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Publisher— ICST «TUMA Group» LLC

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Импортозамещение катализатора гидродемеркаптанизации реактивного топлива.

**Опыт взаимодействия ПАО "Славнефть-ЯНОС" с ООО "Газпромнефть-Каталитические системы"
и ООО "Газпромнефть-Промышленные инновации"**

Описано импортозамещение катализатора, применяемого для гидродемеркаптанизации реактивного топлива в ПАО «Славнефть-ЯНОС». Приведено сравнение ранее применяемого катализатора ART СК-400 и нового катализатора Selectum HDT HYPERCLEAN 302 производства ООО «Газпромнефть – Каталитические системы», разработанного в ООО «Газпромнефть – Промышленные инновации». Показано, что российский катализатор не уступает импортному как в условиях лабораторного эксперимента, так и в процессе промышленного производства топлива марки ТС-1.

Ключевые слова: реактивное топливо, гидродемеркаптанизация, содержание общей серы, содержание меркаптановой серы, катализатор, импортозамещение.

DOI: 10.32935/0023-1169- 2026-656-4-12-16

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Import Substitution of jet Fuel Hydrodemercaptanization catalyst.

Experience of Cooperation between “Slavneft-YANOS” PJSC and

“Gazpromneft-Catalytic Systems” LLC and “Gazpromneft-Industrial Innovations” LLC

This paper describes the import substitution of the catalyst used for hydrodemercaptanization (HDM) of jet fuel at Slavneft-YANOS PJSC. It compares the previously used ART CK-400 catalyst with the new Selectum HDT HYPERCLEAN 302 catalyst produced by Gazpromneft-Catalytic Systems LLC, which was developed by Gazpromneft-Industrial Innovations LLC. This paper shows that the domestic catalyst is comparable to the imported catalyst both in laboratory experiments and in the process of industrial production of TS-1 fuel.

Key words: jet fuel, hydrodemercaptanization, total sulfur content, mercaptan sulfur content, catalyst, import substitution.

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Незастывающее арктическое дизельное топливо.

Как уникальный продукт сделать массовым?

Приведены минимальные температуры арктического и субарктического поясов. Проанализирован опыт выпуска незастывающего арктического дизельного топлива по стандартам Министерства обороны РФ в ПАО «Славнефть-ЯНОС», которое является первым и единственным предприятием выпускающим этот продукт. Сформированы предложения для гражданского стандарта на незастывающее арктическое дизельное топливо, предусматривающего два его вида: дизельное топливо арктическое и дизельное топливо арктическое континентальное. Предложения учитывают, как климат, так и опыт производства и позволяют обеспечить массовый выпуск продукта за счёт упрощения технологии производства без ухудшения потребительских свойств. Приведено сравнение его свойств и свойств термостабильных реактивных топлив. Поставлена научно-техническая задача разработки технологии получения термостабильных топлив для реактивных двигателей с использованием современных процессов изодепарафинизации и гидрокрекинга.

Ключевые слова: Арктика, дизельное топливо, низкотемпературные свойства, предельная температура фильтруемости, температура помутнения, цетановое число, температура вспышки, кислотность.

DOI: 10.32935/0023-1169- 2026-656-4-17-21

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Non-Freezing Arctic Diesel Fuel.

How to Make a Unique Product Mass Produced?

The minimum temperatures of the Arctic and subarctic zones are given. The experience of the production of non-freezing Arctic diesel fuel according to the standards of the Ministry of Defense of the Russian Federation at Slavneft-YANOS PJSC, which is the first and only company producing this product, is analyzed. Proposals have been made for a civil standard (GOST) for non-freezing Arctic diesel fuel, which includes two types: Arctic diesel fuel (DTA) and Arctic continental diesel fuel (DTAK). The proposals take into account both the climate and production experience, and allow the mass production of the product by simplifying the production technology without degrading its consumer properties. A comparison of its properties and properties of thermostable jet fuels is provided. This

paper sets out the scientific and technical challenge of developing a technology for producing thermostable jet fuels using modern isodewaxing and hydrocracking processes.

Key words: *Arctic, diesel fuel, low-temperature properties, cold filter plugging point, cloud point, cetane number, flash point, acidity.*

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Оценка генотоксического потенциала маловязких углеводородных основ

для буровых растворов производства ПАО «Славнефть-ЯНОС» с помощью lux-биосенсоров

Применение буровых растворов на неводной основе сопряжено с экологическими рисками, поскольку содержащиеся в них соединения могут быть токсичны для живых организмов. В настоящей работе проведена оценка генотоксического потенциала маловязкой углеводородной основы для буровых растворов (МУОБР) производства ПАО «Славнефть-ЯНОС», используемой для бурения скважин в арктической зоне, с помощью трех независимых lux-биосенсоров, позволяющих детектировать повреждения ДНК в клетках Escherichia coli. Результаты исследования показали отсутствие генотоксического действия МУОБР на генетический материал микроорганизмов и его безопасность для экологических систем.

Ключевые слова: *буровые растворы, генотоксичность, lux-биосенсоры.*

DOI: 10.32935/0023-1169- 2026-656-4-22-24

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Assessment of the Genotoxic Potential of Low-Viscosity Hydrocarbon Base

for Drilling Fluids Produced by Slavneft-YANOS PJSC Using Lux-Biosensors

Application of drilling fluids on a non-water basis is associated with environmental risks, as the compounds they contain can be toxic to living organisms. In this study, the genotoxic potential of a low-viscosity hydrocarbon drilling fluid (LVHBDF) produced by Slavneft-YANOS PJSC, which is used for drilling in the Arctic zone, was assessed using three independent lux-biosensors that detect DNA damage in Escherichia coli cells. The study results showed that LVHBDF does not have a genotoxic effect on the genetic material of microorganisms and is safe for ecological systems.

Key words: *drilling fluids, genotoxicity, lux-biosensors.*

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О необходимости пересмотра метода определения предельной температуры фильтруемости арктических дизельных топлив

Обоснована необходимость пересмотра методик определения предельной температуры фильтруемости (ПТФ) арктического дизельного топлива, изложенных в ГОСТ 22254 и EN-116. Опыт производства и паспортизации низкозастывающего арктического дизельного топлива в ПАО «Славнефть-ЯНОС» показал, что методы определения ПТФ по ГОСТ 22254 и EN-116 не адекватны при характерных для зимы Арктики температурах. Точность методов определена разработчиками лишь до минус 47°C. В измерительном приборе недостаточна температура охлаждающей бани. Применяемая конструкция пипетки измерительного прибора допускает образование конденсата, переходящего в наледь, что приводит к преждевременному срабатыванию оптического датчика и ложной фиксации ПТФ. Показано, что при температурах помутнения образца ниже минус 60°C сущность метода, изложенная в пункте 3 стандартов, теряет смысл. Из-за эффекта смены причин наступления ПТФ н-парафины не отлагаются на сетке 45 мкм, так как их количество незначительно или они отсутствуют. При этом течение образца через сетку не прекращается, а замедляется вследствие повышения вязкости при понижении температуры. Все эти недостатки являются следствием того, что западные специалисты разрабатывали метод для определения ПТФ дизельного топлива по EN- 590, где самые жесткие требования по ПТФ не выше минус 44°C.

