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Некаталитические технологии переработки нефтяных остатков и тяжелых нефтей

Истощение извлекаемых запасов нефтяного сырья в мире требует квалифицированного подхода к проблеме переработки нефтяных остатков, доля которых возрастает с вовлечением в оборот высоковязких нефтей и природных битумов, обладающих высокой плотностью, вязкостью и низким выходом светлых фракций. Институт нефтехимпереработки традиционно с начала своего существования занимался разработкой проблемы некаталитической переработки тяжелого нефтяного сырья. В работе обобщены разработки Института нефтехимпереработки в этой области, выполненные в течение почти 20 лет, часть которых уже получила промышленное внедрение, а остальная часть подготовлена к внедрению.

Ключевые слова: нефтяные остатки, тяжелые нефти, вакуумная перегонка, битум, деасфальтизация, висбрекинг, замедленное коксование, термолиз, термический крекинг.
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Non-Catalytic Technologies for Processing Oil Residues and Heavy Oils

The depletion of recoverable reserves of crude oil in the world requires a qualified approach to the problem of processing oil residues, the share of which increases with the involvement in the turnover of high-viscosity oils and natural bitumen with high density, viscosity and low yield of light fractions. The Institute of Petrochemical Processing has traditionally been engaged in the development of the problem of non-catalytic processing of heavy oil raw materials since the beginning of its existence. The work summarizes the developments Institute of Petrochemical Processing in this field, carried out for almost 20 years, part of which it has already received industrial implementation, and the rest is ready for implementation.

Key words: *oil residues, heavy oils, vacuum distillation, bitumen, de-asphalting, visbreaking, delayed coking, thermolysis, thermal cracking.*

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Некоторые закономерности изменения свойств дизельных топлив
в условиях низких температур

Обоснованы требования к методу определения седиментационной устойчивости дизельного топлива в условиях отрицательных температур с использованием дифференциальной сканирующей калориметрии. Исследовано влияние скорости охлаждения дизельного топлива на процесс кристаллизации.

Ключевые слова: температура применения, предельная температура фильтруемости, дизельное топливо, дифференциальная сканирующая калориметрия, седиментационная устойчивость, фазовые переходы.

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Some Patterns of Changes in the Properties of Diesel Fuels Euro at Low Temperatures

The article presents method requirements justification for determining the sedimentation stability of diesel fuel at low temperatures with differential scanning calorimeter. The influence of the rate of diesel fuel cooling on the crystallization process was investigated.

Key words: *low temperature operability, cold filter plugging poin, cloud point, diesel fuel, differential scanning calorimeter, sedimentation stability, phase transitions.*

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Влияние компонентного состава нефтей
на их структурно-механические свойства

В работе исследованы нефти, относящиеся к парафинистым смолистым и высокосмолистым, а также малопарафинистым высокосмолистым, для которых определены групповой химический состав, вязкостно-температурные и структурно-механические свойства. По изотермическим кривым течения прямого и обратного хода, полученным при температурах 10, 0 и –10°С, рассчитаны величины внутренней энергии разрушения надмолекулярной структуры (W) нефтей. Установлено, что для всех нефтей при снижении температуры наблюдается возрастание W, что объясняется образованием пространственной кристаллической решетки парафиновых углеводородов в объеме нефти. Показано, что с увеличением значения суммарного содержания твердых парафиновых углеводородов и асфальтенов (П+А) и с уменьшением доли смол (С) степень структурированности нефтяной системы возрастает. Установлено, что при низких температурах для исследованных нефтей величина показателя (П+А)/С равная 0,4 является пороговой, выше которой нефть проявляет тиксотропные свойства, обусловленные структурированностью системы.

Ключевые слова: нефть, парафины, смолы, асфальтены, вязкостно-температурные свойства, структурно-механические свойства, энергия разрушения структуры.

