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**Анализ свойств дизельных топлив различного происхождения с целью их применения
в качестве сырья для получения углеводородных основ для буровых растворов**

Показаны преимущества прямогонного дизельного топлива гидроочищенного при давлении 80 атм. на никель-молибденовом катализаторе перед дизельным топливом гидрокрекинга при использовании в качестве сырья процесса изодепарафинизации для получения углеводородных основ для буровых растворов. По результатам лабораторных исследований проведен промышленный пробег, подтверждающий перспективность крупнотоннажного производства углеводородных основ буровых растворов на блоке депарафинизации установки гидроочистки дизельного топлива. Учитывая простои блока депарафинизации дизельного топлива в летнее время из-за отсутствия спроса на зимние виды топлив, предлагаемая технология существенно поднимает маржинальность производства.

Ключевые слова: буровые растворы, изомеризация, гидрирование аренов, базовые масла, гидроочистка.

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**Analysis of Diesel Fuels Properties of Various Origins in Order to Use Them
as Feed for the Production of Hydrocarbon Base for Drilling Fluids**

The advantages of straight-run diesel fuel hydrotreated at pressure of 80 atm on a nickel-molybdenum catalyst over hydrocracking diesel fuel at the use of isodewaxing process as a feedstock to obtain hydrocarbon base for drilling fluids. Based on the results of the laboratory assessment, a test run was carried out at process unit. It was possible to obtain a hydrocarbon base for drilling fluids at the dewaxing unit of the diesel fuel hydrotreatment unit in the amount of 340 tons/day (14 t/h) without compromising quality. The dewaxing unit is idle in the summer time due to the lack of demand for winter diesel fuel, so its use at this time significantly increases the production margin.

Key words: drilling fluids, isomerization, hydration of arenes, base oils, hydrotreatment, narrow fractions.

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Оптимальные условия одновременного протекания реакций гидрирования ароматических углеводородов и изомеризации в процессе депарафинизации дизельного топлива

В работе представлено исследование для определения оптимальных условий совместного протекания реакций деароматизации и гидродепарафинизации с целью оценки возможности крупнотоннажного производства маловязких углеводородных основ для буровых растворов на секции депарафинизации установки ЛЧ-24/7 без рецикла. Исследовано влияние одного из ключевых факторов, а именно температуры, на ход данных реакций. Работа проводилась с использованием платиносодержащего катализатора депарафинизации на лабораторной установке исследования гидропроцессов. Установлено, что ключевым фактором является температура 280°C, при которой начинают преобладать реакции гидродепарафинизации над реакциями деароматизации. В ходе работы удалось снизить значение содержания ароматических соединений в дизельном топливе до уровня 7%, что является заделом для дальнейших исследований по оценке влияния других параметров, таких как давление и объемная скорость подачи сырья.

Ключевые слова: деароматизация, гидродепарафинизация, дизельное топливо,

маловязкая углеводородная основа для буровых растворов, гидроочистка, содержание ароматических соединений.

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Optimal Conditions for Simultaneous Reactions of Aromatics Hydration and Isomerization during Dewaxing of Diesel Fuel

This paper presents research to determine optimal conditions for simultaneous reactions of dearomatization and hydrodewaxing to evaluate high margin production of low viscosity hydrocarbon base for drilling fluids at dewaxing section of unit LCH-24/7 without recycle. Influence of one of the key factors, namely temperature, on the course of reaction has been studied. This research has been performed with the use of platinum containing dewaxing catalyst at laboratory unit for the study of hydorprocesses. It has been determined that the key factor is temperature 280°C when hydrodewaxing reactions start to prevail over dearomatization reactions. In course of research the content value of aromatics compounds in diesel fuel has been reduced to level of 7%, which is the basis for further research to evaluate the influence of other parameters, such as pressure and volumetric feed rate.

Key words: dearomatization, hydrodewaxing, diesel fuel, low-viscosity hydrocarbon bases for drilling fluids, hydrotreatment, content of aromatic compounds.

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Первая в мире промышленная партия арктического дизельного топлива с температурой применения до –65°C

До недавнего времени арктическое дизельное топливо выпускалось по ГОСТ Р 55475 с предельной температурой фильтруемости до минус 52°C с использованием депрессорно-диспергирующей присадки. Однако в Арктике температура опускается до минус 60°C и ниже, а использование депрессорно-диспергирующей присадки провоцирует расслоение продукта с резким ухудшением свойств нижнего слоя. Указанное обстоятельство ограничивало применение арктического дизельного топлива в Арктике. Для подобных условий Министерство обороны Российской Федерации разработало собственные стандарты на арктическое дизельное топливо без депрессорно-диспергирующих присадок, в которых регламентируются значения не выше минус 65°C для температур помутнения, застывания и предельной температурой фильтруемости. Препятствием для получения продукта с такими свойствами является сложность одновременного обеспечения требуемого цетанового числа и низкотемпературных свойств. В работе предложен способ получения арктического дизельного топлива с заданными свойствами на основе глубокоизомеризованных дизельных фракций. Для реализации проекта был проведен анализ имеющихся установок в ПАО «Славнефть-ЯНОС» и составлена цепочка из установок первичной переработки нефти, гидроочистки 80 атм и изодепарафинизации. В ходе проведенных экспериментов были обнаружены новые явления наступления предельной температурой фильтруемости, которые были объяснены увеличением вязкости дизельного топлива при сверхнизких температурах. Для снижения вязкости продукта в рецептуру

водили керосин гидрокрекинга. В мае 2020 г. были получены разрешительные документы от Министерства обороны России, и в октябре 2021 г. впервые в России и в мире успешно выпущена первая промышленная партия в 3000 т.

Ключевые слова: арктическое дизельное топливо, сверхнизкие температуры, предельная температура фильтруемости, температура помутнения, кинематическая вязкость, изодепарафинизация, платиновый катализатор.

