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Р. З. Сафиева^{1,3}, А. В. Ставицкая¹, Э. О. Сафиева², Т. Н. Александрова³

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Новые приемы снижения содержания серы в нефтяном коксе

Работа посвящена поиску новых эффективных методов снижения содержания серы в сыром нефтяном коксе. Показано, что под действием реакционноспособной промежуточной частицы дихлоркарбена (или хлоркарбена), получаемой в условиях межфазного катализа из хлороформа (или хлористого метилена) и гидроокиси натрия, происходит разрушение C–S-связей ряда индивидуальных серосодержащих соединений с образованием продуктов реакций, идентифицированных классическими методами. Проведена серия опытов с использованием сырого нефтяного кокса, характеризующегося высоким содержанием серы (4,3%), в условиях межфазного катализа и показано, что при оптимизации условий (интенсификация массообмена с применением катализатора межфазного переноса и/или ультразвука) возможно снижение содержания серы в исходном коксе до 2%.

Ключевые слова: нефтяной кокс, межфазный перенос, дихлоркарбен, ультразвук, снижение содержания серы.

R. Z. Safieva, A. V. Stavitskaya, E. O. Safieva, and T. N. Aleksandrova.

New Methods of Reducing Sulfur Content in Petroleum Coke

The objective of this work was to find new efficient methods of reducing sulfur content in crude petroleum coke. It is demonstrated that action of reactive intermediate particles of dichlorocarbene or chlorocarbene produced from chloroform or methylene chloride under interphase catalysis conditions and sodium peroxide causes breakdown of the C–S bonds of some individual sulfur compounds with formation of reaction products identifiable by classical methods. Further, a series of experiments were conducted using crude petroleum coke having high sulfur content (4.3%) under interphase catalysis conditions and it was found that under optimized conditions (intensification of mass transfer using interphase transfer catalysis and/or ultrasound) the sulfur content in the original coke can be reduced to 2% level, which comprises more than 50% of the initial content.

Key words: petroleum coke, dichlorocarbene, chlorocarbene, methylene chloride, interphase transfer, interphase catalysis, ultrasound, reducing sulfur content.

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Процесс получения высокооктановых компонентов моторных топлив из прямогонных бензинов на модифицированных цеолитных катализаторах

Исследовано влияние добавок микро- и наноразмерных порошков диоксида церия на кислотные и каталитические свойства высококремнеземного цеолита типа MFI в процессе получения высокооктановых компонентов моторных топлив из прямогонных бензинов газового конденсата. Введение модифицирующих добавок в исходный цеолит позволяет увеличить его каталитическую активность и концентрацию

кислотных центров. Введение 1% мас. промотирующей добавки наноразмерного порошка диоксида церия в цеолит позволяет увеличить выход аренов в жидком катализате на 4–7% мас., а ОЧ получаемого жидкого катализата — на 2–3 пункта по ИМ. Показано, что цеолит, модифицированный микроразмерным порошком CeO_2 , обладает похожими каталитическими и кислотными свойствами по сравнению с цеолитом, модифицированным наноразмерным порошком диоксида церия.

Ключевые слова: прямогонный бензин, газовый конденсат, высокооктановые компоненты, цеолит MFI, ароматические углеводороды.

I. S. Khomyakov, A. M. Gorshkov, and T. A. Gerasina.

Process of Producing High-Octane Motor Fuel Components from Straight-Run Gasolines on Modified Zeolite Catalysts

The effect of micro- and nano-sized CeO_2 powder additives on acidic and catalytic properties of MFI (modernite-framework-inverted) type of high-silicon zeolite in the process of production of high-octane motor fuel components from straight-run gasolines of gas condensate is studied. Addition of modifying agents to the original zeolite promotes its catalytic activity and concentration of acid centers. Addition of 1 wt. % of promoting additives of nano-sized CeO_2 powder to zeolite enhances yield of arenes in the liquid catalyzate by 4-7 wt. % and octane number (ON) of the obtained catalyzate by 2-3 points in terms of RON. It is shown that zeolite modified by micro-sized CeO_2 powder possesses similar catalytic and acidic properties as does zeolite modified by nano-sized CeO_2 powder.

