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Рациональное использование энергии перепада давления природного газа

В рамках энергосберегающей политики ПАО «Газпром» о повышении энергетической эффективности дочерних обществ и организаций на основе применения инновационных технологий и энергетического оборудования была рассмотрена целесообразность замены дросселирующих устройств, используемых для подготовки газа низкого давления (топливного, пускового) для собственных нужд установок подготовки газа к транспорту на детандерный агрегат. Предложенный способ подготовки топливного газа позволит выработать дополнительное количество экологически чистой, «зеленой» энергии, тем самым сократить эксплуатационные затраты и повысить энергетический КПД всей установки. В работе представлен сравнительный анализ изоэнтальпийного и изоэнтропийного расширения газа с использованием различных устройств. Представленные модели расширения газа выполнены в специализированном программном обеспечении по моделированию химико-технологических систем HYSYS (AspenTech) и позволяют дать количественную оценку энергии перепада давления.

Ключевые слова: природный газ, регулятор давления, эффект Джоуля — Томпсона, изоэнтропийное расширение, энергосбережение.

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Rational Use of Natural Gas Differential Pressure Energy

As part of PJSC Gazprom's energy-saving policy of increasing energy efficiency of subsidiaries and organizations through the use of innovative technologies and energy equipment, the expediency of replacing throttling devices used for low pressure gas treatment (fuel, starting gas) for own needs of gas treatment units for transportation (GTP) with expander unit was considered. The proposed method of fuel gas preparation will make it possible to generate an additional amount of environmentally clean, "green" energy, thereby reducing operating costs and increasing the energy efficiency of the entire plant. The article presents a comparative analysis of the isoenthalpic and isoentropic gas expansion using different devices. The presented gas expansion models are performed in the specialized chemical engineering systems modeling software HYSYS (AspenTech) and allow to estimate the pressure drop energy.

Key words: *natural gas, pressure-control valve, Joule–Thomson effect, isentropic expansion, energy efficiency.*

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Процесс термополиконденсации и производство нефтяного пека

В статье рассмотрены способы получения нефтяного пека термополиконденсации. Основное внимание уделяется характеристикам нефтяного пека, его свойствам, сравнению его с каменноугольным пеком.

Описаны три перспективные технологии производства нефтяного пека: термополиконденсация крекинг-остатка, высокотемпературная термополиконденсация нефтяного сырья и термополиконденсация смолы пиролиза по двухстадийной схеме. Представлены способы получения нефтяного пека в лабораторных условиях, такие как термополиконденсация под давлением и термообработка при пониженном давлении. Подчеркнута актуальность и целесообразность разработок по созданию нефтяного пека и внедрению процессов термополиконденсации в России.
Ключевые слова: каменноугольный пек, нефтяной пек, термополиконденсация.

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Thermal Polycondensation Process and Oil Furnace Production

The article discusses the methods of obtaining petroleum pitch of thermal polycondensation. The main attention is paid to the characteristics of petroleum pitch, its properties, its comparison with coal-tar pitch, the advantages of petroleum pitch in comparison to coal-tar pitch, the processes of production of petroleum pitch by thermal polycondensation are given. Three promising technologies for the production of petroleum pitch have been identified: thermal polycondensation of cracking residue, high-temperature thermal polycondensation of petroleum feedstock and thermal polycondensation of pyrolysis resin according to a two-stage scheme. Methods of obtaining petroleum pitch in laboratory conditions, such as thermal polycondensation under pressure and heat treatment under reduced pressure, are presented. The urgency and feasibility of developments for the creation of petroleum pitch and the introduction of thermopoly-condensation processes in Russia is emphasized.
Key words: *coal tar pitch oil pitch, hydrocarbon composition, thermal polycondensation.*

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Сравнение результатов моделирования процесса ректификации нефтяных фракций с использованием реальных и псевдокомпонентов