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Influence of the component composition of oils on their structural-mechanical properties

In this work, various oils were studied, for which the group chemical composition, viscosity-temperature and structural-mechanical properties were determined. It has been established that these oils are paraffinic, resinous and highly resinous, as well as low paraffinic, highly resinous. For these crude oils, isothermal flow curves of the forward and reverse strokes were obtained at temperatures of 10, 0 and –10°C. The values of the internal energy of destruction of the supramolecular structure (W) of oils were calculated. It has been established that for all crude oils with decreasing temperature, an increase in W is observed. This is due to the formation of a spatial crystal lattice of paraffinic hydrocarbons in the volume of crude oil. It is shown that with an increase in the value of the total content of solid paraffinic hydrocarbons and asphaltenes (P+A) and a decrease in the proportion of resins (S), the degree of structuring of the crude oil system increases. It has been established that at low temperatures for the studied crude oils, the value of the index (P+A)/ S, equal to 0,4, is the threshold value above which the crude oil exhibits thixotropic properties due to the structuring of the system.
Key words: *crude oil, paraffins, resins, asphaltenes, viscosity-temperature properties, structural-mechanical properties, structure destruction energy.*

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Исследование состава и физико-химических свойств модифицирущей добавки
для лигносульфонатного бурового реагента

Исследован состав экспериментальной модифицирующей добавки к лигносульфонатному буровому реагенту методом высокоэффективной жидкостной хроматографии. Методом ИК-спектрометрии модифицирующей добавки обнаружены функциональные группы, соответствующие основному и промежуточному веществу. Экспериментально показана эффективность синтезированного модификатора и лигносульфонатного реагента регулировать параметры бурового глинистого раствора.
Ключевые слова: акриламид, лимонная кислота, синтезированный модификатор, лигносульфонат натрия, модифицированный лигносульфонатный реагент, поверхностное натяжение, буровой раствор.
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Investigation of the Composition and Physico-Chemical Properties
of a Modifying Additive for a Lignosulfonate Drilling

The composition of an experimental modifying additive to a lignosulfonate drilling reagent has been studied by high-performance liquid chromatography. The effectiveness of the synthesized modifier and lignosulfonate reagent to regulate the parameters of drilling mud has been experimentally shown.
Key words: *acrylamide, citric acid, synthesized modifier, sodium lignosulfonate, modified lignosulfonate reagent, surface tension, drilling mud, conditional viscosity.*

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Влияние желатина трески и альгината натрия на нуклеацию газовых гидратов

В данной работе изучено влияние смесей рыбного желатина из кожи атлантической трески (протеин) и альгината натрия из бурых водорослей (полисахарид) на нуклеацию метан-пропанового гидрата кубической структуры II. Для определения переохлаждения, требуемого для образования гидратов как из растворов индивидуальных полимеров, так и их смесей, использовался метод качающихся ячеек при охлаждении с постоянной скоростью. Показано, что альгинат натрия практически не влияет на образование газовых гидратов в отличие от желатина, ингибирующая активность которого приняла промежуточное значение между поливинилпирролидоном и поливинилкапролактамом (коммерческие кинетические ингибиторы образования гидратов). В случае смесей полимеров наблюдалось незначительное снижение эффективности при фиксированном содержании желатина по мере уменьшения концентрации альгината натрия. Полученные результаты свидетельствуют о наличии антагонизма кинетического ингибирования метан-пропанового гидрата смесями полиэлектролитов биологического происхождения. Безусловно, межмолекулярные взаимодействия в комплексах полисахарид-желатин в растворе оказывают влияние на способность полимеров замедлять процесс нуклеации. Более детальное исследование кинетики формирования гидрата в зависимости от соотношения полимеров в растворе позволит выявить механизм их влияния и предложить смесевые реагенты для контроля процесса гидратообразования.

Ключевые слова: газовые гидраты, нуклеация, кинетические ингибиторы гидратообразования, метан-пропановая смесь.

