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Разделение природного газа технологией газогидратной кристаллизации: расчет коэффициентов газогидратного распределения

В работе рассмотрена возможность разделения природного газа Оренбургского месторождения по технологии газогидратной кристаллизации с целью очистки метана от примесей. Математически смоделировано влияние состава смеси, температуры и давления процесса на эффективность разделения смеси $CH_4 - C_2H_6 - C_3H_8 - i-C_4H_{10} - n-C_4H_{10} - C_5H_{12} - N_2 - H_2S - CO_2$. Эффективность определялась на основании коэффициентов газогидратного распределения. Показано, что со временем эксплуатации месторождения коэффициент газогидратного распределения для метана изменился незначительно и составил менее 1. Установлено преимущественное концентрирование CH_4 , $n-C_4H_{10}$, $n-C_5H_{12}$, N_2 , CO_2 в газовой фазе и C_3H_8 , $i-C_4H_{10}$ и H_2S — в газогидратной. В исследованном интервале значений температуры и давления установлен максимальный коэффициент газогидратного распределения при температуре 268,15 К и давлении 8 МПа для C_3H_8 , $i-C_4H_{10}$, H_2S , равный 32,32, 44,66, 31,61 соответственно.

Ключевые слова: газовые гидраты, коэффициент газогидратного распределения, природный газ, метан.

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Natural Gas Separation by Gas Hydrate Crystallization Technology:

Calculation of Gas Hydrate Distribution Coefficients

This work considers the possibility of separating the natural gas from the Orenburg field using gas hydrate crystallization technology to purify methane from impurities. The effect of the mixture composition, process temperature, and pressure on the separation efficiency of the gas mixture $CH_4 - C_2H_6 - C_3H_8 - i-C_4H_{10} - n-C_4H_{10} - C_5H_{12} - N_2 - H_2S - CO_2$ was mathematically modeled. Efficiency was determined based on gas hydrate distribution coefficients. It was shown that the CH_4 gas hydrate distribution coefficient varied insignificantly with the field operation time and amounted to less than 1. The predominant concentration of CH_4 , $n-C_4H_{10}$, $n-C_5H_{12}$, N_2 , CO_2 in the gas phase and C_3H_8 , $i-C_4H_{10}$, H_2S in the gas hydrate phase was established. In the studied temperature (268.15–283.15 K) and pressure (2.00–8.00 MPa) ranges, the maximum gas hydrate distribution coefficient of C_3H_8 , $i-C_4H_{10}$, and H_2S was found to be 32.32, 44.66, and 31.61, respectively, at 268.15 K and 8 MPa.

Key words: gas hydrates, gas hydrate distribution coefficient, natural gas, methane.

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Влияние метанола на кинетику нуклеации и роста гидрата метана

В работе экспериментально исследована кинетика нуклеации и роста гидрата метана в присутствии водных растворов метанола концентрацией 0; 1; 2,5; 5; 10 и 20% мас. Установлено, что добавление метанола статистически значимо уменьшает переохлаждение начала гидратообразования метана ΔT_0 даже при низких концентрациях. Величина ΔT_0 уменьшается в пять раз при переходе от воды к 20% мас. метанола. Обнаружено, что с ростом содержания спирта наблюдается корреляция, связанная с увеличением количества гидрата в конце стадии охлаждения. Добавление метанола к воде также повышает скорость роста гидрата метана. Полученные экспериментальные данные указывают на роль метанола как промотора нуклеации и роста гидрата метана, а также свидетельствуют о двойственной природе метанола, который одновременно является термодинамическим ингибитором газовых гидратов.

Ключевые слова: гидрат метан, метанол, кинетический промотор гидратообразования, нуклеация, переохлаждение, кристаллизация.

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Effect of Methanol on Methane Hydrate Nucleation and Growth Kinetics

In the present work, we experimentally investigated the nucleation and growth kinetics of methane hydrate in the presence of aqueous methanol solutions at alcohol concentrations of 0, 1, 2.5, 5, 10, and 20 mass %. It was found that the addition of methanol statistically significantly reduces the supercooling of the methane hydrate onset ΔT_0 even at low concentrations. The value of ΔT_0 decreases by a factor of 5 when transitioning from water to 20 mass% methanol. We have observed that as the alcohol content increases, there is a correlation with an increase in the amount of hydrate at the end of the cooling stage. Adding methanol to water also increases the rate of methane hydrate growth. Thus, our experimental data indicate the role of methanol as a kinetic promoter of methane hydrate nucleation and growth, and the dual nature of methanol which is also a thermodynamic hydrate inhibitor.