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First in the World Industrial Batch of Arctic Diesel Fuel

with Application Temperature of up to Minus 65°C

Until quite recently, Arctic diesel fuel was produced in accordance with GOST R 55475 with a maximum cold filter plugging point of up to minus 52°C using a depressant-dispersing additive. However, in the Arctic, the temperature drops to minus 60°C and below, and the use of depressant-dispersing additive provokes product stratification with a sharp deterioration in the properties of the lower layer. This limited the application of arctic diesel fuel in the Arctic. For such conditions, the Ministry of Defense of the Russian Federation developed its own standards for Arctic diesel fuel without the use of depressant-dispersing additives, and suggesting values not higher than minus 65°C for the cloud point, pour point and cold filter plugging point. An obstacle for obtaining a product with such properties is the difficulty of simultaneously providing the required cetane number and low temperature properties.

This paper presents a method for obtaining Arctic diesel fuel with desired properties based on deeply isomerized diesel fractions. To implement the project, an analysis of the existing units at Slavneft-YANOS PJSC was carried out, and a chain of units for primary oil refining, hydrotreating 80 atm and isodewaxing was made. In the course of a number of experiments new causes of the onset of cold filter plugging point were discovered, which were explained by an increase in the diesel fuel viscosity at extremely low temperatures. To reduce the viscosity of the product, hydrocracked kerosene was added to the formula. In May 2020, permits were received from the Ministry of Defense of the Russian Federation, and in October 2021, for the first time in the Russian Federation and in the world, the first industrial batch of 3,000 tons was successfully produced.

Key words: arctic diesel fuel, extremely low temperatures, cold filter plugging point, cloud point, kinematic viscosity, isodewaxing, platinum catalyst.

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Перспективные рецептуры моторных масел с нанодисперсными добавками для двигателей внутреннего сгорания

В работе исследовано влияние добавок к маслу на износ основных деталей цилиндро-поршневой группы дизельных двигателей. Установлено, что добавка к моторному маслу Лукойл 15W40 наноструктурированных элементов металлов позволяет снизить износ гильз цилиндров в среднем в 1,36 раза.

Ключевые слова: моторное масло, добавка, наноразмерный и ультрадисперсный порошок, трибологические свойства, детали двигателя, износ, поверхностный слой.

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Promising Formulations of Engine Oils with Nanodispersed Additives for Internal Combustion Engines

The paper presents research materials on the effect of oil additives on the wear of the main parts of the cylinder-piston group. It has been established that the addition of nanostructured metal elements to Lukoil 15W40 engine oil makes it possible to reduce the wear of cylinder liners by an average of 1.36 times.

Key words: engine oil, additive, nanosized and ultrafine powder, tribological properties, engine parts, wear, surface layer.

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Исследование влияния состава и структуры сложных оксидов никеля и хрома на облагораживание тяжелой нефти в сверхкритическом водном флюиде

Проведены исследования синтезированных оксидов Ni–Cr смешанного фазового состава. Определена зависимость между составом и структурными свойствами двойных оксидов Ni–Cr от соотношения катионов Ni²⁺/Cr³⁺ при синтезе их предшественников (гидроксидов). Исследованы продукты преобразования тяжелой нефти в присутствии двойных оксидов Ni–Cr при температуре 380°C и давлении 22 МПа

в избытке гидротермального флюида. Методом адсорбционно-жидкостной хроматографии показано влияние оксидов на изменение содержания насыщенных, ароматических углеводородов, смол и асфальтенов.

Ключевые слова: сложные оксиды Ni–Cr, сверхкритический водный флюид, тяжелая нефть.

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Study of the Influence of the Composition and Structure of Complex Oxides Ni-Cr on the Upgrading of Heavy Oil in a Supercritical Aqueous Fluid

The studies of synthesized oxides Ni–Cr of mixed phase composition were carried out. The relationship between the composition and structural properties of Ni–Cr double oxides on the ratio of Ni^{2+}/Cr^{3+} cations in the synthesis of their precursors (hydroxides) has been determined. The products of conversion of heavy oil in the presence of Ni–Cr double oxides at a temperature of 380°C and a pressure of 22 MPa in an excess of hydrothermal fluid have been investigated. The influence of oxides on the change in the content of saturated, aromatic hydrocarbons, resins and asphaltenes was shown by the method of adsorption liquid chromatography.

Key words: *ecomplex oxides Ni–Cr, supercritical aqueous fluid, heavy oil.*

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Кинетические исследования реакций гидродеазотирования смесового сырья установки каталитического крекинга

В работе проведены кинетические исследования особенностей процесса гидродеазотирования высококипящего смесового нефтяного сырья в широком интервале параметров на катализаторах Ni_6PMo_{12} , $Ni_6PMo_4W_8$, $Ni_6PMo_6W_6$, Ni_6PW_{12} , а также на промышленном образце сравнения. Определена кинетическая модель, рассчитаны параметры, описывающие процесс, исследована активность катализаторов в реакциях гидрирования полициклических ароматических углеводородов.

Ключевые слова: гидроочистка сырья каталитического крекинга, гидродеазотирование, гидрирование, кинетическая модель, азоторганические соединения, полициклические ароматические углеводороды.

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Kinetic Investigations of Hydrodenitrogenation Reactions of Mixed Feedstock of a Catalytic Cracking Plant

In this work, kinetic features of the hydrodenitrogenation process of high-boiling mixed petroleum feedstock in a wide range of parameters on Ni_6PMo_{12} , $Ni_6PMo_4W_8$, $Ni_6PMo_6W_6$, Ni_6PW_{12} catalysts and on industrial one were carried out.

A kinetic model has been determined, parameters describing the process have been calculated, and the activity of catalysts in the hydrogenation reactions of polycyclic aromatic hydrocarbons has been investigated.

Key words: *hydrotreating of catalytic cracking feedstock, hydrodenitrogenation, hydrogenation, kinetic model, organic nitrogen compounds, polycyclic aromatic hydrocarbons.*

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Гидрирование монооксида углерода на композитных каталитических системах на основе никеля и поливинилового спирта

В статье рассмотрены каталитические и физико-химические свойства композитных материалов, полученные термообработкой нитрата никеля, иммобилизованного на поливиниловом спирте. Изучено влияние температуры формирования композита на фазовый состав металлосодержащих частиц и размер частиц. Показано, что полученный композитный материал является активным катализатором гидрирования монооксида углерода без стадии предварительной активации. Достигнуты следующие показатели синтеза: степень превращения монооксида углерода в условиях протекания процесса каталитического гидрирования — 29%, выход метана — 28 г/м³. Сделаны предположения о влиянии размера частиц на активность синтезированного композита и показано влияние объемной скорости на параметры процесса гидрирования монооксида углерода.