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Effect of Cod Gelatin and Sodium Alginate on Gas Hydrates Nucleation

This work studied the effect of mixtures of fish gelatin (protein) from Atlantic cod skin and sodium alginate (polysaccharide) from brown algae on the nucleation of sII methane-propane hydrate. The rocking cell method with ramp cooling was employed to determine the supercooling required for the hydrates formation from solutions of individual polymers and their mixtures. Unlike sodium alginate, which has practically no effect on the formation of gas hydrates, the gelatin inhibitory activity was intermediate between polyvinylpyrrolidone and polyvinyl caprolactam (commercial kinetic hydrate inhibitors). In the case of polymer blends, a slight decrease in the efficacy of gelatin at fixed content was observed as the sodium alginate concentration decreased. The results indicate the antagonism of the

kinetic inhibition of methane-propane hydrate by mixtures of biological polyelectrolytes. Undoubtedly, intermolecular interactions in polysaccharide-gelatin complexes in solution affect the ability of polymers to retard the nucleation process. A more detailed study of the kinetics of hydrate formation depending on the ratio of polymers in solution will make it possible to reveal the mechanism of their influence and to propose mixed reagents to control the hydrate formation.

Key words: *gas hydrates, nucleation, kinetic hydrate inhibitors, methane-propane mixture.*

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Оценка параметра растворимости Гильдебранда смеси растворителей нефтяного происхождения по их структурным элементам

Рассмотрены методические аспекты оценки параметра растворимости Гильдебранда смеси органических растворителей с использованием характеристик их структурных элементов. Предложена методика расчета параметра растворимости для смесей растворителей, отличающихся по составу и структуре в зависимости от соотношения компонентов. Результаты расчетов позволяют прогнозировать оптимальный состав смесей растворителей для полимеров с известным параметром растворимости Гильдебранда. Предложенная методика позволяет оценить параметр растворимости сложных смесей углеводородов нефтяного происхождения, например, вакуумного остатка дистилляции нефти — гудрона — при его использовании в качестве растворителя полимеров. По результатам анализа ЯМР ^{1}H определены структурные элементы гудрона и рассчитан его параметр растворимости Гильдебранда.

Ключевые слова: параметр растворимости, полимеры, смесь растворителей,
набухание полимеров, параметр растворимости гудрона.
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Estimation of the Hildebrand Solubility Parameter of a Mixture Solvents of Petroleum Origin from Their Structural Elements

The work is devoted to the methodological aspects of estimating the Hildebrand solubility parameter of a mixture of organic solvents using the characteristics of their structural elements. A method is proposed for calculating the solubility parameter for mixtures of solvents that differ in composition and structure depending on the ratio of components. The results of calculations make it possible to predict the optimal composition of solvent mixtures for polymers with a known Hildebrand solubility parameter. The proposed method makes it possible to estimate the solubility parameter of complex mixtures of hydrocarbons of petroleum origin, for example, the vacuum residue of oil

distillation - goudron, when it is used as a polymer solvent. Based on the results of ^1H NMR analysis, the structural elements of goudron were determined and its Hildebrand solubility parameter was calculatedn.
Key words: *solubility parameter, polymers, solvent mixture, polymer swelling, goudron solubility parameter.*

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Применение газовой хромато-масс-спектрометрии для определения содержания хлорорганических соединений в химических реагентах

Показаны возможности газовой хромато масс-спектрометрии для определения содержания хлорорганических соединений в химических реагентах. На основе анализа модельной смеси хлорорганических соединений были выбраны оптимальные условия работы хромато масс-спектрометра и оптимальный растворитель для проведения экстракции — изооктан. Для каждого индивидуального соединения были построены градуировочные кривые в режим мониторинга заданных ионов (SIM). В зависимости от физико-химических характеристик химического реагента предложены различные подходы к их пробоподготовке, основанные на разбавлении и/или экстракции. Для анализа химических реагентах, имеющих сильный углеводородный фон в режиме сканирования по полному ионному току, идентификация хлорорганических соединений и последующее количественное определение проводили по масс-фрагментограммам. Для оценки работоспособности методики проводилась оценка полноты экстракции путем добавления к рабочей пробе «маркера» и оценки результатов по значению степени извлечения.