Key words: methane hydrate, methanol, kinetic hydrate promoter, nucleation, supercooling; crystallization.

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Синтез ингибитора гидратообразования на основе водорастворимого полиуретана в реакторах непрерывного и периодического действия

Данная работа посвящена синтезу и оптимизации технологии получения ингибитора гидратообразования низкой дозировки на основе класса водорастворимых полиуретанов. Для оптимизации синтеза ингибитора некоторые мономеры замещены на импортонезависимые и более дешевые реагенты. Апробированы два способа полимеризации: в реакторах непрерывного и периодического действия. Для моделирования условий непрерывного синтеза сконструирована лабораторная проточная установка.

Ключевые слова: газовые гидраты, кинетические ингибиторы гидратообразования, водорастворимые полиуретаны, реакторы непрерывного и периодического действия.

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Synthesis of Hydrate Inhibitor Based on Waterborne Polyurethane in Batch and Flow Reactors

This work is focused on the synthesis and optimizing technology for obtaining a low-dosage hydrate formation inhibitor based on a class of waterborne polyurethanes. In order to optimize the synthesis of the inhibitor, some monomers were replaced by import-independent and lower priced ones. Two methods of polymerization were tested, namely in batch and flow reactors. A laboratory flow unit was designed to simulate the conditions of continuous synthesis.

Key words: gas hydrate, kinetic hydrate inhibitors, waterborne polyurethanes, batch and flow reactors.

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Экспериментальные исследования гидратообразования природного газа в пористой среде в присутствии растворов хлорида и гидрокарбоната натрия

В работе приведены результаты изучения образования и разложения гидратов природного газа в кварцевом песке в присутствии пресной воды, растворов гидрокарбоната (0,25 и 2% мас.) и хлорида натрия (5% мас.). Выбранные растворы являются моделями пластовых вод подмерзлотных водоносных горизонтов Вилюйской синеклизы. Исследование влияния пористой среды и засоленности на образование гидратов проводилось методом дифференциального термического анализа при начальном давлении газа от 4 до 7 МПа. Определены равновесные условия и кинетические параметры образования гидратов. Кинетические параметры гидратообразования в пористых средах в зависимости от засоленности и при каждом значении начального давления уменьшаются в следующей последовательности: 0,25% мас. NaHCO_3 в H_2O > 2% мас. NaHCO_3 > 5% мас. NaCl . Исследована стабильность гидратов, полученных в пористых средах с различной засоленностью. Установлено, что с увеличением концентрации соли в растворах стабильность гидратов в пористых средах уменьшается.

Ключевые слова: газовые гидраты, кварцевый песок, гидрокарбонат и хлорид натрия, дифференциальный термический анализ, кинетические параметры образования и разложения гидратов.

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Experimental Investigations of Natural Gas Hydrate Formation

in a Porous Medium in The Presence of Sodium Chloride and Bicarbonate Solutions

The paper presents the results of investigation of the natural gas hydrates formation and decomposition in quartz sand in the presence of fresh water, sodium bicarbonate (0,25 and 2 mass%) and chloride (5 mass%) solutions. The selected solutions are models of stratum water of subpermafrost aquifers of the Vilyui syncline. The study of the porous medium and salinity influence on the hydrate formation was carried out by differential thermal analysis at initial gas pressures from 4 to 7 MPa. Equilibrium conditions and kinetic parameters of the hydrate formation were determined. The kinetic parameters of the hydrate formation in porous media, depending on salinity and at each value of the initial pressure decrease in the following sequence: 0,25 mass% NaHCO₃ n H₂O > 2 mass% NaHCO₃ > 5 mass% NaCl. The stability of hydrates obtained in porous media with different salinity has been studied. It has been established that the hydrates stability in porous media decreases with an increase of the solution concentration.

Key words: gas hydrate, quartz sand, sodium bicarbonate and chloride, differential thermal analysis, kinetic parameters of hydrate formation and decomposition.

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Изучение процессов образования гидрата природного газа в пористой среде из смеси растворов полимеров с нефтью

В статье представлены результаты исследований равновесных условий и кинетических характеристик процессов образования гидрата природного газа в системах пористая среда – вода – полимер – хлорид кальция – нефть в статических условиях. Установлено, что при выбранных параметрах эксперимента в изучаемых системах образуется смесь гидратов метана и природного газа. Присутствие нефти в реакционной системе в пределах погрешности не приводит к смещению равновесных условий образования газовых гидратов, но при этом снижает скорость гидратообразования и достижимую конверсию воды в гидрат. Присутствие соли CaCl₂ в системе приводит к смещению равновесных условий гидратообразования в область низких температур. Влияние хлорида кальция на кинетику в системе без полимеров имеет экстремальную зависимость и позволяет увеличить скорость поглощения газа вдвое при концентрации 50 г/л. Добавление в систему полимеров (полиакриламид, натриевая соль карбоксиметилцеллюлозы или полиэтиленгликоль) приводит к нивелированию эффекта соли. Полученные данные могут быть полезны при разработке реагентов для полимерного заводнения нефтяного пласта при добыче нефти в условиях стабильности газовых гидратов.