Key words: *straight-run gasoline, gas condensate, high-octane components, zeolite, MFI, aromatic hydrocarbons.*

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Влияние структуры дисперсной системы тяжелой нефти на ее реологические свойства в условиях паротеплового воздействия

Установлены особенности строения и состава углеводородных дисперсных систем в различных типах тяжелых нефтей после паротеплового воздействия, в том числе с использованием легкокипящих углеводородов. Разработаны методологические подходы для определения стабильности тяжелых углеводородных ресурсов в зависимости от состава и строения их дисперсных систем. На основе теоретических представлений о нефтяных дисперсных системах количественно охарактеризован их состав. Отличительной особенностью нефтей, обладающих низкой вязкостью, является более высокая степень сродства компонентов сольватной оболочки и дисперсионной среды. В результате дисперсионная среда в большей степени участвует в структурировании нефтяной дисперсной системы, что приводит к уменьшению степени дисперсности системы и снижению ее вязкости.

Ключевые слова: нефтяная дисперсная система, тяжелая нефть, акватермолиз, групповой состав нефти, ИК-спектроскопия, энергия активации вязкого течения.

I. M. Zaidullin, G. R. Valieva, A. Kh. Aliev, A. I. Lakhova, A. V. Vakhin, and S. M. Petrov.

Influence of the Structure of Heavy Oil Disperse System on Its Rheological Properties under Steam-Heat Impact Conditions

The distinctive features of the structure and composition of hydrocarbon disperse systems in various types of heavy oils after steam and heat treatment, including use of low-boiling hydrocarbons, are determined. Methodological approaches are developed to determine the stability of heavy hydrocarbon resources as a function of composition and structure of the hydrocarbon disperse systems. Based on theoretical concepts of oil disperse systems, the composition of the latter is characterized quantitatively. A notable feature of low-viscosity oils is greater affinity of the components of the solvate shell and the dispersion medium. As a result, the dispersion medium participates in cross-linking of the oil disperse system significantly, which leads to a decrease in dispersity of the system and in its viscosity.

Key words: *oil disperse system, heavy oil, aquathermolysis, oil group composition, IR spectroscopy, viscous flow activation energy.*

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Исследование процессов закоксовывания и регенерации алюмо-никельмолибденового катализатора гидроочистки, сульфидированного трет-бутилполисульфидом и диметилдисульфидом

Рассмотрены результаты исследования процессов закоксовывания и регенерации катализатора гидроочистки, активированного разными сульфидирующими агентами. Описаны методики активации катализатора в каталитической установке высокого давления трет-бутилполисульфидом и диметилдисульфидом. Произведены расчеты энергии активации реакции регенерации катализатора воздухом при различных скоростях нагрева на основе данных дифференциальной сканирующей калориметрии методом Киссинджера — Акахиры — Сёнэйс (KAS)

Ключевые слова: катализатор гидроочистки, обессеривание, сульфидирование, сульфидирующей агент, трет-бутилполисульфид, диметилдисульфид, закоксовывание, каталитическая установка.

E. S. Burdakova and V. V. Petrov

Study of Processes of Coking and Regeneration of Al-Ni-Mo Hydrofining Catalyst Sulfidized by Tert-Butyl Polysulfide and Dimethyl Disulfide

The results of study of processes of coking and regeneration of hydrofining catalyst activated by various sulfidizing agents are analyzed. The procedures for activating catalyst in a high-pressure catalysis unit by tert-butyl polysulfide and dimethyl disulfide are described. The activation energy of the reaction of catalyst regeneration by oxygen is calculated for different heating rates, based on differential scanning calorimetric data.

Key words: *hydrofining catalyst, desulfurization, sulfidizing, sulfidizing agent, tert-butyl polysulfide, dimethyl disulfide, coking, catalysis unit.*

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Разработка технологии получения новых беззольных полимерных присадок — имидапроизводных янтарной кислоты

Разработана технология получения сукцинимидных присадок, обладающих моюще-диспергирующими и антикоррозионными свойствами, применяемых в составе смазочных масел для уменьшения образования углеродистых отложений на деталях двигателей внутреннего сгорания. Синтезированы новые алкиленамидосукцинимиды на основе N,N1-бис(β-этиламино)пиперазина и отхода производства терефталевой кислоты. Испытания показали, что новые присадки соответствуют техническим требованиям к сукцинимидным присадкам.