Ключевые слова: химические реагенты, хлорорганические соединения, экстракция, мониторинг заданных ионов (SIM), газовая хромато-масс-спектрометрия.
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Application of Gas Chromatography-Mass Spectrometry to Determine the Organochlorine Compounds Content in Chemical Reagents

The possibilities of gas chromatography mass spectrometry for determining of organochlorine compounds content in chemical reagents are shown . The optimal operating conditions of the chromato mass spectrometer and the optimal solvent for extraction – isooctane were selected using the example of organochlorine compounds (model mixture analysis. Calibration curves were constructed for each individual organochlorine compound at selected ion monitoring (SIM) mode. Different approaches to sample preparation based on dilution and/or extraction are proposed depending on the physico-chemical characteristics of chemical reagents. For the analysis of chemical reagents having a strong hydrocarbon background in the full ion current scanning mode, the identification of organochlorine compounds and subsequent quantitative determination were carried out by using mass fragmentograms. To estimate the efficiency of the technique, the completeness of extraction was assessed by adding a so-called "marker" to the working sample and evaluating the results by the value of the extraction degree.

Key words: *chemical reagents, organochlorine compounds, extraction, selected ion monitoring (SIM), gas chromatography-mass spectrometry.*

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Гидроформилирование низших олефинов и применение продуктов оксосинтеза на основе альдегидов C_4–C_5 в производстве сложноэфирных смазочных масел. Часть I. Катализаторы и промышленные процессы

Представлен обзор научных и патентных данных, относящихся к гидроформилированию низших олефинов C_2–C_4 в процессах оксосинтеза кислородсодержащих продуктов. Рассмотрены промышленные и перспективные каталитические системы на основе металлоорганических соединений кобальта и родия, модифицированных фосфиновыми и фосфитными лигандами, а также реализованные в промышленности технологические схемы с участием таких каталитических систем.

Ключевые слова: гидроформилирование, оксосинтез, олефины C_2–C_4, кобальтовые и родиевые катализаторы.
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Hydroformylation of Low Molecular Olefins and Preparation of Oxosynthesis Products Based on C_4–C_5 Aldehydes in the Production of Ester Lubricating Oils. Part I. Catalysts and Industrial Processes

The data review of low molecular olefin C_2–C_4 hydroformylation as a key step of oxygenate compound oxosynthesis is presented. The industrial and perspective cobalt and rhodium organometallic catalytic systems modified with phosphine and phosphite ligands as well as the industrial technological schema of hydroformylation assisted with such a catalysts are demonstrated.

Key words: *hydroformylation, oxosynthesis, olefins C_2–C_4, cobalt and rhodium catalysts.*

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Epoxy Resin Water-Based Modification Method

Water-based epoxy resin emulsion was prepared by self-emulsification method, and the surface of the resin was modified by SiO_2. On this basis, a set of modification methods for epoxy resin waterification was formed. The epoxy resin cement slurry system was constructed, and the mechanism of water-based epoxy resin improving the mechanical and cementation properties of cement stone was revealed, that is, solidified film formation can improve the pore structure of hardened cement slurry, increase the impermeability of hardened cement slurry to a certain extent, and

effectively prevent the entry of external corrosive ions. The low temperature strength of resin cement slurry system develops fast – gas «penetration», strong channeling ability – gas «channeling», good toughness – sealing gas «can not go», good cementing quality – no pressure problems. This study lays a foundation for solving the problems of fracture propagation and corrosion faced by traditional cement cement and well integrity of deep gas wells and unconventional wells.

Keywords: *epoxy resin, cement, solidifiable, self-emulsification.*

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Study on Collapse Pressure Prediction of Fractured Strata

The Xujiahe Formation in western Sichuan has complex geological characteristics, fractures and fractures, and is prone to collapse in drilling. In this paper, the in-situ stress field around the wellbore, pore pressure, internal pressure in the wellbore and additional stress field generated by fluid flow are taken into account, and combined with the mechanical strength of rock in the target block, the in-situ stress parameters are calculated, the collapse pressure model of fractured formation is established, and the formation pressure profile of the well area is obtained, so as to predict the safe drilling fluid density window. The results show that the accuracy of the in-situ stress model is high, and the maximum error is 1.3%, which meets the engineering requirements. In the target block, the collapse pressure of Section 5 of Xinsheng 101 well and Section 5 – Section 3 of Xin601 well is high, reaching 1.8 g/cm^3, and the safe drilling fluid density is narrow. Therefore, the drilling fluid density should be carefully designed to ensure the stability of borehole wall and prevent the occurrence of borehole wall collapse caused by too low drilling fluid density.