Ключевые слова: газовые гидраты, дифференциальный термический анализ, растворы полимеров, нефть, пористая среда, хлорид кальция
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Studying the Formation of Natural Gas Hydrates in a Porous Medium from a Polymer – Solution – Oil Mixture

The article presents the results of studies of equilibrium conditions and kinetic characteristics of the processes of formation of natural gas hydrate in systems of porous medium – water – polymer – calcium chloride – oil under static conditions. It has been established that, formation of methane and natural gas hydrates mixture occurs in the systems under study. The presence of oil in the reaction system does not affect the equilibrium conditions of the gas hydrates formation within the error but reduces the hydrate formation rate and water-to hydrate conversion. The presence of the CaCl₂ salt in the system shifts the equilibrium conditions of hydrate formation to the region of low temperatures. The effect of calcium chloride on the kinetics in a system without polymers has an extreme dependence and makes it possible to double the gas uptake rate at 50 g/L. The addition of polymers (polyacrylamide, sodium carboxymethyl cellulose, or polyethylene glycol) to the system suppresses the salt effect. The data obtained can be useful in the development of reagents for polymer flooding of an oil reservoir during oil production under conditions of gas hydrate stability.

Key words: gas hydrates, methane, differential thermal analysis, polymer solutions, oil, porous medium, calcium chloride.

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Образование гидрата метана в замороженных молотых растворах соевого лецитина

В работе представлены результаты исследований кинетики образования гидрата метана из замороженных молотых растворов соевого лецитина (размер частиц 80–140 мкм) с концентрациями от 0,1 до 1% мас. при температуре 273,2 К и начальном давлении около 5 МПа без перемешивания. В ходе работы было установлено, что наличие добавки соевого лецитина в замороженных молотых растворах приводит к увеличению степени конверсии воды в гидрат примерно в два раза по сравнению с молотым льдом. Описаны предполагаемые механизмы прототипирования образования гидрата метана в замороженных молотых растворах соевого лецитина с использованием методов ядерного-магнитного резонанса, вискозиметрии и оптической микроскопии.

Ключевые слова: газовые гидраты, транспорт и хранение газа, метан, биоразлагаемый промотор, соевый лецитин, поверхностно-активное вещество, молотый лед.

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Methane Hydrate Formation in Particles of Frozen Soy Lecithin Solutions

This study presents the experimental investigations on the kinetics of methane hydrate formation from frozen ground solutions (particle size 80-140 microns) of soy lecithin additive with varying concentrations from 0.1 to 1 mass% at 5 MPa and 273.2 K in an unstirred condition. It has been observed that the presence of soy lecithin additive enhances the degree of water-to-hydrate conversion by about twice compared to ground ice. The proposed mechanism of methane hydrate promotion in frozen ground soy lecithin solutions using nuclear magnetic resonance, viscometry and optical microscopy have been discussed in detail.

Key words: gas hydrates, gas transportation and storage, methane, biodegradable promoter, soy lecithin, surfactant, ice powder, NMR.

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Перспективы использования порошковых гидрогелевых систем

для транспортировки газа в гидратном состоянии

В работе изучена кинетика гидратообразования в порошковых гидрогелевых системах, стабилизированных гидрофобными наночастицами при температуре 273,2 К и начальном давлении около 5 МПа. Исследовано влияние состава водной фазы, использовавшейся для насыщения гидрогеля, на кинетику гидратообразования. Исследована стабильность систем в циклах образования и диссоциации гидратов, т.е. их способность сохранять скорость и степень конверсии на высоком уровне при многократном повторном использовании.

Ключевые слова: транспортировка газа, хранение газа, газовые гидраты, метан, кинетика гидратообразования, гидрогель

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Prospects of Using Powder Hydrogel Systems for Gas Transportation in Hydrate State

This paper studies the hydrate formation kinetics at 273.2 K and an initial pressure of about 5 MPa in powder hydrogel systems stabilized by hydrophobic nanoparticles. The influence of composition of the aqueous phase used to saturate the hydrogel on hydrate formation kinetics was investigated. The stability of the systems in hydrate formation – dissociation cycles, i.e., their ability to maintain the hydrate growth rate and water-to-hydrate conversion at a high level in multiple reuses, was also assessed.