Ключевые слова: имид янтарной кислоты, алкиленсукцинимиды, полиальфаолефины, полимерная присадка, масла, терефталевые кислоты, полиамины.

R. N. Zagidullin, V. A. Idrisova, and S. N. Zagidullin.

Development of a Technology for Producing New Ashless Polymer Additives

Like Imido Derivatives of Succinic Acid

A technology has been developed to produce succinimide additives possessing deterging-dispersing and anticorrosion properties, which are usable in lubricating oils for reducing carbonaceous deposit formation on internal combustion engine parts. New alkylene imido succinimides based on N,N¹-bis(b-aminoethyl)piperazine and terephthalic acid production waste are synthesized. Tests showed that the new additives meet the technical specifications for succinimide additives.

Key words: succinimide, alkylene succinimides, polyalphaolefines, polymer additive, oils, terephthalic acids, polyamines.

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Влияние структурной специфичности синтетических масел на базе эфиров вицинальных дикарбоновых кислот на их термоокислительную стабильность

Синтезированы сложные эфиры вицинальных дикарбоновых кислот и показано, что специфичность их структуры играет важную роль. Изучена термоокислительная стабильность сложных эфиров вицинальных дикарбоновых кислот. Методом ИК-спектроскопии выявлено, что окисление протекает по связи C–H третичного атома углерода. Установлено, что связь C=C алкенов не участвует в процессе окисления.

Ключевые слова: вицинальные эфиры, антиокислительные свойства, третичный атом, термоокислительная стабильность, ИК-спектроскопия.

M. A. Mammadyarov, F. Kh. Aliyeva, S. F. Akhmedbekova, and N. A. Javadova

Influence of Structural Specificity of Synthetic Oils Based on Vicinal Dicarboxylic Acid Esters on Their Thermooxidative Stability

Esters of vicinal dicarboxylic acids are synthesized and the specificity of their structure is studied. The thermooxidative stability of the vicinal dicarboxylic acid esters is estimated. It is established by IR spectroscopy that the oxidation proceeds along the C–H bond of a tertiary carbon atom, and C=C bond of alkenes does not participate in the oxidation process.

Key words: vicinal esters, antioxidative properties, tertiary atom, thermooxidative stability.

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Низкотемпературное окисление тяжелой нефти в карбонатной среде с ацетилацетонатом кобальта (III)

Представлены результаты лабораторных экспериментов по моделированию процессов окисления тяжелой нефти в воздушно-кислородной среде с использованием в качестве катализатора ацетилацетоната кобальта при температурах и давлениях, характерных для тепловых методов добычи. Установлено, что в воздушно-кислородной среде при температуре выше 250°C в присутствии катализатора протекают процессы деструкции высокомолекулярных компонентов тяжелой нефти с образованием легкокипящих углеводородных фракций и кислородсодержащих соединений, что приводит к снижению плотности и вязкости преобразованной нефти. Кроме того, в продуктах опытов увеличено содержание асфальтенов и наблюдается наличие тонкодисперсных углистых веществ, что свидетельствует о протекании не только процессов крекинга, но и уплотнения. Результаты проведенных исследований выявили основные направления протекания реакций и превращений углеводородных компонентов тяжелой нефти в исследуемых системах, которые обуславливают возможность использования ацетилацетоната кобальта в качестве катализатора в технологиях внутрискластового низкотемпературного окисления тяжелой нефти в карбонатных коллекторах.

Ключевые слова: термодеструкция, тяжелая нефть, ацетилацетонат кобальта, низкотемпературное окисление, крекинг, карбонатный коллектор.