Keywords: *fractured stratum, complex fracture, well wall collapse, collapse pressure prediction.*

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Study of Risk Matrix for Overflow-Backpressure-Based

Deepwater Managed Pressure Drilling

Overflow accidents are frequent in deepwater managed-pressure drilling, and the monitoring basis and control methods of risks are vague, necessitating the establishment of a suitable risk matrix. Based on the traditional risk matrix analysis method, this paper establishes a overflow-backpressure risk matrix with overflow size and backpressure threshold as judgment criteria, and formulates 11-level backpressure application plans and backpressure application calculation models. The results show that the overflow-backpressure risk matrix with

overflow size and backpressure threshold as judgment criteria meets the requirements of deepwater managed-pressure drilling design and can significantly determine the risk level of overflow occurrence. The formulated backpressure application calculation model refines the backpressure control situation of managed-pressure drilling and can apply different backpressure according to different risk levels. After applying risk control measures, the maximum allowable drilling speed and backpressure in different working conditions of the 3950-4130 m wellbore section were designed on-site at well A1, and the risk level was reduced to 0. This overflow-backpressure risk matrix can classify and control the risk of overflow in deepwater managed-pressure drilling.
Keywords: *deepwater managed pressure drilling, wellbore overflow, backpressure, risk matrix.*

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Interpretable Fuzzy Granular Reasoning Framework

for Industrial Dynamic Complex Event Recognition

Industrial dynamic complex event recognition (CER) can provide decision makers with reference for fault diagnosis and process optimization. It is one of the key steps to ensure the successful completion of each step of industrial production. How to make interpretable reasoning and recognition under incomplete data is a very challenging problem. Our hypothesis is to use our FGR-CER framework to identify complex events in the case of data missing. To address the challenges, we propose a new interpretable fuzzy granular reasoning framework for industrial dynamic complex event recognition framework (FGR-CER). In this framework, event calculus and induction logic are introduced to retain the semantic information of the sensor and make the complex events recognition interpretable. FGR-CER uses the idea of fuzzy set to deal with incomplete data. At the same time, in order to reduce the time complexity of the framework, FGR-CER use the idea of granular computing to optimize the reasoning process, making the reasoning process from coarse-grained to fine-grained according to human thinking. Finally, the proposed FGR-CER is evaluated on the synthetic data set and the real data set, which proved that FGR-CER is better than other algorithms in precision, recall and NDCG for interpretable industrial dynamic event recognition with incomplete data.
Keywords: *event calculus, fuzzy set, granular computing, inductive logic.*

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The Deep Shale Gas Drilling Optimization Method

Based on Real-Time Drilling Parameters

The deep shale gas drilling has high risk, such as the poor drillability and significant changes in formation lithology. It is necessary to optimize drilling parameters. This research established the geological, mechanical model and rock

mechanical models. It can monitor drilling friction, torque, mechanical specific energy, and ECD by real-time tracking optimization software. The results show that the field drilling fluid density can be optimized based on the formation three-pressure profile. This method was successfully applied in the drilling process of deep shale gas wells in the West Chongqing block, and it avoided complex situations such as well control and well collapse. The real-time tracking software EPDOS DMI analyzes the influence of drilling parameters on the mechanical penetration rate and specific energy, such as weight on bit, rotating speed, and working pressure difference. The mechanical penetration rate and mechanical specific energy can timely and accurately judge the bit wear. This research can provide technical support for the safe and efficient drilling of deep shale gas.
Keywords: *drilling optimization; deep shale gas; real-time tracking; mechanical specific energy; bit wear, casing running simulation.*

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Numerical Simulation of Oil Displacement in Complex Fault Block Reservoir