Key words: *gas transportation, gas storage, gas hydrates, methane, hydrate formation kinetics, hydrogel.*

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Влияние поливинилпирролидона на эффект самоконсервации гидрата пропана

Представлены экспериментальные данные по диссоциации образцов гидрата пропана, полученных из объемных образцов льда и замороженных водных растворов поливинилпирролидона. Обнаружено, что в присутствии поливинилпирролидона, при резком сбросе давления, в области температур ниже 271 К, наблюдается аномально низкая скорость диссоциации гидрата пропана (эффект самоконсервации). Результаты экспериментов позволили установить диапазон концентрации поливинилпирролидона в замороженных водных растворах, а также оценить толщину корки льда, сформированную на поверхности газового гидрата в процессе диссоциации, при которых реализуется эффект самоконсервации гидрата пропана. Экспериментально установлено, что экранирующее действие корки льда законсервированного гидрата пропана сохраняется до температуры 272 К и полностью исчезает при 273 К.

Ключевые слова: газовой гидрат, пропан, поливинилпирролидон, эффект самоконсервации.

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Influence of Polyvinylpyrrolidone on the Self-Preservation Effect of Propane Hydrate

Experimental data on the dissociation of propane hydrate samples obtained from the bulk samples of ice and frozen aqueous solutions of polyvinylpyrrolidone are presented. It was revealed that propane hydrate exhibits a self-preservation effect, with a meager dissociation rate when subjected to a sudden drop in pressure in the presence of polyvinylpyrrolidone. This phenomenon occurs at temperatures below 271 K. The results of the experiments made it possible to establish the range of polyvinylpyrrolidone concentration in frozen aqueous solutions, as well as estimate the thickness of the ice crust formed on the gas hydrate surface during dissociation, at which the self-preservation effect of propane hydrate is realized. It has been experimentally established that the shielding effect of the ice crust of preserved propane hydrate is retained up to a temperature of 272 K and completely disappears near 273 K.

Key words: *gas hydrate, propane, polyvinylpyrrolidone, self-preservation effect.*

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Получение и исследование свойств сульфосукцинатов циклических спиртов для применения в технологии хранения и транспортировки газа в гидратной форме

Проведен синтез ряда сульфосукцинатов циклических спиртов и представлены результаты исследования их влияния на кинетику образования гидрата метана в автоклавах высокого давления. Рассмотрено влияние структуры испытуемых соединений на пенообразование, время индукции и конверсию воды в гидрат в сравнении с додецилсульфатом натрия. Подробно представлен процесс получения используемых веществ. Выявлено, что рост размера циклоалкильного фрагмента с C₅ до C₇ приводит к некоторому ускорению нуклеации и роста гидрата метана, тогда как переход к циклу, содержащему 8 атомов углерода, приводит к снижению промотирующего эффекта. Показано, что эффект синтезированных соединений на ускорение образование газовых гидратов сопоставим с таковым для додецилсульфата натрия при лучших эксплуатационных характеристиках предложенных реагентов (не способствуют пенообразованию).

Ключевые слова: газовые гидраты, метан, хранение газа, промотирование гидратообразования, сульфосукцинаты жирных спиртов.

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Synthesis and Investigation of the Properties of Cyclic Alcohol Sulphosuccinates for Hydrate-Based Gas Storage and Transportation Technology

The article presents the synthesis of several cyclic alcohol sulfosuccinates and the study results of their influence on the kinetics of methane hydrate formation in high-pressure autoclaves. The effect of the structure of the tested compounds on foaming, induction time, and water-to-hydrate conversion is considered in comparison with sodium dodecyl sulfate. The process of obtaining the substances used is presented in detail. It was found that an increase in the size of the cycloalkyl fragment from C₅ to C₇ leads to some acceleration of the nucleation and growth of methane hydrate. In contrast, the transition to a cycle containing eight carbon atoms decreases the promoting effect. It is shown that the impact of the synthesized compounds on accelerating the formation of gas hydrates is comparable to that for sodium dodecyl sulfate. At the same time, the proposed reagents possess better performance characteristics (do not contribute to foaming).

Key words: gas hydrates, methane, gas storage, hydrate promotion, fatty alcohol sulphosuccinates.