Устойчивая работа нефтехимического предприятия и его установок, а также его эффективность во многом зависят от надежной и оптимальной работы технологического оборудования. Очень часто встречается, что комплексы технологического оборудования работают не в оптимальном режиме, несмотря на то что управляются современными системами автоматизированного управления. Если по какой-либо причине произойдет остановка оборудования, то никакие наилучшие технологии или управляющие ими системы не смогут восполнить экономические издержки и потери, которые возникают в случае простоя оборудования. Решением данной проблемы является создание компьютерных моделей, которые позволяют с единых позиций охватить технологическое оборудование и провести ряд необходимых экспериментов, не прибегая к действующему оборудованию. В работе произведен расчет и сравнение результатов компьютерного моделирования процесса разделения углеводородных смесей на базе реальных и псевдокомпонентов с использованием пакета программ CHEMCAD. Компьютерная модель блока

ректификации реализована при моделировании участка технологической схемы производства жидкого топлива установки гидрокрекинга вакуумного газойля.

Ключевые слова: ректификация, нефтепереработка, компьютерное моделирование, гидрокрекинг.

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Comparison the Results of the Efficiency of the Simulation the Rectification Processes Using Real and Pseudocomponents

Today the stable work of a petrochemical plant and its installations, as well as its efficiency, mostly depends on the reliable and optimal operation of technological equipment. It is very common that technological equipment complexes do not work in an optimal mode, despite the fact that they are controlled by modern automated control systems. If the equipment is stopped for any reason, then no best technology or management systems can compensate for the economic costs and losses that arise in the event of equipment downtime. The solution to this problem is to create computer models that allow you to cover the technological equipment from a single point of view and conduct a number of necessary experiments without resorting to existing equipment. The computer model of the rectification unit is implemented when modeling the section of the technological scheme for the production of liquid fuel of the vacuum gasoil hydrocracking unit.

Key words: *rectification, oil refining, computer modeling, hydrocracking.*

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Метод управления требованиями к эксплуатационным свойствам горюче-смазочных материалов

Предложен экономичный метод управления требованиями к уровню эксплуатационных свойств горюче-смазочных материалов (ГСМ), включающий установление требований (построение концептуальной и эмпирической моделей) и их количественное выражение через высокоинформативные показатели склонности ГСМ к превращениям, апробацию, спецификацию, реализацию, оценку эффективности и модификацию требований, обеспечивающий повышение эффективности жизненного цикла техники и применения ГСМ. Приведены примеры, иллюстрирующие отдельные положения нового метода применительно к свойствам моторных топлив и гидравлических жидкостей.

Ключевые слова: горюче-смазочные материалы, эксплуатационное свойство, химмотологический процесс, модель, прогнозирование.

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Method of Fuels and Lubricants Performance Properties Requirements Management

The cost-effective method of fuels and lubricants performance properties requirements management is proposed. Method ensures effectiveness enhancement of equipment and of fuels and lubricants life cycles; it includes

requirements establishment (constructing of conceptual and empirical models of requirements), their quantitative expression through highly informative indicators of fuels and lubricants propensity for transformations, then approbation with the use of laboratory, bench and test stands tests, specification, assessment of realization in real world equipment operational conditions, effectiveness evaluation and modification of requirements. Some illustrations of application of the new method phases with regards to motor fuels and hydraulic fluid are provided.
Key words: *fuels and lubricants, requirements management, performance property, engineering, chemmotological process, modeling, forecasting.*

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Кристаллизация и структурное застывание парафинов в растворителях различной природы

Исследованы температуры начала кристаллизации и застывания растворов нефтяных и синтетических парафинов разной концентрации в неполярных и слабо полярных углеводородных растворителях различных по составу и вязкости. Показано, что парафины, различные по происхождению и углеводородному составу, с близкими значениями температур плавления, имеют мало отличающиеся температуры кристаллизации и застывания в данном растворителе. Установлен температурный диапазон между температурами кристаллизации и застывания изученных растворов парафинов.
Ключевые слова: нефтяные парафины, синтетические н-алканы, температура плавления, углеводородные растворители, температуры кристаллизации и застывания.