In China, complex fault blocks occupied an important position in the development of oilfields. Compared with monolithic sandstone reservoirs, complex fault blocks have the characteristics of complex and diverse structures and relatively developed low-level fault blocks. Such special oil reservoirs often have an impact on the development of the injection-production well pattern. Therefore, it is necessary to study its influence and optimize related deployment. According to the parameters of the selected example blocks, an ideal reservoir model is established and four well pattern distribution forms are designed. According to the simulation results, we will choose the best oil displacement pattern. Under the same physical and well pattern distribution conditions, the injected water or CO_2 was simulated and the simulation results were compared. Finally, the influence of the fault length on the oil displacement effect on the two-dimensional plane of the entire reservoir was studied. The results show that under the condition of high injection-production pressure difference, well pattern 1 has the best water drive development effect. Comparing the oil saturation distribution cloud map of water flooding and gas flooding and the oil production rate curve of producing wells, CO_2 is significantly better than water flooding in terms of oil displacement speed and production. After changing the length of the fault, it was found that due to the influence of the openness of the fault, as the length of the fault increases, the overall oil saturation distribution of the reservoir is greatly different. The initial oil production increases rapidly, but cumulative oil production changes. It is not obvious. Research reveals that the transfer of fault length affects the formation pressure and then changes the injection-production pressure difference and ultimately affects the initial oil production.

Keywords: *TOUGH2, complicated fault block reservoir, well-patterns, injection-production pressure difference.*

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Nuclear Magnetic-Seepage Joint Measurement Experimental Technology and Field Application of Shale Oil Reservoir

Shale oil reservoirs in Daanzhai section of central Sichuan are mainly developed in Daer sub-section, with rich resource base and great exploration and development potential. A series of reservoir engineering geological characteristics experiments have been carried out in order to form reservoir reconstruction countermeasures and technology suitable for Daanzhai shale oil. The results show that the average porosity of Daanzhai shale oil reservoir in central Sichuan is 5.9%, with pores mainly concentrated in the range of 1-100 nm, and slightly larger pores mainly concentrated in the range of 250-1000 nm, with micro-scale pores developed; The reservoir is mainly composed of shale and limestone interbedding. The fracture pressure of limestone is 9-10 MPa higher than that of adjacent depth shale, which is not conducive to the longitudinal expansion of the fracture. The test of temporary plugging and diversion fracturing technology has significantly increased the complexity of the fracture; Shale crude oil has the characteristics of high viscosity, low wax content and low gum content. It has good fluidity in shale supporting fractures, natural fractures and dislocation fractures, and hardly flows in the matrix, and is mainly used for oil displacement by osmosis; The innovatively established nuclear magnetic resonance (NMR) – permeability test technology can quantitatively characterize the flow ability of shale oil in porous media and the permeability and oil displacement ability. In the Daanzhai shale oil reservoir, the optimized soak time is not less than 6 days, and the pressure control and fluid drainage has achieved a more stable stage of fluid discharge. The test oil production has increased from "oil flower" to nearly 2 tons/day, making a major breakthrough in "oil production".

Keywords: *Sichuan Basin, Daanzhai section, shale oil, engineering geological characteristics, imbibition displacement, stratified* T_2 *analysis.*

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Optimizing Pendulum Bottom-Hole Assembly Based on New Straightening Capability Evaluation Index

Borehole deviation is an important issue of vertical drilling, and the pendulum bottom-hole assembly (BHA) with one stabilizer is often applied to straighten it. The traditional design and application method mainly takes the bit side force (pendulum force) as the evaluation index of straightening capability. The positive influence of bit side force is often over-emphasized while the negative influences of the other factors are often neglected. To improve the design

and application method of pendulum BHA, the equilibrium tendency method to predict the build-up rate (BUR) of a steerable BHA is introduced to directly predict the inclination change rate of pendulum BHA for the first time, and then taking it as new evaluation index of straightening capability to optimize the pendulum BHA. The main influencing factors and laws of straightening capability of pendulum BHAs in three boreholes are analyzed and compared, and new understandings have been obtained for the first time. The research results have shown that predicting the inclination change rate by the equilibrium tendency method and taking it as the evaluation index of straightening capability can improve the design and application of pendulum BHA. The straightening capability of pendulum BHA significantly changes with stabilizer position, weight-on-bit (WOB), bit anisotropy index and borehole diameter. Compared to the pendulum BHA (optimal stabilizer position is about 20 m, recommended specific WOB is below 0.35 kN/mm) in 215.9 mm borehole, pendulum BHA in larger boreholes can properly increase the stabilizer position and specific WOB, but pendulum BHA in smaller boreholes must properly decrease the stabilizer position and specific WOB. It is suggested not to apply the pendulum BHA in small borehole, because the allowable WOB for deviation control is often too small to meet fast drilling requirement.