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Особенности роста пленок газового гидрата на границе жидкого углекислого газа с водой и раствором додецилсульфата натрия в тefлоновой и стальной кюветах

В работе изучены особенности роста гидратной пленки на границе раздела жидкого углекислого газа с чистой водой и раствором додецилсульфата натрия. Обнаружено, что в тefлоновой кювете во всех случаях происходит образование гидратной пленки на поверхности контакта жидких фаз, после чего видимых изменений не наблюдается неопределенно долгое время. В экспериментах с чистой водой в стальной кювете после зарастания поверхности вода – CO₂ гидратом происходит медленная деформация гидратной пленки,

вызываемая ее разрастанием вдоль линии контакта гидрат – стенка кюветы. В экспериментах с раствором додецилсульфата натрия деформация гидратной пленки выражена значительно сильнее, при этом значительно увеличивается степень превращения воды в гидрат.

Ключевые слова: газовые гидраты, углекислый газ, додецилсульфат натрия, рост пленок

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Peculiarities of Gas Hydrate Films Growth at the Boundary of Liquid Carbon Dioxide with Water and Sodium Dodecyl Sulphate Solution in Teflon and Steel Cuvettes

This work studied the features of a hydrate film growth at the interface between liquid CO₂ and pure water or 0.1 mass% sodium dodecyl sulfate solution. In Teflon cell, a hydrate film in all cases is formed on the contact surface of the liquid phases, after which no visible changes occur for an indefinitely long time. In the case of pure water in a steel cell, the hydrate layer formed at the water–CO₂ interface slowly deforms due to its growth along the contact line between the hydrate and the cell wall. In experiments with a solution of sodium dodecyl sulfate, the deformation of the hydrate film is much more pronounced, and the degree of water-to-hydrate conversion increases significantly. In our opinion, a previously undiscussed mechanism of hydrate capillary growth has been revealed, in which a capillary system is formed at the contact of a previously grown hydrate film with the reactor wall.

Key words: gas hydrates, carbon dioxide, sodium dodecyl sulfate, film growth.

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New Progress in the Study of Mesozoic Siliceous Shales

The Dasanjiang basin is located in the northeast of Heilongjiang Province, at the confluence of the Heilongjiang River, Songhua River, and Ussuri River, and consists of stratum from the Triassic to Jurassic periods. The Dasanjiang basin is a mid-to-late Neogene interbedding basin with low exploration level, and two types of source rock systems exist within the basin, the new upper Mesozoic and middle Cenozoic. The siliceous rock organic matter content is relatively high, and the source rock in the Fuyuan and Red Flag Ridge areas of the Dasanjiang basin respectively reaches good and medium levels. The siliceous rock organic matter type developed in the Fuyuan area, Raohe area, and Red Flag Ridge area of the Dasanjiang basin most belong to the III type, with a few II2 and I types. The silica shale in the Sanjiang Basin is currently in the stage of near-metamorphism-unmetamorphism. The southern region has strong folds and significant soil deformation, resulting in poor conditions for the preservation of oil and gas. The northern region, on the other hand, has weakened folds and magma intrusion, resulting in better conditions for the preservation of oil and gas, and is a beneficial region for future silica rock oil and gas exploration.

Keywords: Dasanjiang Basin, silicate shale, shale gas.

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Simulation Research on EOR Technology and Mechanism of Sandstone Reservoir Injected with Foam

Tight sandstone reservoirs have become the focus of oil and gas resources exploration and development, accounting for an increasing proportion. At present, tight sandstone reservoir is characterized by low permeability, ultra-low permeability and strong heterogeneity, which leads to low recovery factor of the reservoir. To improve the oil recovery of sandstone reservoirs in Ordos Basin, based on the mechanism of foam oil displacement, the depth analysis of oil recovery technology was carried out by optimizing the process parameters of nitrogen injection foam. First, the calculation formula of the maximum adsorption capacity of foam agent was studied, and the optimal concentration of the chemical agent was determined to be 0.5%. The small slug injection method was determined. Secondly, the optimal gas-liquid ratio of nitrogen foam is 4:1, the nitrogen foam injection time is 21 days, and the foaming agent concentration is 0.3%. Finally, on the basis of optimizing technical parameters, the recovery effect of EOR by injecting foam is studied. The results show that the oil recovery rate of nitrogen injection foam production can reach 700 t, which is more excellent than that of steam injection foam production.