Ключевые слова: каталитическое гидрирование, метанирование монооксида углерода, никелевый катализатор, композитный материал.

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Hydrogenation of Carbon Monoxide on Composite Catalytic Systems Based on Nickel and Polyvinyl Alcohol

The article considers the catalytic and physico-chemical properties of composite materials obtained by heat treatment of nickel nitrate immobilized on polyvinyl alcohol. The influence of the composite formation temperature on the phase composition of metal-containing and the particle size is studied. It is shown that the resulting composite material is an active catalyst for the hydrogenation of carbon monoxide without a pre-activation stage. The following synthesis parameters were achieved: the degree of carbon monoxide conversion under the conditions of CO catalytic hydrogenation process: CO conversion — 29%, CH₄ yield — 28 g/m³. Assumptions about the particle size effect on the activity of the synthesized composite and the effect of volume velocity on the parameters of the CO hydrogenation process are made.

Key words: *catalytic hydrogenation, CO-methanation, nickel catalyst, composite material.*

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Углеводородный состав продуктов крекинга мальтенов нафтеновой нефти с добавкой WC/Ni–Cr

Методом хромато-масс-спектрометрии изучен углеводородный состав продуктов крекинга мальтенов тяжелой нафтеновой нефти Усинского месторождения в присутствии добавки WC/Ni–Cr и без нее. Крекинг мальтенов проведен при 450 °С в течение 2 ч в изотермическом режиме. Использование добавки WC/Ni–Cr при крекинге способствует углублению реакций деструкции углеводородов и смол. Показано, что в продуктах крекинга при использовании WC/Ni–Cr существенно возрастает количество низкомолекулярных алканов C₁₁–C₁₉, алкилбензолов C₉–C₁₀, уменьшается содержание циклогексанов и бицикланов, происходит полная деструкция три-, тетра- и пентациклических насыщенных углеводородов по сравнению с крекингом без добавки. Меняется состав нафтоароматических углеводородов. Наряду с реакциями деструкции протекают реакции конденсации, приводящие к образованию полициклических ароматических углеводородов.

Ключевые слова: нафтеновая нефть, мальтены, крекинг, добавка WC/Ni–Cr, алифатические, алкил- и нафтоароматические углеводороды.

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Composition of Hydrocarbons in Maltenes from Naphthenic Crude Oil after Cracking with WC/Ni–Cr Additive

Using GCMS the composition of hydrocarbons in maltenes from heavy naphthenic crude oil (Usa oilfield) after cracking in the presence of WC/Ni–Cr additive and without it has been studied. Cracking of maltenes carried out at 450°C within 2 hours in isothermal mode. Using WC/Ni–Cr additive during cracking contributes to the deepening of the destruction reactions in hydrocarbons and resins. It is shown, the content of low-molecular alkanes C₁₁–C₁₉, alkylbenzenes C₉–C₁₀ increases essentially in the maltenes cracked with the additive while that of cyclohexanes and bicyclanes decreases, tri-, tetra- and pentacyclic saturated hydrocarbons destruct completely as compared with maltenes cracked without the additive. There are changes in the composition of naphthenic hydrocarbons. The reactions of condensation occur along with destruction reactions, leading to the formation of polyaromatic hydrocarbons.

Key words: naphthenic crude oil, maltenes, cracking, WC/Ni–Cr additive, aliphatic, alkyl- and naphthenoaromatic hydrocarbons.

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Образование адамантанов C₁₀–C₁₄ из протоадамантанов нефти

С целью исследования возможности обогащения реактивных топлив углеводородами алмазоподобного строения для улучшения их физико-химических и эксплуатационных свойств был проведен катализ с бромистым алюминием узких 10-градусных фракций нефти морского происхождения в диапазоне 190–250°C. Продукты катализа отбирали в разное время и анализировали методом хроматомасс-спектрометрии. Показано, что при катализе наблюдается полное исчезновение неадамантановых углеводородов и «нафтенового фона» на масс-хроматограммах с m/z 135, 149, 163 и 177, причем на первых стадиях катализа наблюдается образование новых, преимущественно термодинамически слабо устойчивых изомеров адамантанов, а на последующих – высокомолекулярных адамантанов из низкомолекулярных. Установлено, что из узких фракций нефти 230–240°C и 240–250°C, где полностью отсутствуют углеводороды ряда адамантана, из «нафтенового фона» образуются углеводороды ряда адамантана состава C_{12} – C_{14} . Высказано предположение, что причиной образования высокомолекулярных адамантанов из низкомолекулярных является трансалкилирование.

Ключевые слова: адамантаны, протоадамантаны, катализ, трансалкилирование.

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Formation of C_{10} – C_{14} Adamantanes from Petroleum Protoadamantanes

In order to study the possibility of enriching jet fuels with diamond-type hydrocarbons to improve their physico-chemical and operational properties, a catalyse with aluminum bromide of narrow 10-degree fractions of marine oil in the range of 190–250°C was carried out. Catalysis products were selected at different times and analysed by chromatomass spectrometry. It is shown that during catalysis there is a complete disappearance of non-adamantane hydrocarbons and "naphthene background" on mass chromatograms with m/z 135, 149, 163 and 177, with the formation of new, mainly thermodynamically weakly stable isomers of adamantanes, and in subsequent It was found that from the narrow fractions of oil 230–240 and 240–250°C, where there are no hydrocarbons of the series of adamantane series, hydrocarbons of the C_{12} – C_{14} form from the "naphthene background". It is suggested that transalkylation is the reason for the formation of high-molecular adamantans from low-molecular ones.

Key words: adamantanes, protoadamantanes, catalysis, transalkylation.

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Растительная биомасса как сырье для производства продуктов основного органического синтеза

В работе рассмотрено применение растительной биомассы как потенциального возобновляемого сырья для получения CO_2 -нейтрального топлива, не оказывающее влияние на баланс углекислого газа в атмосфере. Оценка характеристики биомассы позволит определить потенциал ее интегрирования в современные процессы нефтехимии и биохимии. Исследованы наиболее распространенные виды растительной биомассы

на территории России — древесные отходы, торф, а также микроводоросли. Описаны основные характеристики биомассы, ее структурный и элементный состав. Проведена оценка количества и энергетической ценности некоторых видов растительной биомассы.