Keywords: *pendulum bottom-hole assembly, straightening capability, bit side force; bit tilt angle, inclination change rate, stabilizer position, weight-on-bit.*

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A Modified Model of Cement Sheath Stress Distribution
with a Fixed Far-Field Displacement Boundary Condition

The existing stress distribution model of casing-cement-formation mostly does not fix the far-field displacement boundary in model building, and the disturbance of formation displacement at infinity caused by the well construction process can not be eliminated, which is not completely in line with reality. Taking the strata stress as the stress boundary and initial stress field condition, and fixing the far-field displacement boundary of the formation, a modified model of casing-cement-formation combination for directional well is derived with the undetermined coefficients method. On the basis, the sensitivity analysis of the mechanical failure law of the wellbore integrity was carried out, and the calculation results showed that, as the elastic modulus of the formation and sheath decreases, the radial and circumferential compressive stresses on the casing and the cement sheath increase. The Poisson's ratio of the cement sheath has little effect on the stress state of the casing and the cement sheath. The radial and circumferential compressive stresses on the casing and the cement sheath increase as the Poisson's ratio of the cement sheath increases. When the pressure inside the casing is high, as the elastic modulus of the cement sheath increases, the tendency of the tensile circumferential stress at the cement sheath increases, and the compressive stress on the casing decreases. The traditional model overestimates the stress distribution of combination and the shear failure risk of the cement, but underestimates the tensile failure risk of the cement.For a vertical well on site in Bohai Bay, the mechanical property of the cement sheath at the 9-5/8" casing were evaluated, and the on-site cement slurry is reasonably used to meet the mechanical requirements of wellbore integrity. This paper can provide a theoretical basis for reasonably choosing cementing slurry formula.

Keywords: *directional well, displacement boundary, modified model, mechanical parameters, sensitivity analysis, cement sheath mechanical integrity.*

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Study on Wettability and Static Imbibition Law of Tight Reservoir

Based on Nuclear Magnetic Resonance Test

The research on tight oil is one of the hot spots nowadays. China has rich tight oil resources, with a wide distribution range and great development potential. For tight reservoirs, this paper proposes a method to test the rock wettability of tight reservoirs using the nuclear magnetic resonance (NMR) technology. Based on the idea of combining the NMR technology with indoor physical simulation, and on the basis of T2 relaxation time, the mixed wettability index is calculated through the limit of T2 relaxation time of 1 ms to evaluate the wettability of tight reservoirs. The design contrast experiment has studied the influence of wettability on the imbibition law, and concluded that the imbibition rate of hydrophilic rock samples is higher than that of lipophilic rock samples, but the ultimate recovery rate of lipophilic rock samples is higher than that of hydrophilic rock samples, which provides a basis for the development of tight reservoirs.

Keywords: *tight reservoir, nuclear magnetic resonance, wettability, static imbibition, imbibition law.*

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Prediction Plugging Material Formulation on Using Neural Networks

Lost circulation occurs frequently during drilling, increasing drilling costs in minor cases and leading to the scrapping of wells in major cases, and plugging leakage has been the focus of related research. An efficient leakage plugging material formulation is an essential tool to cope with this problem. In this paper, a technical solution is proposed to predict a plugging material formulation based on experimental data combined with neural network technology. First, experiments were conducted using rigid mineral particles (classified into four levels) and plugging agent composite plant fibers (classified into four levels) for drilling to obtain sufficient plugging material formulation data and perform the necessary data preprocessing. Then, the basic back propagation neural network prediction model was established, which showed a qualified prediction ability with a prediction error rate of 16.89%, but it was still far from the expected effect. On this basis, the base model was optimized using a genetic algorithm and a biogeography-based optimization algorithm; the prediction error rates were 9.05% and 5.91%, respectively, and the performance of the prediction model was significantly improved. In addition, when the prediction results were

unsatisfactory, the prediction results could be improved by 19.8–26.9% using network integration as an auxiliary means. Finally, three important challenges in predicting plugging material formulations using experimental data are summarized. Overall, this study shows that neural networks are a practical solution for predicting drilling plugging material formulations and have great research value and potential in dealing with plugging problems and that rapid access to effective drilling plugging measures can help people deal with lost circulation events quickly and reduce losses.