S. M. Petrov, G. P. Kayukova, A. I. Lakhova, I. M. Zaidullin, D. A. Ibragimova, and N. Yu. Bashkirtseva.

Low-Temperature Oxidation of Heavy Oil in Carbonate Medium Using Cobalt (III) Acetylacetonate as Catalyst

The results of laboratory experiments on modeling of heavy oil oxidation processes in air-oxygen environment using cobalt (III) acetylacetonate as catalyst at temperatures and pressures typical for thermal production methods are presented. It is established that, in air-oxygen environment at temperatures above 250°C in the presence of the catalyst, processes of degradation of high-molecular components of the heavy oil occur with formation of low-boiling

hydrocarbon fractions and oxygen-bearing compounds, which reduces the density and viscosity of the transformed oil. Also, the products obtained in the experiments show increased asphaltene content and presence of finely dispersed carbonaceous substances, which indicates occurrence not only of cracking, but also of condensation processes. The experimental data indicate the main directions of reactions and transformations of heavy oil hydrocarbon components in the studied systems, which provides the possibility of use of cobalt acetylacetonate as a catalyst in technologies of in-situ low-temperature oxidation of heavy oil in carbonate reservoirs.

Key words: thermal degradation, heavy oil, cobalt acetylacetonate, low-temperature oxidation, cracking, carbonate reservoir.

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Трансформация состава подвижных углеводородов доманиковых отложений Волго-Уральской нефтегазоносной провинции при термическом воздействии

Установлены закономерности преобразования состава подвижных углеводородов образца породы доманиковых отложений Волго-уральской НГП. Проведен анализ ИК-спектров экстрактов, выделенных из породы после термического воздействия при различной температуре, а также смол и асфальтенов. Ароматичность асфальтенов экстремально возрастает с максимумом при температуре 250°C за счет протекания реакций деструкции алифатических заместителей и конденсации ароматических колец в условиях рекомбинации радикалов, что коррелирует с результатами группового анализа, по данным которого при этой температуре наблюдается и наибольшее содержание асфальтенов. Трансформация состава подвижных углеводородов связана с процессами перестройки состава и структуры нерастворимого органического вещества — керогена. Степень зрелости органического вещества доманиковых отложений, характеризующегося невысокой зрелостью, закономерно увеличивается с повышением температуры и достигает максимума при 350°C.

Ключевые слова: доманиковые продуктивные отложения, органическое вещество, кероген, битумоид, термическое воздействие, групповой анализ.

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Transformation of Composition of Mobile Hydrocarbons of Domanik Deposits of Volga-Ural Oil- and Gas-Bearing Province under Thermal Action

The mechanisms of transformation of the composition of mobile hydrocarbons of the rock sample from the Domanik deposits of the Volga-Ural oil- and gas-bearing province (OGP) are established. An analysis has been made of the IR spectra of extracts obtained from the rock after thermal action at different temperatures as well as of resins and asphaltenes. The aromaticity of the asphaltenes increases extremally with a maximum at 250°C due to reactions of degradation of the aliphatic substituents and condensation of the aromatic rings under conditions of recombination of radicals, which correlates with the group analysis results, according to the data of which at this temperature maximum asphaltene content is observed. Transformation of the composition of mobile hydrocarbons is associated

with processes of transformation of the composition and structure of the insoluble organic matter kerogen. The degree of maturity of the organic matter of the Domanik deposits, characterized by low maturity, increases steadily with rise of temperature and reaches the maximum at 350°C.

Key words: Domanik producing deposits, organic matter, kerogen, bitumoid, thermal action, group analysis.

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Research on a Novel Viscoelastic Surfactant-Based Self-Diverting Acid System in Carbonate Acidizing

To enhance reaction retardation and improve conventional viscoelastic self-diverting acid (VDA) systems, a novel VDA system with addition of a cosurfactant, namely, sodium dodecyl benzene sulfonate (SDBS), is studied. The new system viscosifies at about 0.6 pH and attains a viscosity of about 500 mPa·sec. Without addition of SDBS the system viscosifies at 2.2 pH and reaches the final viscosity of 403 mPa·sec. Study of the kinetics of limestone-acid reaction showed that the reaction rate fell from $1.37 \cdot 10^{-4}$ mol/(cm²·sec) for 20 wt. % of HCl solution to $13.2 \cdot 10^{-6}$ and $6.5 \cdot 10^{-6}$ mol/(cm²·sec) for VDA solution without and with addition of SDBS, respectively. The reaction rate constants (k) for negative sample control, VDA system I, and VDA system II were $1.0740 \cdot 10^{-1}$ (mol/cm³)^(-0.3092) (cm/sec), $5.5221 \cdot 10^{-4}$ (mol/cm³)^{0.2822}·(cm/sec), and $6.3154 \cdot 10^{-5}$ (mol/cm³)^{0.5554} (cm/sec), respectively. The dual-core flow test showed that wormholes were produced in both cores for VDA systems rather than a large single channel in high-permeability core when 20 wt. % of HCl solution is used. Thus, a smaller volume of SDBS is needed for formation of flows when VDA solution is added. The study revealed that the new VDA system retards reaction considerably, improves acid diversion, and has a tremendous potential for field applications.