Ключевые слова: биомасса, растительная биомасса, вторичная биомасса, CO₂-нейтральное топливо, основной органический синтез, экологически чистое топливо.

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Plant Biomass as a Raw Material for Obtaining Products of Basic Organic Synthesis

The review considers plant biomass as a potential renewable raw material for the production of CO₂-neutral fuel, which does not affect the balance of carbon dioxide in the atmosphere. Evaluation of the characteristics of biomasses will make it possible to determine the potential for their integration into modern processes of petrochemistry and biochemistry. The work investigates the most common types of plant biomasses for the territory of the Russian Federation - wood waste and peat, as well as microalgae. The main characteristics of biomasses, their structural and elemental compositions are described. An assessment of the amount and energy value of some types of plant biomass has been carried out.

Key words: *biomass, plant biomass, secondary biomass, CO₂-neutral fuel, basic organic synthesis, ecofriendly fuel.*

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Bio-oil: Methods of Production, Modification, and Application

The review presents the history of production and application of bio-oil (also known as pyrolysis oil), discusses its difference from other fuels and chemicals, and considers the difficulty in classifying and defining bio-oils and bio-fuels. The basic physicochemical properties of bio-oil are given along with a demonstration of their variability depending on the origin of the feedstock and the resulting bio-oil. The methods of obtaining bio-oil and modification of its properties are summarized in addition to revealing the main areas of bio-oil utilization.

Keywords: biofuel, bio-oil, pyrolysis oil.

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На основе определения давления в характерных сечениях скважинной эжекционной системы с учетом режимов течения рабочей жидкости в ее элементах получена аналитическая зависимость давления на входе в приемную камеру струйного насоса от величины рабочего расхода. Структура предложенного уравнения включает значения гидростатического давления в скважине, потерь давления в затрубном пространстве и рабочей насадке струйного насоса и величину создаваемого эжекционной системой относительного напора. В процессе анализа результатов моделирования рабочего процесса струйного насоса установлена обратно пропорциональная зависимость величины давления в скважине от расхода рабочего потока и прямо пропорциональная зависимость от соотношения площадей камеры смешивания и рабочей насадки струйного насоса. Показано, что использование струйного насоса позволяет получить двукратное снижение давления в скважине по сравнению с гидростатическим давлением. Длительность процесса ликвидации гидратов и необходимая скорость перемещения эжекционной системы в скважине определяются глубиной и интенсивностью образования отложений, температурой, конструкцией струйного насоса и величиной расхода рабочего потока. Полученные эксплуатационные характеристики подтверждают принципиальную возможность использования струйных насосов для ликвидации гидратов на поверхностях скважинного подземного оборудования.

Ключевые слова: струйный насос, эжекционная система, ликвидация гидратов, режимы работы, моделирование характеристик.

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The Definition of Jet Pump Operational Parameters of a Hydrates Elimination in Oil Drill-Wells

One of the unconventional areas of use of downhole jet pumps is the elimination of hydrate deposits on the surfaces of downhole equipment. The combined use of ejection and coiled tubing technologies makes it possible to reduce the duration of well cleaning in comparison with the use of traditional methods of liquidation of deposits. Reducing the pressure in the well below the dissociation pressure of hydrates when using a jet pump contributes to their decomposition and the elimination of deposits on the surfaces of underground equipment. Based on the determination of the pressures in the characteristic sections of the borehole ejection system, taking into account the modes of flow of the working fluid in its elements, an analytical dependence of the pressure at the inlet to the intake chamber of the jet pump on the value of the working flow rate is obtained. The structure of the proposed equation includes the values of the hydrostatic pressure in the well, the pressure loss in the annulus and the working nozzle of the jet pump, and the value of the relative pressure created by the ejection system. In the process of analyzing the results of modeling the working process of the jet pump, an inverse proportional dependence of the pressure in the well on the flow rate of the

working flow and a direct proportional dependence on the ratio of the areas of the mixing chamber and the working nozzle of the jet pump were established. It is shown that the use of a jet pump makes it possible to obtain a two-fold decrease in the pressure in the well in comparison with the hydrostatic pressure. The duration of the hydrate elimination process and the required speed of movement of the ejection system in the well are determined by the depth and intensity of the formation of deposits, temperature, the design of the jet pump and the value of the flow rate of the working flow. The obtained performance characteristics confirm the fundamental possibility of using jet pumps for the elimination of hydrates on the surfaces of downhole underground equipment.

Key words. jet pump, ejector system, hydrates elimination, simulation of parameters

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3D Real-Time Modeling Based on Lidar for Circular Coal Bunker of Coal-Fired Enterprise

Coal is one of the reserve sources of fuel for many industrial applications. For example, in a coal-fired power plant, coal significantly contributes to the operating costs of the plant. The control over the fuel cost and the level of fuel management can directly affect the economic benefits of the coal-fired power plant. In this study, we have developed a generalized calculation methodology for fuel management in a coal-power industrial enterprise. Based on a three-dimensional LIDAR model, we propose a real-time dynamic system to measure and control coal storage in a circular coal bunker of the coal-fired enterprises. The system can be applied to obtain the accurate position and attitude of the stacker reclaimer in the coal bunker space. The obtained data are further used to control the operation of the stacker reclaimer in a circular coal bunker. The proposed measuring and control system considers the impact of various factors, including fuel input, consumption, and storage. The advanced and practical features of the proposed measuring system have a positive promotion effect on increasing the economic efficiency of a coal-fired enterprise. Due to the wide range of applications, the developed methodology can be also applied in oil refinery enterprises for three-dimensional real-time control and management of solid products, such as asphalt.

Keywords: LIDAR, three-dimensional model, coal bunker, coal-fired enterprise, oil refinery.