Keywords: *formulation prediction, BP neural network, genetic algorithm, BBO algorithm, network integration.*

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Research to Identify Factors Influencing the Country's Energy Security
Based on Text Data Mining Technology

Energy security is a global and strategic national economic and social development issue. It is one of the most urgent challenges in global development. This study takes China as an example to identify the influencing factors of energy security comprehensively. Using natural language processing, social network analysis, and machine learning methods to mine the authoritative media network news text to identify the influencing factors of energy security and their relationships more objectively, comprehensively, and accurately. Seven major energy security themes are proposed. This study provided a reference for risk management and establishing an energy security prediction and early warning mechanism.

Keywords: *energy security, text mining, influence factors, identification.*

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Optimization of Main Functional Groups of High Efficiency Hydration Inhibitors in Shale
Based on Quantum Mechanical Simulation

The hydration of clay minerals in shale is one of the main causes of borewall instability. Efficient shale hydration inhibitors require strong interactions between the inhibitor and the mineral surface, such as van der Waals forces, static electricity, hydrogen bonds, and even the formation of chemical bonds, which can significantly reduce the crystal layer spacing of clay minerals. The selection of main functional group of inhibitor plays a decisive role in the performance of inhibitor. The density functional theory method based on quantum mechanics can simulate and calculate the interaction between inhibitor and montmorillonite (001) plane, and study its electronic structure and properties at the atomic level. The adsorption of C_2H_5–NH_2, C_2H_5–OH, C_2H_5–OCH_3, C_2H_5–CHO and C_2H_5–$COCH_3$ on Montmorillonite (001) was calculated by density functional simulation. The adsorption of inhibitor functional groups on montmorillonite (001) layer was studied comprehensively from the aspects of adsorption configuration, adsorption energy, charge population, frontier orbit and differential electron density distribution. According to this study, the primary amine group is suitable as the main functional group of hydration inhibitor. Meanwhile, this paper provides theoretical support for the development of efficient surface hydration inhibitors.
Keywords: *shale, molecular simulation, quantum mechanics, interfacial interaction, inhibitor.*

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Two-Stage MCMC with Surrogate Models for Efficient
Uncertainty Quantification in Multiphase Flow

We present a novel two-stage Markov Chain Monte Carlo (MCMC) method that improves the efficiency of MCMC sampling while maintaining its sampling rigor. Our method employs response surfaces as surrogate models in the first stage to direct the sampling and identify promising reservoir models, replacing computationally expensive multiphase flow simulations. In the second stage, flow simulations are conducted only on proposals that pass the first stage to calculate acceptance probability, and the surrogate model is updated regularly upon adding new flow simulations. This strategy significantly increases the acceptance rate and reduces computational costs compared to conventional MCMC sampling, without sacrificing accuracy. To demonstrate the efficacy and efficiency of our approach, we apply it to a field example involving three-phase flow and the integration of historical reservoir production data, generating multiple reservoir models and assessing uncertainty in production forecasts.
Keywords: *Markov Chain Monte Carlo, uncertainty quantification, reservoir modeling, Kriging, Bayesian partition modeling.*

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Characteristics and Quantitative Distribution

of Zeolite in Glutenite Reservoirs

The Lower Wuerhe Formation in Mahu 1 well area of Junggar Basin is rich in oil and gas resources, which are rich in zeolite cements. In this paper, based on core observation and scanning electron microscope data, we clarified that there are four types of zeolite minerals, mainly turbidite, followed by zeolite, and occasionally zeolite and clinoptilolite. Based on the data of X-ray diffraction, physical properties and thin sections, there are two genetic modes of zeolite minerals in this area: cementation and volcanic erosion. For the first time, the prediction model of zeolite content was established by the method of multiple regression, and the plane distribution map of the content of turbidized zeolite in the target strata in the study area was established. The study found that zeolite mainly distributed in the conglomerate size in fine conglomerate and small conglomerate, and the microfacies mainly distributed in the front zone of fan delta.

Keywords: *zeolite, minerals, volcanic erosion, conglomerate.*