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Crystallization and Structural Solidification of Paraffins in Various Solvents

The temperatures of the beginning of crystallization and solidification of solutions of petroleum and synthetic paraffins of different concentrations in nonpolar and weakly polar hydrocarbon solvents of different composition and viscosity are studied. It is shown that paraffins of different origin and hydrocarbon composition, with similar melting points, have slightly different crystallization temperatures and solidification in this solvent. The temperature range between the temperatures of the beginning of crystallization and solidification of the studied paraffin solutions is established.
Key words: *petroleum waxes, synthetic n-alkanes, melting points, hydrocarbon solvents, crystallization and solidification points.*

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Синтез и исследование физико-химических свойств и прочностных характеристик носителей на основе алюмосиликатных нанотрубок галлуазита для катализаторов гидропроцессов

Синтезированы носители на основе алюмосиликатных нанотрубок галлуазита с различным содержанием оксида алюминия для катализаторов гидропроцессов и исследованы их текстурные характеристики и кислотные свойства. Изучен компонентный состав и прочностные характеристики алюмосиликатных носителей в форме экструдатов цилиндрической формы и установлено влияние массового содержания бемита, используемого в качестве связующего, на физико-химические свойства материалов. Показано, что по параметру механической прочности на раздавливание характеристики синтезированных носителей на основе алюмосиликатных нанотрубок сопоставимы или превосходят таковые для промышленных аналогов.

Ключевые слова: галлуазит, бемит, носители катализаторов, гидропроцессы, механическая прочность.

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Synthesis and Investigation of Physicochemical Properties and Mechanical Strength of Natural Aluminosilicate Nanotubes Based Supports for Hydroprocesses Catalysts

Supports based on aluminosilicate halloysite nanotubes and alumina of different contents for hydroprocessing catalysts were synthesized and their textural characteristics and acidic properties were investigated. It was shown that the mechanical strength of the support pellets based on aluminosilicate nanotubes and alumina are comparable or superior to those for industrial analogs.

Key words: *halloysite, boehmite, supports, hydroprocesses, mechanical strength.*

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Исследование процесса смешения топлив при их последовательной перекачке по сборно-разборным трубопроводам

Рассмотрены вопросы оценки прогнозируемого объёма смеси, образующейся при последовательной перекачке топлив различных групп и марок по сборно-разборным трубопроводам. Представлена математическая модель процесса смешения топлив при их последовательной перекачке, основанная на Тейлоровской теории продольной диффузии в турбулентных потоках. Предложены аналитические зависимости для выражения вязкостно-температурных характеристик перекачиваемых топлив. Выполнена оценка объема смеси топлив при их последовательной перекачке по сборно-разборным трубопроводам.

Ключевые слова*:* сборно-разборные трубопроводы, последовательная перекачка топлив, эффективный коэффициент диффузии, смешение топлив, коэффициент гидравлического сопротивления, кинематическая вязкость топлив.

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Study of Mixture Formation Process During in Batching for Collapsible Pipelines

The issues of determination mixture volume during in batching for collapsible pipelines of different groups and brands fuels examined. The based on Taylor theory of longitudinal diffusion in turbulent flows a mathematical model of mixture formation process during in batching of fuels was approved. For the fuels viscosity-temperature characteristics analytical presentation proposed dependences. The fuels mixture volume during in batching for collapsible was simulating.

Key words: *collapsible pipelines, fuel batching in pipeline, virtual coefficient of diffusion, fuel mixture formation, Darcy friction factor, kinematic viscosity of fuels.*

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Оценка экономической эффективности применения попутного нефтяного газа для технологии GTL

Одной из основных проблем нефтедобычи остается высокий процент сжигания попутных нефтяных газов (ПНГ) и, соответственно, невысокий уровень их полезного использования. Кроме того с каждым годом растет объем затрат направленных на разработку технологий по снижению выбросов летучих органических соединений и оксида азота в атмосферу. На основе анализа существующей практики оценены экономические перспективы и сформулированы рекомендации по целевому использованию ПНГ, в том числе с целью сокращения выбросов загрязняющих веществ в атмосферу. Рассмотрены технологии уменьшения факельного сжигания, которые применимы на месторождениях трудноизвлекаемых нефтей.