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Biodiesel Production in the Presence of Eggshell Nano-Catalyst

The authors investigate biodiesel fuel and the possibility to utilize biodiesel as an environmentally-friendly alternative fuel for diesel applications in Iran. The common source of oil resources for biodiesel production is the vegetable seeds oil. In this study, the seeds of the castor-oil plant are selected to investigate the process of oil extraction and biodiesel production in a single-phase process. The production process is characterized by the factors of time, choice of catalyst, and the ratio of oil extracted by alcohol (ethanol). The calcined eggshell used as a nano-catalyst in the process of extraction has been previously powdered in a ball mill to the average particle diameter of 500 Å and annealed for two hours under the temperature of 1200°C immediately prior to the extraction reaction. The experimental results show that the optimal conditions for the single-phase process are as follows: the reaction time is 5 h, the catalyst amount is 3 g, and the ethanol/oil molar ratio is 4,5. Due to the presence of the eggshell nano-catalyst, the time of extraction is significantly reduced. Considering the economic and the cost issues, it was shown that the optimal parameters can provide the highest yield of biodiesel of sufficient quality. The results indicate that the vegetable seeds oil can be successfully used for biodiesel production, thus contributing to the fuel supply, as well as reducing air pollution.

Keywords: *biodiesel, castor-oil plant seeds, single-phase extraction, eggshell nano-catalyst.*

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Review of Application of Molecular Simulation in Inhibiting Surface Hydration Expansion of Clay Minerals

The development of shale gas reservoirs with water-based drilling fluids is complicated by the problem of clay mineral hydration. The method of molecular simulation is widely used in many research fields, in both humanitarian and material sciences. In this paper, based on the previously published studies, the authors propose a comprehensive review of molecular simulation of inhibiting the surface hydration swelling of clay minerals. Swelling characteristics and the adsorption properties of clay minerals are reviewed and discussed. The results can be useful for future development of the MD (molecular dynamics) simulation method and its application in studies of inhibition of the surface hydration swelling in clay minerals.

Keywords: *molecular simulation, clay minerals, surface hydration, adsorption properties.*

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Characteristic Research of Cuttings Initiation in Gas Drilling Horizontal Wells

Gas drilling technologies play an increasingly important role in oil and gas exploitation. The modern gas drilling method minimizes reservoir damage and increases the efficiency of oil and gas exploration. The practical use and the

development of the gas drilling technology are limited by the ineffectiveness of migration and control of the cuttings bed, which is unavoidable in horizontal sections during gas drilling. In this paper, the author applies the chemical initiation theory to study the initiation of the cuttings bed migration in a horizontal well in the process of gas drilling. Then, the author deducts the formula to calculate the cuttings bed initial velocity by considering characteristics of the cuttings in a horizontal well during gas drilling. The calculation results show that the initial velocity gradually increases with an increase in the size of cuttings, decrease in the cuttings sphericity, and increase in the degree of exposure in the cuttings window. The results are coherent with the field engineering data. The study can also provide a useful reference for the cuttings bed control in gas drilling of horizontal wells.

Keywords: gas drilling of horizontal wells, cuttings bed, cuttings exposure degree, cuttings initial velocity.

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Research on Capacity Measurement Method of Horizontal Cylindrical Tank Based on Monte Carlo Method

A horizontal cylindrical tank is a common storage device for petroleum products, and its capacity table is an important basis for calculating the volume of liquid poured into and out of the tank. In this study, a method for measuring the capacity of horizontal cylindrical tanks is proposed, focusing on the problems of large workload and time consumption of existing measurement methods. The method is based on the Monte-Carlo algorithm. The capacity table is calculated by arranging the sensor points on the inner wall of the tank, and then counting the number of sample points that fall in the horizontal cylindrical tank according to the coordinates of the sensor point, the distance from the sensor point to the origin, and other parameters. It was found, that the relationship between the relative error of the measured result and the height of the liquid level conforms to the exponential function. Based on this relationship, the error compensation algorithm is established, which can help to reduce the absolute error and relative error of the measurement result.

Keywords: horizontal cylindrical tank; capacity; Monte-Carlo method; error compensation.

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The Antoine Equation of RP-3 Aviation Kerosene Based on a Five-Component Model Blending Fuel

In this paper, based on a model of the five-component surrogate fuel, the authors have studied the relationship between temperature and saturated vapor pressure of the RP-3 aviation kerosene fuel, and derived an experimental function of this relationship. Then, the Antoine equation of the RP-3 aviation kerosene has been obtained by fitting the

experimental data points of the function, and the resulting equation has been verified. The results of this study can provide some theoretical background for engineering practices and further theoretical studies of liquid mixtures.

Keywords: *RP-3 aviation kerosene, surrogate fuel, Antoine equation, data fitting.*

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Technological Process of the Composite Casing Drilling Technology in Deep-Water Riserless Well Construction

The composite casing drilling technology in a deep-water riserless well construction is the technology providing drilling of the tandem borehole composed of the surface conductor borehole and the surface casing borehole in a one-trip drilling operation. The composite casing is put into place and is cemented in one trip. The composite casing drilling technology not only combines the advantages of the drilling method and the jetting technology but also overcomes the limitations of both technologies. The composite casing drilling technology has been successfully applied in the Mozambique block A drilling projects. The results of the field application show that this technology is able to provide secure and efficient drilling operations, which can considerably reduce the installation time and the costs. In this paper, based on the example of application in the Mozambique block A gas field, the process of the composite casing drilling technology is described in detail. Then, the authors analyze the field conditions and put forward an optimization method. The optimization method is applied to select the optimal technology for drilling and installing the surface conductor and the surface casing.

Keywords: *composite casing, riserless well construction, surface conductor, surface casing.*

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Thermodynamic Calculation of the Decomposition of Inorganic Sulphur in Coal in Oxy-Fuel Atmosphere

In this paper, the effect of oxygen and steam on the decomposition of inorganic sulphur in coal in the oxy-fuel atmosphere is investigated using the thermodynamic equilibrium calculation method. To evaluate sulphur distribution in different gas environments, the authors apply the HSC Chemistry software for calculations of various sulphur-related chemical reactions and equilibria parameters, based on the principle of minimizing the Gibbs free energy. The influence of temperature and gas atmospheres on the equilibrium composition is also evaluated. In the experiments, the FeS₂ and FeSO₄ substances are used to simulate the pyrite and sulphate impurities in coal, respectively. The relationships are established between the CO₂ atmosphere and the inorganic sulphur content. It is shown, that the CO₂ presence in the atmosphere enhances the formation of FeO and the decomposition of FeS, resulting in a few intermediate products, including Fe₂O₃, Fe₃O₄, Fe₂S₃, FeCO₃, and COS. The results show that

oxygen has a significant effect on the sulphur distribution. The SO , FeO , and Fe_3O_4 products are formed in the oxygen-deficient environment, while the SO_2 and Fe_2O_3 substances are formed when oxygen is in excess. In the $O_2/CO_2/H_2O$ mixture atmosphere, the oxidation reaction of the sulphur-containing compounds becomes more complicated. A competitive relationship between the reactions of $S-CO_2$ and $S-H_2O$ is observed.