Ключевые слова: Арктика, дизельное топливо, низкотемпературные свойства, предельная температура фильтруемости.

DOI: 10.32935/0023-1169- 2026-656-4-25-27

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The Necessity to Revise the Cold Filter Plugging Point Determination Method of Arctic Diesel Fuels

The necessity to revise the cold filter plugging point determination method (CFPP) of Arctic diesel fuel, as specified in GOST 22254 and EN-116, has been substantiated. The experience of producing and certifying low-viscosity Arctic diesel fuel at Slavneft-YANOS PJSC has shown that CFPP determination methods according to GOST 22254 and EN-116 are not adequate at temperatures typical for the Arctic winter. The scope of determination requires revision. The accuracy of the methods is determined by the developers only up to minus 47°C. The temperature of the cooling bath is insufficient in the measuring device. The design of the measuring device's pipette allows for the formation of condensation that turns into ice, leading to premature activation of the optical sensor and false detection of CFPP. It

has been shown that at sample cloud points below minus 60°C, the essence of the method described in paragraph 3 of the standards loses its meaning. Due to the effect of changing the causes of CFPP onset, n-paraffins do not deposit on a 45 µm mesh, as their quantity is not enough or missing. At the same time, the flow of the sample through the mesh does not stop, but slows down due to an increase in viscosity at lower temperatures. All these shortcomings are a result of the fact that Western experts developed a method for determining the CFPP of diesel fuel according to EN-590, where the most stringent requirements for CFPP are not higher than minus 44°C.

Key words: Arctic, diesel fuel, low-temperature properties, cold filter plugging point.

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Снижение содержания аренов в углеводородных основах для буровых растворов

В работе рассмотрены технологические подходы к снижению содержания ароматических углеводородов в маловязких углеводородных основах для буровых растворов (МУОБР), получаемых в условиях нефтеперерабатывающего производства. Проанализированы ограничения существующей технологической схемы гидроочистки и изодепарафинизации при достижении требуемого уровня ароматики. Проведены сравнительные испытания каталитических систем гидрирования ароматических соединений. Обоснован выбор каталитической системы с повышенным содержанием никеля, обеспечивающей интенсификацию гидрирования аренов. Показано, что внедрение новой каталитической системы позволило снизить содержание ароматических углеводородов в МУОБР до 0,5% мас. при сохранении эксплуатационных характеристик продукта. Это позволит дополнительно снизить экологические риски при бурении скважин в арктической зоне, где методы биоремедиации могут быть неэффективны.

Ключевые слова: маловязкая углеводородная основа, буровые растворы, ароматические углеводороды, гидроочистка, гидрирование аренов, каталитические системы, изодепарафинизация, экологическая безопасность

DOI: 10.32935/0023-1169- 2026-656-4-28-31

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Reducing the Content of Arenes in Hydrocarbon Bases for Drilling Fluids

Aromatic hydrocarbons contained in low-viscosity hydrocarbon bases for drilling fluids (LVHBD) are toxic to living organisms and pose a serious threat to the Arctic ecosystem. This paper discusses technological approaches to reducing the content of aromatic hydrocarbons in MUOBR produced in oil refining facilities. The limitations of the existing hydrotreating and isodewaxing process in achieving the required level of aromatics are analyzed.

Comparative tests of catalytic systems for the hydrogenation of aromatic compounds have been conducted. The choice of a catalytic system with a high nickel content, which provides the intensification of the hydrogenation of arenes, has been substantiated. It has been shown that the introduction of a new catalytic system has made it possible to reduce the content of aromatic hydrocarbons in the MUOBR to 0.5% by weight, while maintaining the performance characteristics of the product. This will allow to further reduce the environmental risks when drilling wells in the Arctic zone, where bioremediation methods may be ineffective.

Key words: low-viscosity hydrocarbon base, drilling fluids, aromatic hydrocarbons, hydrotreating, aromatic hydrogenation, catalytic systems, isodewaxing, environmental safety.

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Перспективы выпуска термостабильных реактивных топлив с использованием гидропроцессов

Произведен комплексный анализ свойств узких фракций продукта гидрокрекинга (смеси керосина и дизельного топлива) и маловязких углеводородных основ для буровых растворов (фракции 180–320°C установки производства масел третьей группы) в качестве компонентов для производства термостабильного реактивного топлива. Выявлены зависимости температуры начала кристаллизации, содержания n-алканов и ароматических соединений, а также плотности от утяжеления фракционного состава. Показана возможность получения термостабильного реактивного топлива Т-8В из фракций 180–290°C установки производства базовых масел третьей группы и фракций 150–220°C установки гидрокрекинга. Получен лабораторный образец, который проанализирован по всем показателям качества, предъявляемым к авиационному топливу Т-8В. Анализ подтвердил соответствие всех показателей установленным нормам.

Ключевые слова: термостабильное реактивное топливо, дозвуковая и сверхзвуковая авиация, комплексный анализ свойств узких фракций, маловязкая основа для буровых растворов, керосин и дизельное топливо гидрокрекинга.

DOI: 10.32935/0023-1169- 2026-656-4-32-37

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Perspectives of Thermostable Jet Fuels Production with the Use of Hydroprocesses

A comprehensive analysis of narrow fractions properties of the hydrocracking products (kerosene and diesel fuel blends) and low-viscosity hydrocarbon bases for drilling fluids (fractions 180–320°C of Group III Base Oils

Production unit) as components for the production of thermostable jet fuels has been conducted. The dependence of the chilling point, the content of n-alkanes and aromatic compounds, and the density on the heaviness of the fractional composition has been identified. The possibility of obtaining thermostable jet fuel T-8V from fractions 180–290°C of Group III Base Oils Production unit and fractions 150–220°C of the Hydrocracking unit has been demonstrated. A laboratory sample has been obtained, which has been analyzed for all quality indicators required for aviation fuel T-8B. The analysis has confirmed that all indicators meet the established standards.

Key words: thermostable jet fuel, subsonic and supersonic aviation, complex analysis of narrow fractions properties, low-viscosity base for drilling fluids, hydrocracking kerosene and diesel fuel.

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Совершенствование и перспективы процесса гидродемеркаптанизации реактивного топлива

Описан процесс разработки и модернизации процесса гидродемеркаптанизации реактивного топлива, текущий подход к его применению в ПАО «Славнефть-ЯНОС». В ходе опытно-промышленного пробега оценены возможности процесса гидродемеркаптанизации по очистке прямогонной керосиновой фракции на катализаторе в начале цикла работы в интервале параметров, разрешенных действующей технологией производства топлива ТС-1. Проведен лабораторный эксперимент по оценке влияния технологических параметров процесса гидродемеркаптанизации на глубину очистки высокосернистого сырья. Показана возможность снижения содержания общей серы помимо меркаптановой. Сформулировано направление дальнейшего развития процесса гидродемеркаптанизации и цель его применения.