Key words: acidizing, VDA system, viscoelastic surfactant, self-diverting acid, cosurfactant, SDBS, dual-core flooding.

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О регенерации использованных нефтепродуктов

Обобщены известные технические решения регенерации отработанных топлив и масел. Исследованы новый экстрагент на основе ортофосфорной кислоты и предложенный способ экстракционной очистки (рафинирования) отработанных промышленных масел и дизельного топлива. Предложены технологическая схема и лабораторно-опытный регламент процесса рафинирования (осветления) отработанных нефтепродуктов (отходов) в качестве углеводородного сырья.

Ключевые слова: экстрагент, ортофосфорная кислота, отработанные промышленные масла, дизельное топливо, диспергирование, степень очистки масляных остатков.

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Regeneration of Used Petroleum Products

The known technical solutions for regeneration of used fuels and oils are generalized. A new extractant based on orthophosphoric acid is studied and a method for extractive cleaning (refining) of waste industrial oils and diesel fuel is proposed. A technological scheme and a laboratory experimental procedure of refining (clarifying) waste petroleum products as a hydrocarbon stock are proposed.

Key words: *extractant, orthophosphoric acid, waste industrial oils, diesel fuel, dispersion, degree of oil residue cleaning.*

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Метод оценки адгезионных свойств смазок

Представлен новый метод количественной оценки адгезионных свойств смазок и их дисперсионных сред, основанный на определении сил сцепления между смазкой и металлической поверхностью, а также между элементами структурного каркаса смазки при разрушающем действии центробежной силы. Представлены результаты исследования влияния типа базового масла и природы загустителя на адгезионные свойства смазок.

Ключевые слова: *смазка, адгезия, когезия, базовое масло, загуститель.*

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A Method for Appraising Adhesive Properties of Lubricants

A new method of quantitative appraisal of adhesive properties of lubricants and their dispersion media, which is based on determination of the forces of adherence between the lubricant and the metallic surface as well as between the elements of the structural framework of the lubricant under destructive impact of centrifugal force, is described. The results of investigation on the influence of the base oil type and the nature of the thickener on the adhesive properties of the lubricants are reported.

Key words: *lubricant, adhesion, cohesion, base oil, thickener.*

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Application of Artificial Fish Swarm Algorithm in Solving Multiobjective Trajectory Optimization

The drilling field faces many problems relating to complex designing and multiobjective optimization. Solution of these problems is also an important and complex part of well trajectory designing, optimization, and control. Scientists have developed for this purpose a multitude of algorithms, which, however, suffer from certain deficiencies. Let us take the shortest total length of the borehole, the highest target shooting accuracy, the lowest cost, and the

minimum friction as the multiobjective function and use the fish swarm algorithm to optimize the trajectory. In this work, we have introduced the idea of nondominant relation to flaws in the algorithm and used the MATLAB optimization toolbox (software) to get all numerical solutions that satisfy the constraints. It is, therefore, well adaptable for introducing the idea of nondominant sorting into multiobjective optimization problems based on fish swarm algorithm. The article gives an example of calculation and shows the accuracy and reliability of the algorithm and the calculation procedure. The algorithm has a simple structure, a small number of calculations, and good convergence.