Keywords: pyrite, sulphate, CO_2 , H_2O , HSC chemistry.

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Simulation Analysis of Drilling Process in Horizontal Wells with Mechanical Rotary Percussion Tool

Holding pressure is an important factor affecting the rate of penetration (ROP) in horizontal wells. The holding pressure problem is directly and effectively solved by using the vibrating drag-reduction tools. In this paper, the finite element method is used to model the drilling process in a horizontal well with and without rotary percussion. The established model is based on a rotary percussion tool driven by PDM. Based on the simulation results, the authors compared and analyzed the impact of rotary percussion on the weight-on-bit (WOB), torque, acceleration and ROP in drilling process. The results show that the rotary percussion tool can effectively solve the problem of the holding pressure, increase the overall level and the fluctuation range of WOB, and improve ROP in the drilling process. It also increases the torque-on-bit and axial acceleration parameters. The analysis results can provide theoretical guidance for the parameter design and type selection of tools under different working conditions

Keywords: rotary percussion tool, PDM, horizontal well, drilling process, vibrating drag reduction, rate of penetration.

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Influence of Measurement Parameters on the Accuracy of Determining the Capacity of a Vertical Tank

Vertical tanks are commonly used for oil storage. The accuracy of measurement of the tank's capacity depends directly on the method used for processing the experimental data. When the Monte Carlo method is applied for evaluating the capacity of a vertical tank, the measurement result is determined by the factors of sensor point distribution, sensor point density, and sample point density. Therefore, in this study, we investigate the impact of these factors and their influence on the evaluated capacity of a vertical tank based on the Monte Carlo method. The research results show that the absolute and relative errors of the orderly distribution are similar to those of the rotary distribution, their absolute errors do not exceed $\pm 0.1 m^3$, and the relative errors can be converged to within 0.1%.

When the sensor points are randomly distributed, the stable value of the absolute error differs from 0, and the relative error cannot be converged to within 0.1%, thus, the random distribution is not acceptable for measuring the capacity of vertical tanks. When the sensor point density is higher than or equal to 1.44 /m², the absolute error of the measurement result does not exceed ±0.1 m³, and the relative error can be converged to within 0.1%, which is acceptable for measuring the capacity of vertical tanks. The higher the sample point density, the smaller the absolute error range and the faster the relative error convergence speed. When the sample point density is higher than or equal to 1745.23 /m³, the relative error can be converged to within 0.1%.

Keywords: vertical tank; sensor point distribution; sensor point density; sample point density; capacity; Monte Carlo method.

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Numerical Simulation of Injection Parameters of Polymer/Surfactant Binary Composite Flooding in High Watercut Reservoir

Due to the limitations of laboratory experiments in parameter optimization of binary compound flooding systems and the uncertainty of optimization results of the field tests, the authors have applied the numerical simulation analysis to optimization of the injection parameters of binary-compound flooding systems in the 552 high-watercut reservoir of Xinjiang oilfield. The tNavigator software was used to study the impact of the parameters including polymer concentration, surfactant concentration, slug size, and injection rate on the increase of the recovery rate. The results show that when the concentration of polymer solution is 1000 mg/L, the surfactant content is 0.3%, the slug size is 0.5 PV, and the injection rate is 0.1 PV, the estimated efficiency of the binary-composite flooding system is 18.6 times higher than that of the water flooding.

Keywords: binary composite flooding, numerical simulation, injection parameters, recovery.

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Analysis of the Origin of Calcite Cements and Fluid Sources in Limestone Formations Based on Petrology and Geochemical Data

In this paper, the authors have summarized and analyzed the petrology and isotope and trace element characteristics of host rocks and calcite cements in the Yingshan and Yijianfang formations of Lower-Middle Ordovician in the Shunbei area of the Tarim Basin. The result successfully reveals four types of limestones and four types of calcite cements, such as the sparry grainstone (SG), the microcrystalline grainstone (MG), the micrite (MC), the silicified limestone (SL), the calcite coexisting with silicon in SL (C1), the calcite which develops in fractures or between the broken siliceous breccias (C2), the calcite which fills between the broken particles (C3), and the calcite filling the

fractures of all the host rocks and cements (C4). The high U/Th and Sr/Ba ratios of all the calcite cements indicate that the fluids that formed them were of comparatively higher salinity in burial environments, and the differentiation of their Sr-isotopes, Fe, and Mn contents clearly shows two types of diagenetic fluids: the fluid forming C2 and C3 is the inherited seawater closely related to the host rocks, and the fluid forming C1 and C4 is the silica-rich hydrothermal fluid from the lower strata and flowed through the possible clastic strata.

Keywords: petrology, isotopes, trace elements contents, calcite cements, Yingshan and Yijianfang Formation, Shunbei area, Tarim Basin.

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Analysis of China's Oil Trade Pattern and Structural Security Assessment from 2017 to 2021

Oil is an important strategic resource of the country, and the oil trade structure is related to national oil security. In this paper, based on the data of China's oil import trade from 2017 to 2021, using the methods of import concentration, the Shannon entropy index, and quantitative evaluation of trade structure, the authors analyze the import pattern and the trade structure security of 7 oil varieties, including crude oil, vehicle gasoline, aviation gasoline, naphtha, aviation kerosene, No. 5-7 fuel oil, unburned petroleum coke, and petroleum asphalt. The research shows that the trend of the large-scale and diversified import patterns of China's oil import is obvious, and the main importing countries of various oil varieties are relatively stable. The structural security of crude oil is the highest, and the import structure is a medium and highly-centralized oligopoly. The import structure of other oil varieties belongs to a highly-centralized or very highly-centralized oligopoly. The security of the import structure of China's oil varieties is low and shows a downward trend. As shown by the early warning calculations of the trade structure, increasing the number and transaction proportion of the trading partners in the collaborative growth zone and reducing the number and transaction proportion of the trading partners in reverse inhibition zone, we can optimize the oil varieties import structure of China.