Ключевые слова: реактивное топливо, гидродемеркаптанизация, содержание общей серы, содержание меркаптановой серы, глубина очистки, лабораторная установка, опытно-промышленной пробег.

DOI: 10.32935/0023-1169- 2026-656-4-38-45

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Improvement and Prospects of the Jet Fuel Hydrodemercaptanization Process

The process of developing and improving the jet fuel hydrodemercaptanization process and the current approach to its application at Slavneft-YANOS PJSC are described. During the test run, the hydrodemercaptanization process was evaluated for its ability to treat the straight-run kerosene fraction on a catalyst at the beginning of the cycle within the parameters allowed by the current technology for producing TS-1 fuel. A laboratory experiment was conducted to assess the impact of the hydrodemercaptanization process parameters on the treatment depth of high-sulfur feed. The

possibility of reducing the total sulfur content in addition to mercaptan sulfur was demonstrated. The direction of further development of the hydrodemercaptanization process and the purpose of its application have been established.

Key words: jet fuel, hydrodemercaptanization, total sulfur content, mercaptan sulfur content, treatment depth, laboratory unit, test run.

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Увеличение объемов выпуска топлива для реактивных двигателей марки ТС-1 в ПАО «Славнефть-ЯНОС» за счет расширения возможностей использования компонента гидродемеркаптанизации

В статье рассмотрены результаты выполненных работ, позволяющих повысить объем выпуска качественного топлива для реактивных двигателей ТС-1 в ПАО «Славнефть-ЯНОС» за счет расширения фракционного состава компонента топлива ТС-1 – гидродемеркаптанизированной фракции. Результатами испытаний подтверждено, что происходящее при этом повышение температуры начала кристаллизации компонента гидродемеркаптанизации до минус 57 °С с учетом последующего смешения с компонентом гидрокрекинга, имеющего значительный запас качества по этому показателю, в рамках действующей технологии промышленного производства не приводит к ухудшению качества готового топлива.

Ключевые слова: топливо для реактивных двигателей, компонент гидродемеркаптанизации, компонент гидрокрекинга, температура начала кристаллизации, нормы.

DOI: 10.32935/0023-1169- 2026-656-4-46-49

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Production Increase of TS-1 Fuel For Jet Engines at Slavneft-YANOS PJSCby Expanding The Possibilities of Using the Hydrodemercaptanization Component

This paper reviews the results of the performed work, which make it possible to increase the production of high-quality TS-1 fuel for jet engines at Slavneft-YANOS PJSC by expanding the fractional composition of the TS-1 fuel component, the hydrodemercaptanized fraction (HDM). The test results confirm that the resulting increase in the chill point of the HDM component to minus 57°C, followed by mixing with the hydrocracking component, which has a significant quality margin in this regard, does not lead to a deterioration in the quality of the finished fuel within the current industrial production technology.

Key words: fuel for jet engines, hydrodemercaptanization component, hydrocracking component, chill point, standards.

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Отбор светлых на установках АВТ сверх потенциала.

Разработка инновационной технологии производства

В работе предложено повысить выход светлых нефтепродуктов на установках АВТ сверх потенциала за счет утяжеления 95%-ной точки выкипания дизельного топлива с 360 °С (требование ГОСТ) до 378°C. Далее фракционный состав облегчается за счет гидрирования ароматических соединений, селективного гидрокрекинга длинноцепочечных n-парафинов и их изомеризации в тяжелой части дизельного топлива в процессе гидроочистки. Эти процессы протекают на специально разработанной компанией «HAIHUA INDUSTRY GROUP» каталитической системе гидроочистки с функцией облегчения фракционного состава. Эффективность данного подхода подтверждена в ходе опытного пробега.

Ключевые слова: первичная переработка нефти, светлые нефтепродукты, дизельное топливо, гидроочистка, катализаторь.

DOI: 10.32935/0023-1169- 2026-656-4-50-57

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Yield of light petroleum products at CDU Units beyond the potential.

Developing the production process innovation

It is proposed to increase the yield of light petroleum products at the AVT (atmospheric vacuum pipestill) units beyond the potential by weighting the 95% boiling point of diesel fuel from 360 °C (GOST requirement) to 378 °C. Further,

the fractional composition is lightened by the hydrogenation of aromatic compounds, selective hydrocracking of long-chain n-paraffins and their isomerization in the heavy part of diesel fuel in the hydrotreatment process. These processes take place on a specially developed "HAIHUA INDUSTRY GROUP" catalytic hydrotreatment system with a function of lightening the fractional composition. The effectiveness of this approach has been confirmed during a test run.

Key words: *primary oil refining, light oil products, diesel fuel, hydrotreatment, catalyzer.*

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Борьба с коррозией в ПАО «Славнефть-ЯНОС»

В статье рассматриваются типичные виды коррозионных повреждений металла оборудования и трубопроводов НПЗ, описаны мероприятия по защите оборудования от коррозии и методы контроля скорости коррозии. Предложены перспективные направления в области мониторинга коррозии.

Ключевые слова: *коррозия, химико-технологическая защита, метод электрического сопротивления, ультразвуковой мониторинг коррозии, техническое обслуживание и ремонт оборудования, легкие органические кислоты, искусственный интеллект.*

DOI: 10.32935/0023-1169- 2026-656-4-58-64

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Corrosion Control at Slavneft-YANOS PJSC

This paper reviews typical types of corrosion damages of refinery equipment and pipelines, and describes measures to protect equipment from corrosion as well as corrosion speed control methods. Perspective activity directions in the field of corrosion monitoring are suggested.

Key words: *corrosion, chemical and technological protection, method of electrical resistance, ultrasonic monitoring of corrosion, maintenance and repair of equipment, light organic acids, artificial intelligence.*

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Fischer–Tropsch Co-Catalysts Supported on Mesoporous MCM-41

We compared four Fischer–Tropsch catalysts containing 15 mass % cobalt supported on ordered MCM-41 mesoporous silica samples differing in the procedure for introducing the acidic component: 1) an additive-free system (Co/MCM-41), 2) mechanical mixtures of MCM-41 with natural halloysite aluminosilicate nanotubes

(Co/MCM-41+HNT), 3) with alumina (Co/MCM-41+Al₂O₃), and 4) a composite, in which MCM-41 was grown on the surface of halloysite nanotubes (Co/MCM-41/HNT). The supports and catalysts were characterized by x-ray diffraction, low-temperature nitrogen adsorption, temperature-programmed reduction with hydrogen, and transmission electron microscopy. The Co₃O₄ crystallite diameters (4.9-8.0 nm) and cobalt dispersion (4.2-6.8%) were determined using the Scherrer equation. The governing parameter was shown to be not the dispersion as such but rather its combination with reducibility. Cobalt was found more highly dispersed in the silica- and halloysite-containing systems ($D = 6.5\text{--}6.8\%$) yet strongly bound to silica and reduced only above 735°C, while alumina weakens this interaction (permitting reduction at 688°C) with moderate particle growth ($D = 4.2\%$). Following this preliminary screening, only Co/MCM-41+Al₂O₃ was subjected to further catalytic testing, which showed 13.5% CO conversion, C₅+ selectivity of 76.9%, and minimum methane yield of 13.6%.

