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Особенности экономической оценки применения попутного нефтяного газа для технологии GTL

Утилизация попутного нефтяного газа (ПНГ) представляет значительный интерес и является одним из приоритетных направлений развития нефтегазовой отрасли. При этом одновременно решается проблема экологической безопасности процессов добычи углеводородных газов. Сжигание нефтяного газа на месторождениях в факельных установках негативно воздействует на экосистему, а также приводит к экономическим потерям. На снижение экологических и экономических потерь при добыче попутного нефтяного газа направлены специальные проекты, реализуемые крупными нефтегазовыми компаниями. В статье рассмотрены механизмы экономической и экологической оценки основных современных направлений использования нефтяного газа. Представлены мероприятия, позволяющие учесть особенности химического состава попутного нефтяного газа при выборе способа его утилизации. Для решения данной проблемы применен комплексный подход к оценке и определению эффективных методов полезного использования попутного нефтяного газа и получению продукции с высокой добавленной стоимостью.

Ключевые слова: попутный нефтяной газ, полезное использование, технология GTL, газовые двигатели, энергосбережение, переработка газа, жидкие углеводороды.

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Features of Economic Assessment of Application of Associated Oil Gas for GTL Technology

Associated petroleum gas utilization is of considerable interest and is one of the priority directions of development of the oil and gas industry. At the same time, the problem of environmental safety of hydrocarbon gas extraction processes is being solved. Combustion of oil gas at flare installations negatively affects the ecosystem and also leads to economic losses. Special projects implemented by large oil and gas companies are aimed at reducing environmental and economic losses in the extraction of associated petroleum gas. This article discusses the mechanisms of economic and environmental assessment of the main modern trends in the use of petroleum gas. The measures are presented that allow to take into account the peculiarities of the chemical composition of associated petroleum gas when choosing the method of its utilization. To solve this problem, an integrated approach has been applied to the assessment and determination of effective methods for the beneficial use of associated petroleum gas and the production of products with high added value.

Key words: associated petroleum gas, beneficial use, GTL technology, gas engines, energy saving, gas processing, liquid hydrocarbons.

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Исследование состава и свойств продуктов гидротермального сжижения биомассы микроводорослей

Проведены исследования процесса гидротермального сжижения биомассы микроводорослей при различной температуре, продукты проанализированы методами термогравиметрии, элементного анализа и газовой хромато-масс-спектрометрии. Сделаны выводы о влиянии температуры на выход и состав продуктов.

Определено количественное содержание мажорных компонентов бензиновой фракции получаемой бионефти.

Основными компонентами бензиновой фракции являются ароматические углеводороды, алканы и циклоалканы. В значительных количествах в продуктах гидротермальной переработки содержатся также фенолы, органические сульфиды и азотсодержащие органические соединения, это делает невозможным прямое использование получаемых продуктов в качестве топливных компонентов.

Ключевые слова: бионефть, гидротермальное сжижение, мокрый пиролиз, биомасса микроводорослей.

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Study of Composition and Properties of the Microalgae Biomass

Hydrothermal Liquefaction Products

Studies of the hydrothermal liquefaction of microalgae biomass at different temperatures were carried out. The products were analyzed by TGA, elemental analysis and GC-MS. The effect of temperature on the yield and composition of products was studied. The quantitative content of the major components of the gasoline fraction of the produced bio-oil was determined. The main components of the gasoline fraction are aromatic hydrocarbons, alkanes and cycloalkanes. Phenols, organic sulfides and nitrogen-containing organic compounds are also found in hydrothermal processing products in significant quantities. This makes it impossible to direct use of obtained products as fuel components.

Key words: bio-oil, hydrothermal liquefaction, wet pyrolysis, microalgae biomass.

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Цеолитсодержащие и бесцеолитные катализаторы на основе модифицированных железом каолинитов в крекинге вакуумного газойля

Приведены данные по активности бесцеолитных и цеолитсодержащих катализаторов HCeY на основе H-форм каолинитов казахстанских месторождений, модифицированных железом, в крекинге вакуумного газойля. Определены физико-химические свойства катализаторов. Установлено, что основным продуктом крекинга вакуумного газойля на бесцеолитных модифицированных железом H-каолинитах является легкий газойль, выход которого составляет 65,3 -67,3%. Введение цеолита приводит к увеличению выхода бензина до 22% при достаточно высокой (до 90,3%) конверсии сырья.

Ключевые слова: каталитический крекинг, вакуумный газойль, каолинит, бензин, легкий газойль.