Keywords: oil trade, pattern security, assessment, import.

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Development and Performance of Urea–Formaldehyde Resin/Montmorillonite Intercalation Composite Horizontal Well Plugging Agent

Accurate identification of the water outlet point after a horizontal well has produced water is difficult, resulting in difficulty in blocking water. This article proposes improved water plugging technology for general plugging of the

wellbore. In this technology, the organic polymer UF and the inorganic rigid reinforced particle MMT are combined to obtain composite at the nanometer scale for a horizontal well plugging. FIRT, XRD, TG-DSC, SEM, and other methods are used to characterize the structure of intercalated composite materials. The results show the successful MMT modification and pre-polymer synthesis reaction. The performance of the composite plugging agent is evaluated by a rotating rheometer, mechanical experiment, and plugging experiment. The initial viscosity of the plugging agent in a rheological test is 28.81 mPa·s, which shows that the plugging agent has good injectability and is not affected by shear. The solidified strength of the plugging agent material is 11.45 MPa, which meets the plugging requirements. In the core physical simulation experiment, the breakthrough pressure gradient reaches 86 MPa/m, indicating that the plugging strength of the plugging agent is high, the plugging rate is still more than 90% after 40 hours of water scouring, and the erosion resistance is strong. Compared with other plugging agents, UF-OMMT plugging agent has better thermal stability. Hence, the developed plugging agent has good application prospects.

Keywords: horizontal well, montmorillonite, urea resin, general blocking.

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Study on the Preparation and System of Desulfonated Anti-High Temperature Fluid Loss Agent

In this study, a desulfonated hybrid organic/inorganic fluid loss agent resistant to high temperatures is synthesized by using free-radical copolymerization. The fluid loss agent consists of the organic monomer acrylamide (AM), N-vinylpyrrolidone (NVP), dimethyl diallyl ammonium chloride (DMAAC), and the inorganic monomer KH570 modified by nano-silica (M-SiO₂). A field emission transmission electron microscope, an infrared spectrometer, and a thermogravimetric analyzer are used to examine the morphology and structure of the fluid loss agent. The results show that the inorganic nanoparticles and organic polymers are successfully grafted, and the resulting “core-shell” structure is connected by molecular chains. When 2% wt of the synthetic fluid loss additive E(AND-SiO₂) is added to the base slurry, the normal-pressure fluid loss (FLAPI) and high-temperature, high-pressure fluid loss (FLHTHP) of the slurry are determined by the aging tests at 150, 160, 170, 180, 190, and 200°C for 16 hours. The results show that when the temperature is 180°C, FLAPI is 6.4 mL, FLHTHP is 28 mL, and temperature resistance is good. The biological toxicity and biodegradability tests show that the fluid loss control agent does not only effectively reduce the fluid loss, but also easily degrades, making it an environmentally-friendly treatment agent.

Keywords: hesulfonation fluid loss agent, anti-high temperature fluid loss agent, water-based drilling fluid, nano-SiO₂.

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Mechanism and Adaptability Evaluation of Well Soaking in Tight Reservoir

Tight oil reservoirs are characterized by low porosity, low permeability, small seepage channels (micro-nano-scale pore development), and low pressure coefficient. The existing development technology can not solve the problems of low output, fast decline, difficulty in replenishing energy, and low recovery ratio. In this paper, the T2 spectrum of saturated oil samples is detected by NMR analyzer, and the spontaneous imbibition and pressurized imbibition experiments are carried out with deuterium water. By scanning the T2 spectrum of nuclear magnetic resonance, the peak value of T2 spectrum decreases with the imbibition process, which indicates that the oil in the core is gradually imbibed, and the change trend of spontaneous imbibition quality is basically consistent with that of the spectral area. The experimental results show that the effects of soaking wells on the oil recovery of different wells are obviously different. There are many factors that affect the effect of well soaking, including porosity, permeability, mineral composition, and so on, which together affect the final effect of the well soaking. From the experimental results, the clay minerals in the core, especially the illite-montmorillonite mixed layer, have an obvious influence on the imbibition rate. The higher the content of the illite-montmorillonite mixed layer, the faster the imbibition rate. This study is of great significance for the development of the tight oil.

Keywords: *tight oil reservoirs, imbibition rate, well soaking, spontaneous imbibition.*

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Study on the Velocity of the Temporary Plugging Agent along Wellbore in a Fracturing Operation

In this study, considering the factors of gravity, buoyancy, drag force, inertia force, and so on, the migration movement model of the temporary plugging agent is established. The migration trajectory of the temporary plugging agent can be directly obtained by using the four-order Runge-Kutta method and by the input of the initial conditions. With the help of programming language, the model is solved and a specific well example is taken as an example. The results show that the acceleration of the temporary plugging agent increases with the increase of density at the initial stage. When the temporary plugging agent accelerates to a certain speed, the resistance increases with the increase of speed, the combined external force gradually decreases until the combined external force is 0, and the temporary plugging agent keeps uniform motion. The migration velocity of the temporary plugging agent increases with the increase in displacement. With increase in the well depth, the temporary plugging agent migrates from an inclined section to a horizontal section. The migration speed of the temporary plugging agent can provide help for targeted temporary plugging.

Keywords: *targeted temporary plugging, temporary plugging agent, migration trajectory, wellbore, particle size migration speed.*

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Finite Element Analysis and Installation Optimization Design of Negative Pressure Vibrating Screen Exciter

In this study, to focus on the problems of a negative pressure vibrating screen, a three-dimensional model of the exciter and the screen is established by using the modeling software, and a finite element model of the screen is then established by the ANSYS software. The analysis of the screen model is carried out to evaluate the natural frequencies and vibration modes of the screen. Based on the analysis results, the constraints and the vibration conditions are imposed on the screen, and the harmonic response analysis is performed. It is concluded that under the condition of the same number of the vibration exciters, the effect of the screen filtration is improved by using the eight-shaped arrangement of the vibrating rods, compared with the parallel arrangement.