Keywords: Fischer–Tropsch synthesis, cobalt catalysis, mesoporous MCM-41, halloysite, aluminosilicate nanotubes, bifunctional catalysts, diesel fraction, cobalt reducibility.

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Effect of Syngas Composition on Alcohol Synthesis over an Fe-K-V/Chitosan-Derived Carbon Catalyst

This study investigates the effect of feed composition (CO/H₂, CO₂/H₂, and CO/CO₂/H₂) on the catalytic properties of an Fe-K-V catalyst supported on a chitosan-derived carbon matrix in the synthesis of aliphatic alcohols. The highest CO conversion, up to 98.3%, was achieved with the CO/H₂ feed, whereas the maximum alcohol selectivity of 23-25% was obtained when CO and CO₂ were co-fed. At 280°C, the mass fraction of alcohols in the hydrocarbon phase reached 24.2 wt% with the CO/CO₂/H₂ feed, more than twice the value obtained with the CO/H₂ feed; alcohols up to C₁₈ were identified among the reaction products. Fourier-transform infrared spectroscopy indicated that thermal treatment of chitosan resulted in the formation of a nitrogen-containing carbon matrix. X-ray diffraction analysis demonstrated that the phase composition of the iron-containing components depended on the feed composition: □-Fe₅C₂, Fe₃C, □-Fe, and Fe₃O₄ were identified after catalytic testing with the CO/CO₂/H₂ feed.

Keywords: carbon oxide hydrogenation, oxygenates, higher alcohols, iron-based catalysts.

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Thermal Treatment of Solid Oily Industrial Waste:

Experimental Study of the Coking Process

This paper presents a laboratory study of the application of coking to a wide range of solid waste contaminated with oils and petroleum products and generated at metallurgical plants. The results demonstrate that coking provides

effective feedstock dewatering and oil removal while producing a carbonaceous residue suitable for use in sinter production and liquid hydrocarbons that can potentially serve as low-viscosity boiler fuel. The main process challenges, including foaming, feedstock carryover, and the formation of stable emulsions, were identified, and methods for their control were proposed.

Keywords: coking, oily waste, waste treatment, emulsions, foaming, boiler fuel, sinter feedstock.

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Adsorption of Lead Ions on Modified Adsorbents Derived from Sunflower Heads

Results are given for a study of the modification of de-seeded sunflower heads used in the production of adsorbent materials for the removal of lead ions from aqueous solutions. The raw material was subjected to thermal, chemical, thermochemical, and steam-gas activation, as well as sequential steam-gas and chemical activation. All the modification methods studied increase the content of oxygen-containing functional groups in comparison with the starting raw material. Chemical, thermochemical, and combined steam-gas and chemical activation provided for predominance of carboxyl over hydroxyl groups. The maximum adsorption capacity (24.7 mg/g) was achieved for the sample obtained by consecutive steam-gas and chemical activation. Scanning electron microscopy was used to show that the modified samples have a well-developed surface and mesopores with diameter about 1 mm not found in the starting raw material. The lead ion adsorption by the starting sample is described by the Freundlich model, while the Langmuir model is characteristic for the modified adsorbents, indicating different interaction mechanisms. Thus, sunflower heads can serve as a useful raw material source for obtaining adsorbents, while combined activation provided for the most efficient lead ion adsorption.

Keywords: sunflower heads, modification, adsorption, lead, SEM, Langmuir equation.

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Current Industrial Technologies for the Treatment and Recovery of Solid Oily Waste from Petrochemical and Metallurgical Industries

This article reviews current industrial technologies for the treatment and recovery of solid oily waste generated in large volumes by petrochemical, metallurgical, and machine-building enterprises. An extended classification of treatment methods is presented in detail, including physical (landfilling, separation, agglomeration, extraction, and filtration), thermal (drying, incineration in various types of furnaces, pyrolysis, gasification, thermal cracking, and plasma treatment), chemical (solidification), biological (bioremediation and vermiculture), and combined methods.

The advantages and limitations of these methods are discussed in terms of energy efficiency, environmental risks, hydrocarbon recovery, and capital and operating costs. Emerging technologies in this field are outlined, and the potential of combined treatment approaches to maximize the recovery of secondary resources while minimizing environmental impact is discussed.

Keywords: *solid oily waste, classification of treatment methods, waste treatment and recovery, emerging treatment technologies.*

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Modern Approaches to Controlling Petroleum System Properties in Heavy Feedstock Processing

This review systematizes current concepts of crude oils and petroleum products as petroleum disperse systems, together with approaches to the targeted control of their structural state in the processing of heavy petroleum feedstocks and manufacture of bituminous materials. The causes and manifestations of non-additive changes in properties during blending of crude oils, intermediate streams, and finished products are examined, along with the problem of component incompatibility and the methods available for assessing the stability of petroleum systems. The review analyzes trends in the feedstock base for bitumen production, opportunities for blending off-specification feed components, approaches to the mathematical modeling of bitumen properties, and the application of digital technologies, including machine-learning methods, to production control. It is shown that combining the principles of the physicochemical technology of petroleum with modern computational tools creates opportunities for improving both the efficiency of heavy feedstock processing and the quality of the resulting products.

Keywords: *petroleum disperse systems, heavy petroleum feedstock, crude oil incompatibility, blending; petroleum bitumen, mathematical modeling, machine learning, digitalization.*

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Research on Oil Demand Prediction and Purchase Intention under the Dual Carbon Target

Aiming at the problems of low prediction accuracy, poor adaptability to complex factors, and insufficient integration of purchase intention factors in traditional oil demand prediction methods, this study proposes an oil demand prediction model based on Convolutional Neural Network (CNN), and integrates the dual carbon policy factors, economic indicators, and market purchase intention characteristics to construct a comprehensive research framework. The influencing factors of oil demand and purchase intention under the dual carbon target are systematically analyzed, including economic growth, industrial structure adjustment, dual carbon policy intensity, energy substitution effect, and consumer purchase preference. CNN model is optimized by improving the network structure, adjusting the convolution kernel size, and introducing the dropout mechanism to avoid overfitting, so as to realize the accurate prediction of oil demand. At the same time, the Logit model is used to analyze the influencing factors of purchase intention, and the interaction mechanism between purchase intention and oil demand is explored. Taking China's oil market as an example, the simulation experiment is carried out by using the data from 2005 to

2024. The experimental results show that the proposed CNN prediction model has higher prediction accuracy than the traditional LSTM, BP neural network, and ARIMA models, with the mean absolute error (MAE) reduced by 18.3-32.7% and the root mean square error (RMSE) reduced by 20.1-35.4%. The research results can provide important theoretical support and practical reference for energy management departments, oil enterprises, and related institutions to formulate low-carbon energy policies, optimize oil supply chain management, and guide rational purchase behavior. This study enriches the research on oil demand prediction under the dual carbon target, and provides a new method and idea for the integration of deep learning models and purchase intention analysis in the energy field.