Key words: *multiobjective optimization, artificial fish swarm, algorithm, well trajectory, sorting.*

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Limit Drainage Radius for Different Types of Well in Shale Reservoir

Unusually complex pore structure of shale reservoirs is responsible for their low porosity and permeability. Due to threshold pressure gradient, fluid seepage in low-permeability reservoirs does not obey Darcy law. Horizontal well drilling and fracturing are effective ways of developing low-permeability reservoirs because they increase well drainage area. In this work, mathematical models were derived based on the seepage theory. The pressure distribution and relationship between threshold pressure gradient and limit well spacing were obtained by using point-source function and Laplace transforms. The limit well spacing increases with decrease of threshold pressure gradient. This method has an important guiding importance for determining appropriate spacing between different types of well for shale gas development.

Key words: *shale gas, limit well spacing, threshold pressure gradient, volume fracturing, formation pressure.*

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A Numerical Model for Evaluating Well Kick with Lost Circulation During Managed Pressure Drilling

Managed pressure drilling (MPD) well control is an advanced technology to deal with gas kick problems. Unlike conventional well control methods (driller's and wait/weight methods), it utilizes a closed-loop drilling system with a series of wellhead equipment to quickly and precisely handle the kicks without shut-in procedure. Currently, researches on MPD well control are focused mostly on simple gas influx conditions, but less on common problems of killing a kick in the bottomhole when circulation loss occurs in the weak zone. Based on the fast-changing casing pressure method and the multiphase flow theory, a transient of MPD well control mathematical model was developed

for combining complete kick circulations with drilling mud loss in a single fracture. The finite difference method was used to iteratively solve this model. The calculated model values agreed well with the experimental results, which confirms reliability of the model. The casing pressure, casing shoe pressure, pit gain, outlet flow, and opening in the whole well control process were analyzed. The simulation results show that equality of flow out and flow in does not always imply influx stoppage when a kick is coupled with mud loss. In addition, the loss rate in the casing shoe with lapse of time initially increases linearly, decreases exponentially, and finally becomes steady. After completion of well control, drilling can be continued safely until the loss is negligible. This study may provide a theoretical basis for better control of wells with complex kick situations and circulation loss and improve the MPD well control method.

Key words: *managed pressure drilling, lost circulation, casing pressure, outflow, inflow, loss rate.*

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Research on Obstacle Performance of Downhole Tractor in Horizontal Well

Downhole tractor is a quick and efficient tool for transporting logging device, and its obstacle performance directly influences the tractor work quality and is very crucial for the study of obstacle overcoming process. The process of creating a more accurate obstacle-overcoming tractor model consists of the following: 1) study of obstacle-overcoming statics of downhole tractor, including the relationship between the motor driving force, tractor resistance, and obstacle height, and establishment of a static balance equation for the obstacle overcoming process; 2) dynamic analysis of the downhole tractor obstacle overcoming process, including D'Alembert dynamic equation systems for initial force and D'Alembert inertial moment, more detailed description of the downhole tractor obstacle overcoming process, and more accurate calculation of the driving force required by the downhole tractor. Downhole tractor prototype test data matched the data calculated by the analytical method, proving that the model obtained is applicable. Use of this dynamic model can enhance obstacle overcoming success ratio of the downhole tractor in a horizontal well and solve the technical problems of downhole obstacle overcoming.

Key words: *downhole tractor, static analysis of obstacle overcoming, dynamic analysis of obstacle overcoming, D'Alembert equation of obstacle overcoming, D'Alembert inertial moment.*

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A Simplified Pore Network Model to Analyze Flow Capacity and Remaining Oil Distribution Based on Computerized Tomography

Pore network can be used not only to describe the pore geometry inside the rock, but also to calculate various fluid flow properties on a micro scale. A simplified pore network model was developed based on a digital core extracted by

micro computerized tomography (m-CT). This study simplifies the pore structure into a lattice of cubes. The pore size, pore distribution, tunnel connectivity (pore networks), fluid viscosity, interfacial tension, and external driving pressure gradient are considered for each adjacent cube to evaluate the flow capacity of the pore network. Permeability, effective permeability, and sweep efficiency were calculated. The results show that the fluid flow initially starts in the largest tunnel, which corresponds to the threshold pressure of the rock sample. Permeability changes in a nonlinear pattern before all the tunnels are involved in flowing. The change in the dynamic microscopic residual oil distribution and oil sweep efficiency is visualized based on 3D location of each pore. Visualization shows that more oil will remain in underground formation with a greater heterogeneity and a higher oil viscosity.