Keywords: *tight sandstone reservoir, eor, foam flooding, chemical concentration, numerical simulation.*

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Research on Fuel Temperature Control Method for Operation Safety of Railway Diesel Locomotive in Low Temperature Period

This paper mainly studies the safety and cost control challenges faced by diesel locomotives operating in cold environments. In order to meet this challenge, the author solves the fuel system problem of railway diesel locomotive in cold environment by deeply understanding and optimizing the chemical properties of fuel oil, and by designing and implementing effective heating system. First, the author investigates and summarizes the chemical properties of the fuel and the ambient temperature required for the fuel. The change of chemical properties of fuel under normal and low temperature is verified by experiments, and the specific demand relationship between the safe operation of railway diesel locomotive and the chemical properties and temperature of fuel is clarified. These implements provide strong data support for the realization of low fuel combustion. Subsequently, based on the above research results, the author designs a fuel temperature control system that can meet the low-burning fuel demand. In the design process, the chemical properties of fuel and the particularity of the material and structure of fuel tank in a railway diesel locomotive are fully considered, and a fuel heating scheme is proposed. Finally, it is verified by actual measurement that the scheme has the

ability of fine control of temperature and synchronous heating of multi-temperature zones, which meets the actual demand of low fuel combustion.

Keywords: *railway, safety, cost, fuel, temperature control.*

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Study on Different Kinds of Drill Bits and Their Usage in Hard-To-Drill Formations

The choice of bits is a crucial factor for drilling performance in deep and hard-to-drill formations. This paper explores the characteristics, application scopes, and performance advantages of various shaped cutters that are used in PDC (Polycrystalline Diamond Compact) bits. It also examines the suitability and effectiveness of PDC bits, hybrid bits, and roller cone bits for different kinds of hard-to-drill lithologies. The paper offers a reference for bit selection in challenging drilling conditions.

Keywords: *cutters, drill bit, PDC bit, roller cone bit, hybrid bit.*

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«Two Wide and One High» 3D Horizontal Well Real Time Steering Technology and Its Application in Engineering Field

The tight sandstone gas reservoir is thin, highly heterogeneous, and its spatial distribution is very complex. Its development is faced with the problems of low gas reservoir drilling rate and poor fracturing effect. In order to overcome the difficulties in the development of horizontal wells in tight gas reservoirs, the real-time steering technology of seismic geological integration horizontal wells based on 3D seismic data of “two wide and one high” is proposed in this paper. The pilot test of 12 horizontal wells has been completed using the proposed technology. The average horizontal section length is 1755 meters, the sandstone length is 1506 meters, the sandstone drilling rate is 85.7%, the effective reservoir length is 1290 meters, the effective reservoir drilling rate is 74.5%, the coincidence rate of seismic prediction is 91.7%, the success rate of one shot is 100%, and the structural prediction error is 0.45 ‰. This technology can effectively improve the drilling rate and fracturing effect of horizontal wells in tight sandstone gas reservoirs, and has guiding significance for the development of horizontal wells in tight sandstone gas reservoirs.

Keywords: *3D horizontal well real-time steering technology, tight sandstone gas reservoir, drilling rate of sandstone, reservoir prediction, seismic.*

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Calculation of Wellbore Fracture Pressure under Multi Field Coupling Based on M-integral of Configuration Mechanics

This paper proposes a new idea and method which is to use configuration mechanics to describe the evolution of complex microstructures and multiple defects such as discontinuity, heterogeneity and anisotropy in the borehole rock under the coupling of mechanics and chemistry. It is used to deal with the evolution of complex microstructures and multiple defects in the borehole rock that are difficult to deal with in the traditional fracture mechanics and damage mechanics of the continuum theory. The two-dimensional/three-dimensional M-integral is numerically calculated using the domain integration method, and the material failure criterion based on configuration force and conservation integral is used to calculate the shale lining fracture pressure. The results show that the calculation results can better predict the fracture pressure. It shows that the established multi-field coupling borehole rupture pressure model based on the M-integral of configuration mechanics can provide a theoretical reference for the complex formation stability under multi-field coupling and the wellbore stability control during field operations.

Keywords: configuration mechanics, M-integral, multi field coupling, wellbore stability, fracture pressure.

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Research on Optimal Design of Screen out Fracturing in Unconsolidated Sandstone Reservoir Based on Fluid Solid Coupling Theory

Loose sandstone reservoirs account for a large proportion of oil and gas resources in the world, but due to weak cementation and serious sand production problems, oil well production is seriously affected. Screen out fracturing can not only effectively control sand production, but also improve reservoir production. It is an efficient development mode for loose sandstone reservoirs, but its internal mechanism needs further study. Therefore, the interaction of reservoir stress and fluid seepage in the development of unconsolidated sandstone is fully considered, the fluid solid coupling deformation field equation and seepage field equation of unconsolidated sandstone are derived, and the fluid solid coupling mathematical model of unconsolidated sandstone reservoir is established. The COMSOL software is used to conduct numerical simulation of horizontal well staged screen out fracturing in Gudao Oilfield, verify the rationality of the model, and analyze the impact of fluid solid coupling on the productivity of unconsolidated sandstone reservoir, The screen out fracturing parameters of unconsolidated sandstone reservoir are further optimized. The research shows that the simulation results of the established numerical model agree well with the actual production data, and the average error is controlled within 5%; Fluid solid coupling has a great impact on the initial productivity of unconsolidated sandstone reservoirs, but the impact can be ignored when the production days exceed 350 days; Taking productivity as

the optimization objective, the number of fractures, fracture length and fracture conductivity of staged screen out fracturing for horizontal wells are optimized.