Keywords: dual carbon target, oil demand prediction, purchase intention, CNN model, simulation experiment, energy transformation.

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Research on Oil Demand Prediction and Purchase Intention under the Dual Carbon Target

Aiming at the problems of low prediction accuracy, poor adaptability to complex factors, and insufficient integration of purchase intention factors in traditional oil demand prediction methods, this study proposes an oil demand prediction model based on Convolutional Neural Network (CNN), and integrates the dual carbon policy factors, economic indicators, and market purchase intention characteristics to construct a comprehensive research framework. The influencing factors of oil demand and purchase intention under the dual carbon target are systematically analyzed, including economic growth, industrial structure adjustment, dual carbon policy intensity, energy substitution effect, and consumer purchase preference. CNN model is optimized by improving the network structure, adjusting the convolution kernel size, and introducing the dropout mechanism to avoid overfitting, so as to realize the accurate prediction of oil demand. At the same time, the Logit model is used to analyze the influencing factors of purchase intention, and the interaction mechanism between purchase intention and oil demand is explored. Taking China's oil market as an example, the simulation experiment is carried out by using the data from 2005 to 2024. The experimental results show that the proposed CNN prediction model has higher prediction accuracy than the traditional LSTM, BP neural network, and ARIMA models, with the mean absolute error (MAE) reduced by 18.3-32.7% and the root mean square error (RMSE) reduced by 20.1-35.4%. The research results can provide important theoretical support and practical reference for energy management departments, oil enterprises, and related institutions to formulate low-carbon energy policies, optimize oil supply chain management, and guide rational purchase behavior. This study enriches the research on oil demand prediction under the dual carbon target, and provides a new method and idea for the integration of deep learning models and purchase intention analysis in the energy field.

Keywords: dual carbon target, oil demand prediction, purchase intention, CNN model, simulation experiment, energy transformation.

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Applications and Development Trends of Electrochemical Treatment on Oily Wastewater

Oily wastewater, characterized by its complex composition and high degree of emulsification, is often difficult to treat effectively and meet discharge standards using conventional methods. Electrochemical technology has emerged as a research hotspot and key solution for treating various types of oily wastewater, owing to its high efficiency, controllability, minimal chemical consumption, and potential for resource recovery. This paper systematically reviews the current applications of electrochemical and its hybrid processes in treating typical oily wastewaters, including produced water from oil and gas fields, refinery effluents, shale oil wastewater, and ship-generated bilge water. Research indicates that, tailored to the specific water quality characteristics of different sources, optimizing the electric field configuration and integrating it with electrocoagulation/electroflotation /electrocatalytic oxidation, or coupling it with ultrasound, membrane separation, or microbial fuel cells (MFC), can significantly enhance the removal efficiency of oil, ammonia nitrogen, and refractory organic pollutants. This technology not only achieves deep purification and water reuse but also enables concurrent recovery of oil-phase resources while reducing sludge production and operational costs. In the future, electrochemical technology will evolve towards being more efficient, low-energy, green, and intelligent, providing a sustainable solution for oily wastewater treatment.

Keywords: electrochemistry, oilfield oily wastewater, refinery wastewater, shale oil wastewater, ship oily wastewater.

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Comparative analysis and application research

on dynamic analysis methods for different types of oil reservoirs

Different types of reservoir dynamic analysis methods have varying dynamic analysis contents and focuses. This paper analyzes the dynamic analysis contents and focuses of three different types of analysis methods based on object, time, and development stage, and studies their application situations. The study finds that from the object dimension, single-well dynamic analysis focuses on wellbore conditions and near-wellbore zone characteristics evaluation. From the time dimension, short-term analysis focuses on production anomaly diagnosis and treatment, mid-term analysis focuses on the evaluation of development plan implementation effects, and long-term analysis focuses on reservoir characteristics understanding and development strategy adjustment. From the development stage dimension, the early stage focuses on reservoir understanding and development mode optimization, the mid-term stage focuses on water injection effect evaluation and measure optimization, and the later stage focuses on tapping the potential of remaining oil and enhancing oil recovery technology application. The conclusions of

this paper are helpful for achieving the goal of fine reservoir description and efficient development through the organic combination of multi-dimensional dynamic analysis methods.

Keywords: multidimensional perspective, oil reservoir, dynamic analysis, analytical method, applied research.

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Research on the Transportation Mode of Mountain Machinery

Based on Laser Terrain Point Cloud

At present, in the maintenance and repair of oil and gas pipelines in the complex mountainous environment of Southwest China, there are practical problems such as difficulty in screening large-scale machinery and equipment transportation modes and low efficiency. In order to quickly optimize the transportation mode of mountain machinery and equipment and improve the efficiency of pipeline repair, this paper proposes a planning method of transportation mode of machinery and equipment based on laser terrain point cloud data. Firstly, the three-dimensional point cloud data of the working belt is obtained based on the laser radar. On this basis, a linear domain terrain parameter estimation algorithm is proposed. The algorithm extracts the key terrain characteristic parameters such as longitudinal slope, transverse slope and obstacle distribution of the working belt through the steps of linear region segmentation, sub-linear region segmentation and mesh generation. Furthermore, the terrain parameters are combined with the artificially perceived working condition parameters, and the traversal analysis and multi-objective screening of various candidate transportation modes are carried out to determine the mountain machine transportation scheme. The corresponding construction guidance parameters are generated for the transportation modes that need on-site construction such as climbing plough and light rail. The application shows that this method can effectively identify topographic features such as slope and obstacle points, provide scientific planning scheme and quantitative construction basis for the transportation of pipeline repair equipment in complex mountainous areas of southwest China, and significantly improve the safety, rationality and repair response efficiency of hoist transportation.

Keywords: Mountain machinery, laser radar, terrain point cloud, mode of transport, characteristic parameter estimation algorithm.

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A Data-Physical Model Fusion Framework for Oil Pipeline

Leakage Detection, Localization and Simulation

As critical infrastructure for oil and gas transportation, the safe operation of oil pipelines is crucial. Therefore, reliable real-time leak detection is essential, but traditional periodic inspections and alarm systems based on simple thresholds have encountered challenges. This study presented a systematic investigation of a data-physical model

fusion framework for oil pipeline leak detection, localization and simulation. The framework integrated data preprocessing and filtering, leak detection, and leakage localization based on negative pressure wave propagation. An “estimation-simulation” two-stage paradigm was introduced, which enabled leakage characteristic estimation and leakage simulation of the entire process from pre-leak state to leakage occurrence, development and to post-leak state. A systematic analysis and full-process verification was carried out based on a hypothetical pipeline section. The results indicated a relative deviation of 0.03% in leak detection time, and a relative deviation of 5.05% in leakage localization. It was concluded that the fusion of data-driven perception and physical model cognition offered a viable technical approach for the development of intelligent leakage detection in oil pipelines.

Keywords: oil pipeline, leak detection, leakage localization, data-physical model fusion, framework.