Ключевые слова: попутный нефтяной газ, энергосбережение, переработка газа, жидкие углеводороды, продукция с высокой добавленной стоимостью.

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Evaluation of the Economic Efficiency of the Associated Petroleum Gas Application for the GTL Technology

The main problem still remains a rather low level of useful use of associated components of oil production and, consequently, a high percentage of combustion of associated hydrocarbon compounds. In addition, companies are increasing the amount of costs aimed at reducing volatile organic compounds and nitrogen oxide every year, which significantly reduces the productivity of equipment. Based on the analysis of existing practices, the economic prospects are evaluated and recommendations

for the targeted use of APG are formulated. The study briefly outlines technologies for reducing on-site flaring that are applicable in hard-to-recover oil fields. Information on technologies is collected and evaluated from a review of previous studies, technical documents, and analysis of open international sourcess.
Key words: *associated petroleum gas, GTL technology, energy saving, gas processing, liquid hydrocarbons, high value-added products.*

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Современное состояние разработок в области пластичных смазок

На основании анализа научно-технической и патентой литературы описаны основные направления в области разработки пластичных смазок: сверхщелочные кальциевые смазки для высоконагруженных узлов трения, исследование возможностей наноразмерных частиц как добавок к многофункциональным смазкам, получение низкотемпературных смазок на биоразлагаемых полиэфирных основах. Рассмотрены также особенности смазывания узлов трения электромобилей.
Ключевые слова: пластичные смазки, нанодобавки к смазкам, графен.

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Review of Recent Research on Grease

Based on the analysis of scientific, technical, and patent literature, the main directions of the development of greases are described: super-alkaline calcium greases for highly loaded friction units, research into the possibilities of nanosized particles as additives to multifunctional greases, and the production of low-temperature greases on biodegradable polyester bases.
Key words: *greases, nano-lubricants, graphene.*

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Dynamic Analysis Method Research and Application of Shale Gas Horizontal Well

As a rule, the production rate of a shale gas well is high at the initial stage and decreases within approximately one year of production. On the one hand, the rate of production of the horizontal shale gas well is obviously affected by the bottom hole liquid accumulation when even a cubic meter volume of accumulated liquid can lead to a complete cessation of gas production. On the other hand, the production rate is also sensitive to gas transmission pressure and the transmission mode. Due to the great difference in the gas production and percolation mechanism between a shale

gas reservoir and a conventional gas reservoir, the error of prediction of the gas flow pattern can be very high. Based on the modern shale gas dynamics, the method of multiple regression analysis is proposed to predict the average pressure drop gradient of a gas well, and the average error rate is 9.0%. The new method has the advantages of high efficiency and low cost. According to the actual production data fitting, the gas wells are divided into stable production and unstable production wells, depending on the average pressure drop gradient, which effectively reflects the implementation of a well drainage gas production technology.
Keywords: dynamic analysis; flow pattern plate; multiple regression analysis; horizontal shale gas well.

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Forecasting Oil Demand with the Development of Comprehensive Tourism

The prediction of oil demand is an important issue related to national energy security and economic development. With the COVID-19 outbreak, the international oil price fluctuates sharply, and oil consumption growth slows down. Therefore, accurate prediction of oil demand plays an important practical and theoretical role. In this paper, in accordance with the Chinese state policy of stimulation of domestic demand for energy resources, we have selected 15 major factors and analyzed their influence on the domestic oil demand from the perspective of comprehensive tourism analysis. Based on the data analysis of oil consumption from 2000 to 2018, four neural network methods are used to predict the influence of selected factors on oil consumption demand in China. The experimental results show that the best correlation is obtained between domestic tourism revenue and total tourism expenditure factors and oil demand, and the Layer Recurrent Neural Network method has high prediction accuracy, stronger stability, and the best performance.