Key words: loose sandstone, screen out fracturing, fluid structure coupling, numerical simulation, optimal design.

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Evaluation Method of Shale Water-Based Drilling Fluid Plugging Based on "Thick Mud Cake" Simulation

The preparation of true shale cores is limited by the characteristics of shale formations, such as the development of bedding and micro-fractures, poor cementation, and fragility. Artificial cores cannot meet the requirements of shale at the nanometer scale and are not representative. Existing plugging evaluation methods have problems such as cumbersome steps, long time consumption, and low evaluation accuracy. Therefore, this paper proposes a shale plugging evaluation method based on the simulation of "thick mud cakes". This method analyzes the effects of factors such as bentonite dosage, type and dosage of treatment agent, barite content and particle size distribution on mud cake parameters through approximation experiments, establishes a standard slurry formula for "thick mud cakes", and prepares a standard "thick mud cake" with a thickness of 10.03mm and a permeability of 4.79×10^{-4} mD to evaluate the plugging effect by the reduction rate of permeability. Based on this method, four plugging agents were selected and combined to obtain the best compound plugging agent. The drilling fluid system plugging evaluation was carried out on both the standard "thick mud cake" and thin mud cake, and the microscopic plugging mechanism of shale was analyzed. The results show that this method is simple to operate, has good reproducibility and high accuracy in plugging evaluation results, and has strong application potential.

Keywords: Shale; Standard "Thick Mud Cake"; Plugging Effect; Evaluation Method

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Increasing drilling speed in hard-to-drill formations with various types of tools

Drilling speed-increasing tools are essential in increasing penetration rate in deep and hard-to-drill formations. This paper delves into the characteristics, application scopes, and performance advantages of commonly used tools, such as torsional impact tools, friction reduction by impact tools, positive displacement motors (PDMs), turbodrills, and Gyro Stable Drilling tools. The suitability and effectiveness of these drilling speed-increasing tools for different types of hard-to-drill lithologies are also examined. This paper serves as a reference for selecting the appropriate drilling tools in challenging drilling conditions.

Key words: *drilling speed-increasing tools, TorkBuster, HPG, high torque motor, turbodrill, Gyro Stable Drilling tools, hard-to-drill formations*

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Study of Injected Water Mineralization Injury to Injection Pipe Network

The injected water at Xinjiang Bailian station has caused serious damage to the injection pipe network, severely impacting the production. To address the injury of injection water mineralization to the main water pipeline network, this paper investigates the injury law and main control factors of injection water mineralization to the water injection pipeline network using a combination of indoor static experiments and Scalechem software simulation. The results show that temperature is the most influential factor in corrosion rate. The main cause of scaling injury is the high content of HCO_3^- and Ca^{2+} in the injection water. Therefore, during the water injection process, the focus should be on controlling the variation of HCO_3^- and Ca^{2+} concentrations in the injection water. The results of this paper are an important guide for how to reduce the damage of injection water to the injection pipe network in the process of improving the recovery rate through injection water in Xinjiang Bailian Station.

Keywords: *increase of salinity, corrosion, scaling, orthogonal experiment, Scalechem scaling prediction.*

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Molecular Dynamic Simulation on the Synergistic Corrosion Inhibition Effect and Mechanism of Quinoline Quaternary Ammonium Salt and L-Methionine