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Investigation of the Non-Equilibrium Development Mechanism

of Near Saturated Condensate Gas and Volatile Oil in Fractured Buried Hill Reservoir

In this work, the non-equilibrium depletion experiments under different depletion rates were carried out in the upper condensate gas and the lower volatile oil of the buried hill reservoir through the long core experiments, and the effects of different depletion rates on the recovery of condensate oil and volatile oil were investigated. The effective range of non-equilibrium effect and reasonable non-equilibrium depletion rate are clarified, and the influence of different permeability on the retrograde condensation damage degree during the depletion process is revealed. The results show that the production dynamics of condensate gas and volatile oil in buried hill reservoir present obvious dual medium characteristics, the fluid in fracture is the main contribution to production, and that in the matrix pore can only be heavy supplied at the late stage of depletion process under large pressure difference; the larger non-equilibrium depletion rate, the higher condensate oil recovery, however, the non-equilibrium effect has an effective range, the increase of condensate oil recovery is not obvious when the depletion rate is more than 10 MPa/h, large depletion rate may lead to the early retrograde condensation phenomenon in the far well area, moreover, increasing the depletion rate can make the volatile oil degassing speed slows down, the bubble flow phenomenon early occurs in the reservoir; the degree of retrograde condensation damage is negatively correlated with the core permeability, and the degree of retrograde condensation damage is increased significantly before the condensate oil reaches critical flow saturation, and the lower permeability, the earlier retrograde condensation damage reaches the maximum value. Therefore, considering the reservoir edge and bottom water situation, reasonably increasing the development speed will obtain higher recovery of condensate oil and volatile oil.

Keywords: fractured buried hill reservoir, condensate gas, volatile oil, non-equilibrium depletion, long core experiments.

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Study on Pore Characteristics of Hydrocarbon Occurrence in Continental Shale with Medium-High Maturity

In order to accurately and quantitatively characterize the pore space where the continental shale oil in different types of lithofacies occurs, we sampled the rock cores from the Middle Jurassic Lianggaoshan Formation in the southeastern Sichuan Basin of the Upper Yangtze Area. Results show significant differences in pore space characteristics for the occurrence of shale oil in different types of lithofacies. In organic-rich mixed and clayey mudstones with the highest TOC content, the free shale oil, occupying the largest reservoir space, mainly occurs in macropores and mesopores; and the adsorbed shale oil, occupying the largest reservoir space, mainly occurs in mesopores. In the organic-bearing clayey mudstone, the free shale oil takes a larger reservoir space and mainly occurs in macropores, followed by mesopores; and the adsorbed one, occupying a larger reservoir space. The organic-bearing mixed mudstone has a moderate TOC content, in which the free shale oil occupies a smaller reservoir space and primarily occurs in mesopores, followed by macropores; and the adsorbed one, which takes larger reservoir space, all occurs in mesopores. In the fine sandstone, the free shale oil occupies a smaller reservoir space and is primarily occurred in mesopores; while the adsorbed one occupies a smaller reservoir space and all occurs in mesopores.

Keywords: shale oil, continental shale, pore space, different types of lithofacies, pore volume, pore surface area.

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Pore Scale Simulation of Oil-Water Two-Phase Flow in Heterogeneous Offshore Sandstone Reservoirs

Waterflooding is a widely adopted technique in the development of sandstone oil reservoirs. A clear understanding of the remaining oil distribution patterns is essential for subsequent enhanced oil recovery applications. Variation in pore-throat structures and fluid flowing conditions lead to different remaining oil distribution characteristics and oil recovery factors. This study investigates the remaining oil distribution of sandstone samples taken from an offshore oil reservoir with different microscopic pore structures. The pore structures of different samples were quantitatively characterized using high-resolution 3D micro-computed tomography (CT) and digital rock reconstruction techniques, and corresponding unstructured tetrahedral mesh models were established. The volume of fluid (VOF) method coupled with Navier-Stokes equations was adopted to simulate oil-water two-phase flow in rock samples with different permeabilities. The effects of pore-structure heterogeneity, injection pressure, wettability, mobility ratio on oil recovery factor were analyzed. The results indicate that heterogeneity of pore structures exerts a prominent influence on microscopic oil recovery. Under identical conditions of water injection pressure, wettability and mobility ratio, oil recovery factor increases significantly with the increase of the permeability. Moreover, increasing water injection pressure, altering rock wettability from oil-wet to water-wet, and reducing the mobility ratio can effectively enhance oil recovery (EOR). Pore structure heterogeneity has a pronounced impact on the effectiveness of EOR strategies. Specifically, reservoirs with lower heterogeneity typically yield better oil recovery increments when subjected to identical EOR strategy.

Keywords: digital rock, pore structure heterogeneity, pore scale simulation, oil-water two-phase flow, oil recovery efficiency.

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Intelligent Optimization of Drilling Fluid Parameters

Based on Improved Particle Swarm Optimization

Proper drilling fluid parameters are critical to safe and efficient oil and gas drilling operations, yet traditional empirical design methods struggle to achieve global optimal solutions for multi-parameter coupled optimization, and existing intelligent optimization studies rarely focus on the intrinsic rheological parameters of drilling fluids. This study developed a hybrid Particle Swarm Optimization-Simulated Annealing model for the intelligent optimization of key drilling fluid parameters. Based on over 300,000 field drilling datasets, six parameters (apparent viscosity, density, API fluid loss, HTHP fluid loss, final gel strength, and yield point) were selected as decision variables via the maximum relevance and minimum redundancy algorithm. The hybrid model integrated the Metropolis criterion of SA into the particle update strategy of PSO, with a weighted fitness function constructed to maximize daily drilling footage and Rate of Penetration (ROP). Convergence analysis over 100 iterations shows the model has superior stability with a standard deviation of 0.002. Experimental data indicate that daily drilling footage increases from 76.77 m/d to 93.32 m/d and ROP from 8.89 m/h to 10.36 m/h, outperforming standalone PSO and SA algorithms. This hybrid approach effectively balances convergence efficiency and global optimization accuracy, providing a reliable data-driven paradigm for intelligent drilling fluid design.

Keywords: particle swarm optimization, simulated annealing, drilling fluid, parameter optimization, digital model.

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Study on Pore Fluid Chemical Characteristics and Seepage Mechanism

of Unconventional Oil and Gas Reservoirs

To clarify the coupling relationship between pore fluid chemical characteristics and microscopic seepage mechanism of unconventional reservoirs, this paper takes typical tight sandstone, continental shale and low-permeability carbonate unconventional reservoirs in the Ordos Basin as research objects. The results show that the formation water of unconventional oil and gas reservoirs in the study area is dominated by CaCl₂ water type with high total dissolved solids and weak acidic environment. The main cations are Na⁺ and Ca²⁺, and the dominant anion is Cl⁻. Mineral dissolution, clay mineral hydration expansion and ion exchange induced by fluid chemical reactions are the key causes of pore throat heterogeneity enhancement and permeability damage. Under formation water salinity of 25000–35000 mg/L, the critical seepage pressure gradient of tight sandstone reservoir ranges from 0.032 to 0.045 MPa/m, and the seepage compliance coefficient decreases by 28.6–35.2% compared with pure hydrocarbon fluid. Ion exchange between fluid and clay minerals changes the Zeta potential of rock surface, increases the boundary layer thickness by 15.3–22.7%, and significantly restricts hydrocarbon migration in microscopic nanopores. This study systematically reveals the microscopic seepage control mechanism of pore fluid chemical characteristics from the perspective of fluid geochemistry, and provides theoretical basis and technical reference for efficient development, water injection optimization and fracturing fluid formulation design of similar unconventional oil and gas reservoirs.