Keywords: negative pressure vibrating screen; vibration exciter; screen; ANSYS simulation; model analysis.

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Finite Element Analysis and Application of a Chain Pumping Unit Frame

The rack is a key supporting part of a chain pumping unit. Its reliability and the service life directly affect the performance of the pumping unit. Considering the working load status of the frame, the authors have applied the SolidWorks software to develop a 3D model of a 600 broadband chain-reversing pumping unit. The ABAQUS software is adopted to calculate and analyze structural strength of the frame and the stress and strain distribution under the action of the suspension point load and the balance box load. Besides, the stress concentration and the dangerous section position of the frame are obtained to verify the rationality of the closed frame structure. Moreover, modal analysis of the frame is conducted to obtain the displacement response characteristics of the frame to different frequency loads. The research results provide scientific guidance and reference for the optimized design and safe exploitation of the frame. The application practices in the mineral field of the Shengli oil field in eastern China have shown that the optimized chain oil-pumping machine has a reduced failure rate and an extended life span. Also, it meets the working requirements of the long stroke and low-stroke times for heavy oil, high viscous oil, and low osmotic depth wells. Besides, it provides a higher average load utilization than the beam oil pumping machine and has low energy consumption in the development of high oil, high viscous oil, and low osmotic depth wells.

Keywords: chain pumping unit; frame; stress cloud map; modal analysis.

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Changes of Microorganism and Corrosion Tendency during Fracturing of Flowback Fluid Recovery Wells of Shale Gas

The study is focused on understanding microbiological changes and the corrosion tendency in the fracturing wells with a flowback fluid reuse during the exploration and production process in the Changning shale gas field, Sichuan. High-throughput sequencing technology and electrochemical workstation were used to analyze the pre-fracturing fluid, the flowback and produced water (FPW) at each stage of the production process of a single shale gas well in Southern Sichuan. The fracturing fluid was prepared with the flowback fluid. The results showed that during exploration and production, the dominant bacteria is Roseovarius (32.69%), and the others include Arcobacter, Marinobacter, Marinobacterium, etc. The dominant archaea is Methanothermobacter (59.19%), and the others include Methanlobus, Thermococcus, etc. The enrichment of the halophilic and halotolerant microorganisms is due to the changes of the fluid salinity. Besides, the relative abundance of the sulfate reducing bacteria (SRB) which can be identified as the cause of the microbiologically influenced corrosion (MIC) during the exploration and production process first dropped sharply from 21% to below 1% and finally rose to 31%. It is worth noting that the corrosion tendency shown by the electrochemical results is basically consistent with the change in abundance of SRB. This study preliminarily reveals the changes of microorganisms in the exploration and production process of fracturing with the flowback fluid, and provides new ideas for the prevention and control of corrosive microorganisms, protection against pipe corrosion, and effective management of water resources.

Keywords: shale gas, reuse of the flowback fluid, high-throughput sequencing, electrochemistry, microbial diversity.

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The Wellbore Stability Study in Bedding Shale Formation on the Condition of Plasticity

Horizontal drilling is an effective way to increase the capacity of shale formations. However, in the horizontal shale drilling, the major difficulties are the problems of the wellbore stability and the well collapse prevention. In this paper, a jointed-material model is adopted to simulate the strength anisotropy and the permeability anisotropy of the bedding shale. The model is used to obtain the distribution of the plastic regions in the vicinity of the well under the condition that the stress state matches the failure criterion. The shale permeability anisotropy also contributes to the nonuniform propagation of pressure in the formation. The model is applied to study the wellbore stability law of a shale gas well in the Longmaxi formation in Sichuan Basin, China. It is shown that the drilling fluid preferably invades in the bedding plane, resulting in a higher pore pressure in the bedding plane than that in the adjusting layers. The lower strength of the bedding shale weak planes could create four plastic shear failure locations around the wellbore. This tendency is different from the normal dog-ear-shaped breakout. The study also shows that the

sealing performance of the drilling fluid plays an important role in maintaining the wellbore stability. If the wellbore wall is perfectly penetrated, the increased mud weight will enlarge the plastic zone area around the well and increase the drilling risks.

Keywords: *wellbore stability, bedding shale, collapse, sealing performance.*

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Research on the Measurement of Ship's Tank Capacity Based on the Monte Carlo Method

Focusing on the problems of large workload, long time consumption, and high manual involvement on the current methods of the ship's tank capacity measurement, in this study, a Monte Carlo method is applied to measure the ship's tank capacity. The established method realizes the measurement of the tank capacity by arranging the sensing points, conducting a subsequent Monte Carlo test, and performing the error compensation. The results show that when the Monte Carlo method is used to measure the capacity of the tank, in the case when the lower part of the tank is irregular and the upper part is regular, the absolute error of the measurement result is within $\pm 0.1 \text{ m}^3$, and the relative error convergence value is less than 0.1%. The relationship between the absolute error of the measurement result and the height before error compensation is presented in a form of a Boltzmann curve.

Keywords: *ship's tank, capacity, Monte Carlo method, Boltzmann curve.*

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Study on Factors of the Fracture Width in Tight Sandstone

Based on the material balance principle, the fluid mechanics theory, the theory of elastic mechanics, and the fracture mechanics theory, the authors have established a model of a quasi three-dimensional crack extension of the artificial interlayer fracture, combined with the boundary conditions and the initial conditions. Based on the analysis and the solution of the established quasi three dimensional crack extension model, the simultaneous equation of continuity, the pressure drop equation, the equation of the crack width, and the equation of the fracture height are obtained. The analysis results show that the fracture height decreases with the increase in the sand content. When the proppant sinks to the bottom of the fracture, the artificial plugging section is formed. The fracture height decreases with the increase in the buoyancy agent content in the reservoir. With increase in the displacement, the fracture length tends to increase. With increase in the Poisson's ratio, the fracture length decreases.

Keywords: *tight sandstone, fracture height, displacement, fracture length, fracture height.*