Keywords: oil demand, forecasting, comprehensive tourism, recurrent neural network.

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Experimental Study on Synergistic Application of Temporary Plugging and Propping Technologies in SRV Fracturing of Gas Shales

This paper introduces a new technical idea of synergistic application of temporary plugging and propping technologies to SRV fracturing, consequently effectively improving the effective stimulated reservoir volume (ESRV) in gas shales under the existing fracturing conditions. Experimental studies on factors influencing the efficiency of plugging and removal in a temporary plugging zone, as well as the residual propped fracture conductivity have been carried out. The results show that the greater the mass ratio of the temporary plugging agent to the proppant, the higher is the efficiency of the temporary plugging zone in the process of plugging. However, it is recommended to use a low concentration of the temporary plugging agent since it is conducive to the fracture conductivity recovery of the temporary plugging zone. Thus, based on the plugging and removal efficiency evaluation in the temporary plugging zone and the formation damage rate, the weight combination formula has been developed to determine the optimal combination ratio of the temporary plugging agent with the proppant. The results show that when the optimal mass ratio of the temporary plugging agent to the proppant is 16%, the comprehensive performance values reach the maximum when the temporary plugging zone is composed of 40/70 or 70/140 mesh size proppant and 20/100 mesh size temporary plugging agent. The 16% mass ratio of the temporary plugging agent to the proppant is optimal, which can well meet the application requirements of the temporary plugging and propping technologies to SRV fracturing in gas shales.
Keywords: gas shales; SRV fracturing; temporary plugging agent; proppant; fracture conductivity.

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Research on Fracturing Well Selection and Layer Selection Method Based on Fine Numerical Simulation and Data Mining

Fracturing stimulation plays an important role in providing high and stable production and oil and water control in oil wells in the high water cut and extra-high water cut stages. To optimize the wellbore fracturing potential, it is necessary to study the influence of different factors on fracturing, based on the analysis of the remaining oil potential in the block. In this paper, the precise dynamic and static parameters affecting fracturing are obtained using a fine reservoir numerical simulation technology, which provides accurate and reliable parameter data for the well and layer selection method. Based on the data mining technology, the research of fracturing well selection method includes the correlation analysis of various factors affecting fracturing, cluster analysis between various factors, weight evaluation of each factor to the fracturing effect, determination of the range of optimum parameters, and the final analysis of the oil well fracturing potential. The application results show that the method has high accuracy and can play a guiding role in the application of oil well fracturing operations.
Keywords: fine numerical simulation; fractured well formation; data mining; Euclidean closeness.

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Modeling and Experimental Study of Self-Suspension Fracking Liquid Containing Nanoparticles

Self-suspension systems for fracturing technology has proved to provide great convenience when used in oilfield operation. However, most fracturing fluid systems contain mainly cationic surfactants, which can easily cause reservoir damage, solution residue, and poor temperature resistance. In the case of the cationic-surfactant fracturing system, the fluid sand carrying capacity is not high enough to change the formation pressure, and the failure of the self-suspension ability leads to a decline in well production capacity and other problems. In this paper, we have proposed an architecture model of a self-suspension solution containing nano-particles, including the model of nano-particle monolayer adsorption on the proppant surface and the three-dimensional network-structure model of nano-particle adsorption on micelles in the solution. The rheological properties, temperature resistance, viscoelasticity, sand-suspending capacity, gel-breaking properties, and core damage of the modified solution are tested and evaluated. The viscosity and temperature resistance, enhanced sand suspension, and sand-carrying capacity are verified by field application experiments. The results show that the modified fluid system has obvious advantages over traditional fracturing fluid systems and can eliminate the shortcomings of conventional fracturing. The proposed nanoparticle self-suspension solution technology helps to overcome construction difficulties and to reduce engineering costs and environmental pollution, as well as to increase production of the oil wells. The experimental validation results prove that the proposed fluid system can be successfully applied in complex oilfield formations.