Keywords: unconventional oil and gas reservoir, pore fluid, chemical characteristics, fluid–rock interaction, seepage mechanism, low permeability, boundary layer effect.

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Research on Comprehensive Pressure Assessment Method

for Free-Spanning Subsea Pipelines Based on Multi-Source Data Fusion

and Three-Dimensional Modeling

Taking a certain offshore section of the China-Myanmar oil and gas pipeline as an example, high-precision data on seabed topography, geomorphology, pipeline spatial positioning, and free-spanning status were acquired through synchronized shipborne surveys using multi-beam echo sounding, side-scan sonar, and sub-bottom profiler systems. A refined three-dimensional geometric model incorporating realistic seabed topography, three-dimensional pipeline

spatial curves, and free-spanning morphology was innovatively constructed. Based on this model, a comprehensive pressure calculation framework was established, accounting for the combined effects of hydrostatic pressure, ocean current dynamic pressure, internal pressure, thermal stress, and bending stress. The precise directions and points of application for each load were determined through three-dimensional spatial vector calculations. Combined with pipeline properties and design parameters, a quantitative analysis of combined stresses under three-dimensional spatial conditions was conducted for an identified 11 m free span. The calculation results demonstrate that the comprehensive equivalent stress, accounting for pipeline spatial curvature and localized scour topography, reaches 144.8 MPa, which exceeds the allowable stress under current operating conditions, indicating insufficient structural safety reserve. The three-dimensional modeling and coupled calculation method established in this paper achieves a leap from “two-dimensional simplified analysis” to “three-dimensional spatial accurate assessment,” significantly improving the accuracy and reliability of free span risk assessment for subsea pipelines, thereby providing a novel technical approach for precise pipeline maintenance and safety decision-making.

Keywords: *subsea pipeline, multi-source data fusion, three-dimensional modeling, free span identification, comprehensive pressure assessment, coupled analysis, spatial stress.*

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Spatiotemporal Evolution and Petroleum System Model of Tectonically Controlled Clastic Reservoirs

The Tahe Oilfield hosts Triassic thin-sand clastic reservoirs formed under strong tectonic inheritance, multi-phase deformation, and staged hydrocarbon charging. To resolve imaging and prediction challenges, we integrate fit-for-purpose 3D seismic processing (micro-log-constrained statics, amplitude-preserving denoising, deconvolution with spectrum extension, anisotropic velocity modeling, and pre-stack TTI depth migration) with map-section-consistent interpretation, thin-bed forward modeling, facies-controlled inversion, pre/post-stack fluid detection, and well-seismic calibration. The results clarify the spatiotemporal evolution of the system: Indosinian–Yanshanian–Himalayan structural stages produced X-type conjugate shears, en-echelon normal faults, and salt-related deformation that partition thin-sand fairways (SQ2–SQ6) and govern seal continuity. We identify a hierarchical seal framework and evidence for multi-episode charging that together explain observed vertical/lateral pay patterns. On this basis we build a petroleum system model that couples source kitchens, fault-assisted stepwise versus blanket-like migration, trap formation/preservation, and risk levers (caprock integrity, small-fault sealing, and reactivation history). Application in the S41–T903A area yields improved thin-sand detectability, coherent closure geometry, and a ranked target set validated by plan-profile consistency and fluid indicators. The model provides deployable rules for exploration and appraisal in tectonically segmented clastic plays across Tahe and analogous basins.

Keywords: *Tahe Oilfield, triassic thin-sand bodies, re-stack TTI depth migration, facies-controlled inversion, petroleum system model.*

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Characterization of Pore Structure and Fluid Mobility in Tight Sandstones Using Fractal Theory

The pore structure, fluid mobility and its controlling factors of the tight sandstone reservoir of the Xujiahe Formation in Tianfu area were studied by various experimental analyses and fractal theory. The results show that: The reservoir of the Xu 4 member in the researching area is mainly lithic feldspar sandstone, and feldspar dissolved pores and a small amount of residual intergranular pores are developed. The pore structure of Xu 4 member is divided into three types. The pore throat size of type I pore structure is larger, the connectivity and sorting are better, the fractal dimension is small, the fluid mobility is strong. The pore throat radius of type II is small and the pore throat sorting is poor. The average movable fluid porosity and saturation are 1.13 % and 14.3 %. The pore throat radius of type III is small, the pore throat structure is the most complex, and the fluid mobility is the worst. The sandstone formed under strong hydrodynamic conditions has coarser grain size, physical properties and stronger fluid mobility. Sandstone with high quartz content, low calcite and clay mineral content has better pore structure and fluid mobility. The higher the chlorite content, the better fluid mobility of the reservoir.

Keywords: tight sandstone reservoir, pore structure, fluid mobility, high pressure mercury injection, nuclear magnetic resonance.

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Tectonic Characteristics and Evolution of the Caledonian Extensional Fault Systems on the Southern Slope of an Intra-Cratonic Paleo-Uplift

By leveraging advanced 3D seismic data, this study conducted a detailed analysis of the geometries and structural properties of the major fault zones on the southern slope. These zones are characterized as normal fault systems, exhibiting segmented, arc-shaped traces connected by relay structures that reflect non-coplanar fault segment arrangements. The tectonic activity of these fault systems developed in two distinct phases. During the Middle to Late Cambrian, extensional faulting began, forming high-angle normal faults that caused significant dislocation of the Sinian and Cambrian strata. In the second phase, during Feixianguan Formation deposition, parts of these faults were reactivated along pre-existing fault surfaces, evolving into extensional fault-propagating folds. Above the fault tips, Permian to Lower Triassic strata were primarily subjected to shear deformation, indicating secondary tectonic adjustments. Structural restorations using 2D and 3D seismic data highlight a strong correlation between the normal fault system's formation and the uplift of the central paleo-uplift. The fault orientations consistently align with the paleo-uplift's strike, and the arc-shaped fault traces conform to the uplift margins. These findings suggest

that vertical uplift of the central paleo-uplift during the early Caledonian induced normal faulting, driving substantial structural changes. The combination of fault-controlled migration pathways, effective seals, and post-Caledonian tectonic stability enabled long-term preservation of hydrocarbons, ultimately shaping the present enrichment pattern of Cambrian reservoirs in the southern slope of the Central Uplift.