*The synergistic effect and synergistic mechanism of quinoline quaternary ammonium salt (QQAS) and L-methionine (L-Met) as Q235 carbon steel corrosion inhibitors in 1 M HCl solution were studied by weight-loss and electrochemistry and theoretical methods at 60°C. Both the weight-loss and the electrochemistry experiment results show that there is obvious synergistic effect with a synergistic index of 8.81 between QQAS and L-Met. The results of the electrochemical experiments show that the inhibition efficiency of the mixture corrosion inhibitor reaches 98.46% when the concentration of the mixture inhibitor is 50 mg/L with the molar ratio of QQAS and L-Met of 3 to 1. The quantum chemical parameters calculated at B3LYP/6-311++G** level indicate that QQAS can be preferentially adsorbed for its stronger offer electron ability. The results of molecular dynamics studies show that QQAS is preferentially adsorbed onto the surface of carbon steel forming the framework of the corrosion inhibitor film. And L-Met molecules fills the gap to make the film more condensed. The adsorption energy and the density distribution of the inhibitor and water molecules indicate that the corrosion inhibition performance is the best when the molar ratio of QQAS and L-Met is 3:1. And the synergistic inhibition mechanism is the monolayer adsorption mechanism. These results can provide useful guidance for further study on the synergistic corrosion inhibition effects of QQAS and other compounds.*

Keywords: *quinoline quaternary ammonium salt, molecular dynamics simulation, L-methionine, synergistic effect, corrosion inhibition mechanism.*

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A New HAZOP Automated Method for the Oil and Gas Complex Equipment

Hazard and Operability (HAZOP) analysis is crucial for ensuring the safe operation of process unit. Traditional HAZOP analysis is timeconsuming, laborious, and influenced by the professional competence of analysts, resulting in uneven analysis quality. To solve this problem, this paper proposes an automated method of HAZOP analysis based on SDG and ontology: based on the HAZOP analysis process, using the symbolic directed graph (SDG) to establish the process unit model, introducing the ontology model to represent the HAZOP knowledge, and developing the inference algorithm based on semantic inference engine to automatically generate HAZOP analysis table.

Keywords: *SDG, ontology, inference algorithm, automatic.*

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A Novel Resource Prediction Technology for Shallow Earth Seismic Fault Detection

The Guizhou Province is located in a mountainous area, so it is very important for the future layout and planning of the city to study the underground geological structure of the city based on seismic technology. In this paper, taking the underground active fault in the Liupanshui City, Guizhou Province, China as an example, a set of evaluation techniques for the accurate spatial location, structural characteristics and latest activities of the fault in the mountainous area are proposed. Through pre-stack noise suppression, amplitude fidelity and consistency processing, and multiple iterative analysis of velocity residual statics, the resolution of the geological structure of the underground rock has been significantly improved. Based on the detailed interpretation of the shallow seismic data and the regional geological analysis, it is concluded that the main fault trend of the Weining - Shuicheng section of the Weining - Shuicheng fault is NW, mainly normal fault, and the dip angle is 60-80°. The strata of the two fault plates are strongly compressed and broken, and the limestone and dolomite are generally recrystallized, and calcite veins and masses can be seen.

Keywords: *shallow seismic, mountain landform, Liupanshui City, severance; normal fault.*

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Development and application of a novel nano-micron plugging agent with core-shell structure for oil-based drilling fluids

China is rich in Shale gas resources, and the preliminarily predicted geological resource reserves are about $134 \times 10^{12} \text{ m}^3$, with a technically recoverable reserve of approximately $25 \times 10^{12} \text{ m}^3$. The Weiyuan-Rongxian area has abundant natural gas resources, but its geological conditions are complex, characterized by poor drillability of local formations, deep burial of reservoirs, and uneven horizontal distribution. These complex geological conditions result in low mechanical drilling speed, long drilling cycles, and high drilling costs, posing severe challenges and challenges to drilling engineering. In view of the technical difficulties of oil-based drilling fluid in the deep shale high-pressure fracture formation in this block, this paper has developed a particle size variable nano micron plugging agent CLG-NM suitable for the high-pressure fracture formation in the deep shale gas formation. Its molecular structure was characterized, its nano micron plugging characteristics were evaluated, and its microscopic mechanism was discussed. The research results indicate that the median particle size D_{50} of the newly developed variable nano micron sealing agent CLG-NM is 89.4 nm. After high-temperature aging at 150 °C, the filtration loss of the experimental slurry showed a gradually decreasing trend with the increase of the amount of sealing agent CLG-NM added. When the dosage of sealing agent is 1%, the filtration loss of sand disc sealing is only 4.2mL, demonstrating strong nano micron sealing performance. On this basis, CLG-NM was applied on-site in the Longmaxi Formation of Well Weiye 32-3HF. Field tests have shown that during the drilling process of the Weiye 32-3HF Longmaxi Formation, there were no complex downhole situations such as well leakage or wellbore instability. The drilling was successfully completed, with a pure drilling time of 42 hours, an average drilling speed of 7.81 m/h, and a density reduction of about 0.08–0.10 g/cm³ compared to the adjacent well.

Keywords: *oil based drilling fluids, nano micron sealing agent, sealing performance, shale reservoirs, on-site application.*