Keywords: self-suspension fracturing fluid; nanoparticles; temperature resistance; self-crosslinking; proppant monomer; surface activity; thickener.

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Microdisplacement Mechanism of Polymer Flooding and Distributional Characteristics of Remaining Oil in Heavy-Oil Reservoirs

Most of the heavy-oil reservoirs in China belong to little fault blocks. These reservoirs are characterized by high heavy-oil viscosity, severe reservoir heterogeneity, and poor water-flooding development effect, resulting in low oil recovery and exploitation difficulties. Methods to enhance oil recovery are widely investigated both in China and abroad. They also provide an important approach to guarantee the energy supply in China. Modern physical experiments and simulation methods, such as laser confocal experiments and micro-displacement analysis, are used to study the micro-displacement mechanism of polymer flooding and the distributional characteristics of the remaining oil in heavy-oil reservoirs. The results show that polymer flooding can synergistically affect the reservoir and form a plug with the high viscosity heavy oil. High viscosity heavy oil has a better profile control effect and an expanding swept volume effect of displacement than that of thin oil. In the process of heavy oil polymer flooding, most of the remaining oil occurs in a surface-bound state in the pores of the formation, forming a laminar-film type on the surface. In-depth research on improving the physical properties of heavy oil and core wettability after the polymer flooding operations is important for further enhancing the recovery in the heavy-oil reservoirs.

Keywords: polymer flooding; oil-displacement mechanism; remaining oil distribution; heavy-oil reservoir; enhanced oil recovery.

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Characteristics of Preferential Flow Paths in Reservoirs after Polymer Flooding and an Adaptive Compound Flooding Method

When a reservoir is subjected to long-term water and polymer flooding, the formed preferential flow paths are widely distributed in the formation, and the displacing fluid effect is reduced, thus leaving a large amount of remaining oil unexploited. To enhance the oil recovery efficiency after polymer flooding, it is important to provide effective methods to block the preferential flow paths. The statistical data analysis results of 20 wells after polymer flooding in the Daqing oilfield show that the remaining oil and the preferential flow paths are mainly distributed vertically in the sedimentation units named PI2 and PI3, and the physical plugging and traditional adjusting techniques are not effective. Considering the above, an adaptive compound flooding method is put forward, which is based on the idea of "plugging, adjusting, and flooding. Laboratory experiment results show that the enhanced oil recovery (EOR) of the new polymer flooding method is 13.6%, which is 4.9% higher than that of alkaline/surfactant/polymer (ASP) flooding. The polymer consumption of the new method is more than 10% lower than that of conventional polymer flooding.

Keywords: after polymer flooding; interface performance; preferential flow paths; adaptive compound flooding; enhanced oil recovery.

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Fracture Trajectory Simulation of Steering Fracturing Based on Three-Field Coupling Stress

Steering fracturing is the key technology applied to stimulate and enhance oil recovery in tight sandstone reservoirs. In this paper, based on the integration of theoretical background of the porous media fluid mechanics, rock mechanics, and thermodynamics, a heat-fluid-solid three-field coupling stress model is established to simulate the steering fracturing, considering the adjacent well production and rock deformation. To solve the coupling flow equations and coupling temperature field equations, the finite difference method is adopted, while the finite element method is applied to solve the rock deformation equations and provide an explicit alternative approach to the whole model. The model is used to predict stress variations during production/injection processes and multistage artificial fracturing based on the heat-fluid-solid three-field coupling effect. The impact of multiple-field induced stresses on

steering fracturing in wells containing vertical fractures can be quantitatively analyzed and simulated accordingly. Finally, a case study is performed to verify the model according to the characteristics of fiber steering fracturing, failure pressure distribution around the well-bore, characteristics analysis of G-function, and interpretation results of microseismic monitoring.

Keywords: three-field coupling; production and injection; induced stress; horizontal principal stress; steering fracturing; fracture trajectory.