Keywords: *Central Sichuan paleo-uplift, propagating normal fault, paleo-uplift and normal fault system.*

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Control of **Formation Pressure on the Productivity**

in Tight-Sandstone Gas Pools and Seismic Prediction Method

Formation pressure is a key indicator for predicting unconventional hydrocarbon resources such as tight sandstone gas and shale gas. The technical difficulty of predicting formation pressure and coefficients is the key to limiting the development of tight-sandstone gas in Sichuan Basin. This study proposes three sand body architectures based on the filling styles within the channels, along with the differences in sand and mud combinations and particle size distributions. Three levels of faults have been identified. The J1 Fault connects the source rocks, resulting in a widespread distribution of high pressure conditions. Pressure gradually decreases with distance from the J1 Fault. River-channel sand bodies are widely distributed and exhibit high porosity, providing ample reservoir space for the accumulation of natural gas under relatively high pressure conditions. The results indicate that the fault level and sand body architecture control the formation pressure of tight-sandstone gas pools. This study utilized the Eaton method and big data AI techniques to predict formation pressure, comparing the advantages and disadvantages of each method. The predictions from the Eaton method and the effective stress method are consistently higher without any notable pattern. In contrast, the predictions generated by the AI method align more closely with the drilling data. The effective stress method produces a concentrated range of values, making it difficult to capture lateral variations in detail. In the eastern part of the study area, the AI method better aligns with geological interpretations.

Keywords: *formation pressure, tight sandstone, seismic prediction, AI method, productivity.*

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Research on the Identification Method of Microscopic Physical Characteristics of Fuel and Adaptive Investigation Techniques

This paper systematically summarizes the performance boundaries of conventional detection approaches for blended fuel-oil specimens. Gas chromatography-mass spectrometry (GC-MS) is adopted as the core micro-identification tool. A total of 12 groups of representative oil samples covering base fuel oil components and multi-component blended specimens with variable mixing ratios are prepared for systematic testing. Through quantitative processing

of chromatographic fingerprint data, distribution rules of n-alkanes, isoprenoid hydrocarbons, polycyclic aromatic hydrocarbons and characteristic heteroatomic compounds are analyzed. Twelve tables are arranged to demonstrate experimental parameters, routine physical-chemical test results, component statistical data, fingerprint characteristic-peak information and comparative discrimination indexes. On this basis, a multi-dimensional micro-identification workflow for oil samples oriented to investigation-related technical requirements is constructed. The study reveals that macroscopic physical-chemical indexes alone cannot fully characterize compositional distinctions of blended oil samples. Characteristic fingerprint features obtained by GC-MS, including n-alkane envelope distribution, biomarker-ratio parameters and relative abundance of polycyclic aromatic hydrocarbons, can serve as stable discrimination markers. The established technical workflow provides reliable technical support for fine identification and source correlation of complex unknown oil samples for investigation-oriented technical applications. It can better adapt to the practical needs of various investigative-technique businesses for fine discrimination of unknown oil samples.

Keywords: fuel oil, blending, GC-MS fingerprint, conventional physical-chemical detection, micro-identification, investigation-related technique, hydrocarbon composition.

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A Deep Neural Network-Based Surrogate Model

for Numerical Simulation Of Functional Water Flooding

This paper proposes an improved Convolutional Neural Network (CNN) model integrating attention mechanism for oil energy demand forecasting. First, a multi-dimensional feature index system is constructed from four dimensions: low-carbon constraint, green economic security, macroeconomic operation, and energy market dynamics. Then, the traditional CNN is improved by introducing a channel attention mechanism to enhance the model's ability to extract key feature information. Finally, based on the global oil market data from 2000 to 2024, simulation experiments are carried out to compare the proposed model with traditional forecasting models such as BP neural network, support vector regression (SVR), and standard CNN. The results show that the improved CNN model has higher forecasting accuracy, with the mean absolute percentage error (MAPE) reduced by 3.21-8.76% compared with the comparison models. It can effectively capture the dynamic changes of oil demand under the dual goals, providing a reliable decision-making basis for energy security guarantee and low-carbon transition planning. The research also reveals that carbon emission intensity, renewable energy penetration rate, and petrochemical industry development level are the key factors affecting oil demand under the dual goals.

Keywords: deep learning, surrogate modeling, reservoir simulation, functional water drive, enhanced oil recovery, uncertainty quantification.

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Analysis of Composite Oil Repelling System in Terms of Enhanced Oil Recovery

Ordos Basin is one of the important oil and gas-bearing basins in China, with complex geological conditions, and the main oil reservoirs are dominated by low-permeability-tight sandstone, which are characterized by poor reservoir physical properties, strong non-homogeneity, and insufficient natural energy, etc. In this paper, we developed a binary composite oil driving system and evaluated the comprehensive performance of the system through indoor experiments. In this paper, a binary composite oil repellent system was developed, and the comprehensive performance of the repellent system was evaluated by indoor experiments. The results show that: the binary composite oil repellent system has strong temperature resistance, after aging at 115°C, the viscosity retention rate of the system can still reach more than 90%, and the interfacial tension can still reach 10^{-3} mN/m order of magnitude; when the mineralization degree is greater than 100000 mg/L, the system can still maintain high viscosity and low interfacial tension; the system has good long-term aging stability, and it has good stability under the conditions of reservoir temperature and mineralization. The system has good long-term aging stability, the viscosity retention rate is above 85% after aging for 60d under the condition of temperature and mineralization, and the interfacial tension is always maintained in the range of 10^{-3} mN/m; the oil repellent system can still maintain high viscosity and low interfacial tension after adsorption for 6 times under the condition of stratum, and it has good antisorption performance, and it has achieved good results in the field application.

Keywords: binary composite drive, emulsification performance, adsorption performance, oil driving performance, enhanced recovery.

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Multidimensional Modeling and Analysis of Oil-Related

Regional Economic Disparities Based on an Improved Convolutional

Neural Network in the Context of Green Economy

This paper proposes an improved Convolutional Neural Network (CNN) model integrating attention mechanism for oil energy demand forecasting. First, a multi-dimensional feature index system is constructed from four dimensions: low-carbon constraint, green economic security, macroeconomic operation, and energy market dynamics. Then, the traditional CNN is improved by introducing a channel attention mechanism to enhance the model's ability to extract

key feature information. Finally, based on the global oil market data from 2000 to 2024, simulation experiments are carried out to compare the proposed model with traditional forecasting models such as BP neural network, support vector regression (SVR), and standard CNN. The results show that the improved CNN model has higher forecasting accuracy, with the mean absolute percentage error (MAPE) reduced by 3.21-8.76% compared with the comparison models. It can effectively capture the dynamic changes of oil demand under the dual goals, providing a reliable decision-making basis for energy security guarantee and low-carbon transition planning. The research also reveals that carbon emission intensity, renewable energy penetration rate, and petrochemical industry development level are the key factors affecting oil demand under the dual goals. The analysis further reveals that oil-related regional economic disparities, reflected in uneven GDP growth, industrialization, urbanization and oil import dependence across economies, shape divergent oil demand trajectories and call for differentiated regional energy policies.

Keywords: low-carbon constraint, green economic security, oil energy demand forecasting, improved CNN, multi-dimensional feature modeling, regional economic disparities.