Key words: *pore network model, nonlinear flow, distribution of remaining oil, computerized tomography.*

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Influence of Working Fluids on Coalbed Methane Desorption Capacity and Diffusibility

Gas migration includes desorption, diffusion, and seepage processes. Desorption and seepage are the key processes for coalbed methane extraction. Study of the influence of working fluids on coalbed methane desorption and diffusion capacity is important for developing coal beds. The influence of working fluids on coalbed methane desorption was studied using test samples from Qinshui Basin coal and employing an analytical-experimental equipment developed by us. The experimental results indicate that 0.5% microemulsion in the working fluid produces the maximum impact on coalbed methane desorption capacity, the desorption degree being 65%, and anionic surfactants, the minimum impact on coalbed methane desorption capacity. Invasion of working fluid into coalbed causes water blocking and solid particle plugging and thereby reduces desorption and diffusion process efficiency. It is advisable to avoid use of working fluid that is prone to cause great damage during fracturing operation for enhancing coalbed methane deliverability.

Key words: *coalbed methane, working fluid, desorption, diffusibility, coal cleat.*

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Micro-CT Scanning of Gas Hydrate Decomposition in Model Porous Media

The results of study of gas hydrate decomposition processes in model porous media are analyzed using Micro-CT Test System. The objects of the study were natural gas hydrates produced at specified pressure and temperature using porous media consisting of sand with three particle size ranges (0.85-1.18, 1.18-2.85, and 2.85-4.8 mm). The microstructural characteristics and the porosity of the obtained gas hydrates in the decomposition process were studied. Also studied was the dependence of the microstructural characteristics of the gas hydrates on the nature of the porous medium, based on which the hydrates were produced. The results indicate that the hydrate is distributed uniformly and fill the pores of the porous media almost completely.

Key words: *porous medium, natural gas hydrate, gas hydrate, micro-CT scanning, structural characteristics, decomposition. formation, deformation.*

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Numerical Simulation of Nitrogen Oxide Emission Characteristics on a Retrofitted Chain Grate Boiler

Raw coal is burned in furnaces or chain grate boilers. In this work, we studied the chamber combustion mechanism in a chain grate boiler (CGB) with a capacity of 20 tons/h. A mathematical model was built using Computational Fluid Dynamics (CFD) tool. It was found that chamber combustion with swirl burners instead of grate firing has a positive effect on NO emissions. NO emissions dropped from 700 ppm in case 5 to 250 ppm in case 1. The calculated and measured NO emissions agreed well, with a discrepancy of less than 15%, except on plane 2 for four calculated cases. For the temperature field, the discrepancy between the measured and simulated values was below 12% for the four cases. These discrepancies between calculated and measured results are acceptable. For designing and reconstructing CGBs, our research provides a good idea. The reconstruction method can be used for CGB instead of grate firing system for reducing NO emissions

Key words: chain grate boiler, pulverized coal combustion, CFD, industrial furnace, tangential firing, CGB.

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Numerical Simulation for Optimizing Injection-Production Parameters of Keeping Pressure–Thermal Process in Offshore Heavy Oil Field

To enhance oil recovery ratio, research was conducted using numerical simulation. In conformity with the results obtained by pilot testing of the referred field, which was carried out by polymer gel flooding and cyclic hot-fluid injection, this article reports the results of the research on optimization of injection-production parameters. Injection-production is a combined operation involving polymer gel flooding and hot-fluid injection, which is called, in short, keeping pressure–thermal process. The research results show that this process is influenced by a host of factors, such as hot fluid temperature, input speed, soak time in the reservoir, cyclic injection volume and cyclic soak time, polymer gel concentration, slug size, flooding time interval, production factor, etc. Based on the results, the importance of these parameters can be put in the following order: cyclic hydrothermal fluid injection time > production factor > cyclic hydrothermal fluid injection volume > soak time > hydrothermal fluid injection temperature > polymer concentration > slug size > polymer gel flooding time interval > hydrothermal fluid input speed.

Key words: heavy oil reservoir, cyclic hydrothermal fluid injection, polymer gel flooding, numerical simulation, parameter optimization.