, and establishes the well group classification method using the gray correlation method and mathematical statistical analysis method; on this basis, the EnKF method is used to invert different well groups. Through the combination of EnKF method and polymer flooding numerical simulation technology, the physical parameters of flooding and the relative permeability curve are used to predict the development effect of different types of polymer flooding well groups, and the development effect standards of different types of polymer flooding well groups are given.

Key Words: Classification method of well group, Grey correlation method, EnKF, Enhanced oil recovery effect standard, Numerical simulation

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A New Method for Calculating the Characteristic Shape of the Water Ridge under Horizontal Production Wells in Marine Sandstone Heavy Oil Reservoirs with Bottom Water

The static and dynamic characteristics of a marine sandstone bottom water heavy oil reservoir are low structural amplitude, thin thickness, strong bottom water energy, high water cut rise speed, great differences in the water cut change law of wells, etc. It is difficult to accurately describe the sweep range and ridge shape of high water cut production wells, and further evaluate the distribution of the remaining oil and the feasibility of the adjustment wells. In this paper, the dynamic characteristics of the water ridge of horizontal production wells in marine sandstone bottom water heavy oil reservoirs are studied. Firstly, through physical simulation experiments, the overall morphological characteristics of the water ridge after the rise of bottom water and the changes after the influence of an interlayer when horizontal production wells and natural water driving are applied are discussed. Secondly, a new method for calculating the characteristic shape of the water ridge in the heavy oil reservoir with bottom water is derived. Use of this new method enables quick and accurate calculation of the three-dimensional shape of a water

ridge under horizontal production wells in reservoirs with or without interlayers. This new method also facilitates the ability to quantitatively obtain the water ridge sweep range of production wells in different high water cut periods, and further appraise the remaining oil distribution range and reserves, which provides important technical support for development adjustment and potential tapping of this kind of heavy oil reservoir with bottom water.

Keywords: heavy oil reservoir with bottom water, water ridge, interlayer, sweep radius, residual oil.

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Simulation of Filtration Fields with Different Completion Methods

in Carbonate Gas Reservoirs

The Longwangmiao Fm gas reservoirs in the Moxi tectonic structure in Sichuan basin are featured by deep buried, high temperature, high pressure, huge thickness, high acidic gas and high production rate. The perforating and slotted liner completion are usually applied to this area, and the filtration models of reservoir near wellbore were established by finite element method, on the basis of model hypothesis. The reservoir filtration fields of pressure and flow velocity were analyzed, and the influence of skin by perforation on filtration fields was also debated. The simulation model results showed that the pressure cone of depression were presented under the two completions, which means from the pressure of supply boundary to wellbore pressure, and the pressure cone of depression under the perforation was more noticeable than that of slotted liner. The gas flow velocity of the perforation hole is higher than that of slotted liner opening. The two gas wells with different completions were exemplified, which had the homologous physical property. Through stimulated by the same acidizing technique, the testing production of gas well with perforation is higher than that of the gas well with slotted liner completion, which was accordant with the simulation model results. The filtration models of near wellbore established by finite element method were helpful to the selection of completion type, which could provide the theory criterion.

Key words: Sichuan Basin, Longwangmiao zone reservoir, completion method, finite element method, filtration field, stimulation

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Experimental Research on Cyclone Air Flotation Separator in Wastewater Containing Polymer

It is difficult to separate oil and water from the produced liquid in polymer injection oilfield. According to the water quality characteristics of the polymer-containing sewage, an improved cyclone air flotation separation device was designed and tested in an oilfield treatment station to investigate the sewage treatment volume and return flow. The effect of ratio, split ratio and bubble size on the air floatation cyclone was studied. The results showed that under the conditions that the sewage treatment volume of polymer-containing sewage was $7 \text{ m}^3 \cdot \text{h}^{-1}$, the reflux ratio and the split ratio were 20% and 11%, respectively, and the bubble size was large, the oil content of the sewage after treatment decreased from $500.6 \text{ m}^3 \cdot \text{h}^{-1}$ to $45.75 \text{ m}^3 \cdot \text{h}^{-1}$, and the suspended solids content dropped from $601.7 \text{ m}^3 \cdot \text{h}^{-1}$ to $206.1 \text{ m}^3 \cdot \text{h}^{-1}$. Finally, outlets could fit the requirements for entering the filtration process.

Keywords: air floatation swirl; sewage treatment; oil content; integration

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Identification of Natural Gas Components by Using Support Vector Machine Model

Gas component identification is of great significance in natural gas measurement which determines natural gas flow. In thermal measurement of natural gas, accurate acquisition of its components is important. The thermal measurement principle is the hot point of current research and development trend of natural gas measurement technology. Therefore, a method based on principal component analysis is proposed in this study. Data dimensionality reduction and pre-classification were carried out effectively to eliminate the partial correlation between samples by analyzing the physical parameters of the target natural gas and retaining the most information of the data. New samples are used as the input of support vector machine to reduce the input of the network and ensure the recognition efficiency. The method can accurately classify the existing types of natural gas and provide reliable data for thermal metering of natural gas.

Keywords: Natural Gas Components; SVM Model; Principal Component Analysis; Thermal Metering

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A Research on Influencing Factors of Weak Alkali Surfactant Polymer Flooding System

After 43 years of water drive development, DG oilfield is in the stage of high recovery and ultra-high water cut. At present, enhanced oil recovery (EOR) by water flooding is small, and the foundation of stable production in DG

oilfield is weak. To explore a new EOR mode, pilot tests from water flooding to weak alkali ASP (alkali/surfactant/polymer) flooding were conducted, and formulation systems of weak alkali ASP flooding were developed through laboratory experiments. The objective is to maintain the stability of the system under reservoir conditions. In this paper, we focus on the influencing factors such as sodium and potassium ions, calcium and magnesium ions, water quality, and shear action on a self-made weak base ASP system. The results show that: (1) The interfacial tension of self-made weak base ASP system can reach an ultra-low level of below 10^{-3} mN/m at different ion concentrations and at three different kinds of water quality, and the influence of sodium and magnesium ions on the system is slightly higher than that of potassium and calcium ions, respectively. (2) With cost consideration, it is recommended that self-made weak base ASP system should be diluted with clean water, and the calcium and magnesium ions should be removed before preparation. (3) Pore throat of $95 \times 10^{-3} \mu\text{m}^2$ permeability has little effect on the molecular weight and viscosity of the system after shearing.

Keywords: Ultra-high water cut, Weak ASP flooding, Enhanced oil recovery, Influencing factors.