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Mechanism of Imbibition in Shale Pores Based on Imbibition Nuclear Magnetic Experiment and LBM Method

The spontaneous imbibition of fracturing fluid in the shale matrix is one of the main reasons for the low hydraulic fracturing flowback rate. The distribution characteristics of fracturing fluid in the shale spontaneous imbibition process are studied by the low-field nuclear magnetic resonance (NMR) method. An improved pseudo-potential lattice Boltzmann model is proposed to simulate the spontaneous imbibition behavior in a three-dimensional porous shale structure. The results show that the viscosity, sample length, and permeability of the imbibition solution have an important influence on the imbibition characteristics of the samples. In the imbibition process based on the SC-LBM model, due to the capillary force effect, the imbibition liquid preferentially enters the larger pores of the wetting phase and then gradually distributes in the adjacent pores.

Keywords: spontaneous imbibition; nuclear magnetic resonance; shale; hydraulic fracturing.

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Research on The Exploration of Petrochemical Virtual Simulation Laboratory Construction Based on VR Technology

With the advancement of science and technology, petrochemical experiments have become increasingly complex, potentially dangerous, costly, and can cause safety hazards. The virtual experimental technique using VR technology enables researchers to simulate the experiment process in a modeled environment. The obtained initial experimental results can provide a process background for subsequent real-life experiments. In this paper, the authors have systematically expounded the overall approach and framework of VR technology in the design of petrochemical virtual simulation experiments. The new VR technology method is designed to meet the

diversified needs of professional experimental researchers, including the main experiment objectives, the design of the system function modules, and overall planning and layout. The efficient VR technology experiment reduces safety risks and provides a useful reference for upgrading and transformation of conventional petrochemical laboratories.

Keywords: VR technology; petrochemical industry; virtual simulation; laboratory design.

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Experimental Study on Areal Flowing During Depletion
of a High-Pressure Heterogeneous Gas Reservoir

Experiments to characterize the constant-rate gas depleted production behavior in core samples were performed to study the areal gas flowing mechanism of a high-pressure low-permeability heterogeneous gas reservoir, including a newly designed long-core experiment on areal heterogeneity constant-rate gas depleted production considering fracturing. In the experiments, the fluid pressure increased up to 45 MPa, and the cores of the near-wellbore high permeability area before and after fracturing and the cores of the low permeability non-fractured area were connected in series to simulate the gas flowing process of the dual-area composite gas reservoir. When the irreducible water saturation is considered, the gas permeability in a high permeability area after fracturing increased threefold. Experimental results indicated that the pressure difference in the near-wellbore high permeability area decreased rapidly after fracturing and increased in the low permeability area. The recovery factor of each area increased after fracturing. Fracturing could have a significant effect on increasing the recovery factor when the average permeability is relatively low. The greater the gas rate, the higher is the built-up pressure after shut-in. Fracturing in the near-wellbore area may cause a significant decrease in the shut-in built-up pressure value.

Keywords: areal flow, low permeability, high-heterogeneity reservoir, gas production depletion.

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Water Cone Dynamic Prediction of Bottom Water Reservoir
Considering Oil-Water Interface Dynamic Change

The usual numerical simulation of the oil-water two-phase water cone is difficult to popularize because of its complicated method and the large amount of calculations and data involved. Based on the assumption that oil is supplied horizontally at the outer radius of the oil zone, some simplified water cone calculation methods ignoring the lifting process of the oil-water interface have been proposed. These are not in line with the actual conditions in the oilfield. Therefore, to overcome the shortcomings of the previously developed calculation methods, this paper

provides a quick and simple calculation method, which takes into account the influence of liquidity ratio, reservoir heterogeneity, degree of drilling, fluid production rate, and well spacing. In the framework of the new prediction method, the initial limit production, water breakthrough time, water rising content, anhydrous recovery, and final recovery characteristics are calculated. The results can be used to study the effect of various factors such as flow ratio and drilling degree on the development effectiveness of bottom water reservoirs and to select the best development plan for bottom water reservoirs.
Keywords: water cone; bottom water reservoirs; initial limit yield; well spacing; water breakthrough.