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Zeolite Containing and Zeolite Free Catalysts Based on Kaolinites Modified by Iron in the Cracking of Vacuum Gas Oil

The data on the activity of zeolite free and HCeY-zeolite-containing catalysts based on H-forms of iron-modified kaolinites of Kazakhstan deposits in the cracking of vacuum gasoil are presented. The physicochemical properties of the catalysts were determined by the methods of BET, TPD ammonia, electron probe analysis and Mössbauer spectroscopy. It was found that the main product of the cracking of vacuum gasoil on the zeolitic iron-activated H-kaolinites is light gasoil. The yield of light gasoil is 65.3–67.3%. The introduction of zeolite leads to the increasing of the gasoline yield up to 22% at a sufficiently high (up to 90.3%) conversion of raw materials.

Key words: catalytic cracking, vacuum gas oil, kaolinite, gasoline, light gasoil.

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NiMo/WO₄²⁻/ZrO₂-цеолитсодержащий катализатор гидродеароматизации для улучшения эксплуатационных и экологических характеристик дизельного топлива

С использованием синтезированных вольфрамированного диоксида циркония WO₄²⁻/ZrO₂ и никель-молибденового комплекса приготовлен цеолитсодержащий катализатор деароматизации дизельного топлива. Катализатор испытывали в процессе деароматизации дизельного топлива при давлении 4,5 МПа, объемной скорости подачи сырья 1,5 ч⁻¹, объемном соотношении водород/сырье 1000 нм³/м³ в интервале значений температуры 270–330°C. При температуре 290°C была достигнута максимальная конверсия полициклических ароматических углеводородов 78,8% и максимальное повышение цетанового числа. Также наблюдалось снижение температуры помутнения и застывания дизельного топлива на 23–25°C за счет реакций крекинга при 310–330°C и большой доли реакций изомеризации при 290°C, что подтверждается выходом целевой дизельной фракции — 69,8–72,9 и 89,2% мас. соответственно.

Ключевые слова: гидродеароматизация, гидрирование, селективное раскрытие нафтенового кольца, цеолит USY, цеолит Beta, никельмолибденовый катализатор, дизельное топливо.

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NiMo/WO₄²⁻/ZrO₂-Zeolite-Containing Hydrodearomatization Catalyst for Improvement of Performance and Ecological Characteristics of Diesel Fuel

Using a synthesized tungstated zirconia WO₄²⁻/ZrO₂ and a nickel-molybdenum complex, a zeolite-containing catalyst for diesel dearomatization was prepared. The catalyst was tested in diesel hydrodearomatization at a pressure of 4.5 MPa, the liquid hour space velocity of 1.5 h⁻¹, hydrogen to feed volume relation of 1000 нм³/м³ in the reaction temperature range of 270–330°C. At a temperature of 290°C, a maximum conversion of polycyclic aromatic

hydrocarbons of 78.8 % and a maximum increase in the cetane number were achieved. Decrease in cloud point and pour point of diesel by 23–25 °C was also observed: due to cracking reactions at 310–330 °C and a large proportion of isomerization reactions at 290 °C, as proved by the yield of the target diesel fraction — 69.8–72.9 wt % and 89.2 wt % respectively.

Key words: hydrodearomatization, hydrogenation, selective naphthene ring opening, zeolite USY, zeolite Beta, nickel-molybdenic catalyst, diesel fuel.

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Разработка восстанавливающих резиносодержащих добавок

для состаренного дорожного битума

Раасмотрены современные представления о процессе старения дорожных вяжущих и принципах восстановления их свойств и структуры. Предложена технология производства стандартных восстановленных дорожных вяжущих (битумов и полимерно-битумных материалов) с использованием девулканизата резиновой крошки, полученной в процессе дробления отработанных автопокрышек, элементной серы, нефтяных диспергирующих агентов (асфальтита процесса деасфальтизации гудронов и тяжелого газойля каталитического крекинга) и полимера — термоэластопласта.

Данная технология обеспечивает квалифицированное использование элементной серы, асфальтита — отхода процесса деасфальтизации гудронов, и прямогонного гудрона, избыточного на многих предприятиях нефтепереработки. Проанализированы физико-химические свойства восстановленных дорожных вяжущих на соответствие их требованиям российских и американских стандартов.

Ключевые слова: состаренный битум, восстанавливающая добавка, резиновая крошка из отработанных автопокрышек, дорожные вяжущие, термоэластопласт, асфальтит, газойль каталитического крекинга, элементная сера, гудрон, система Суперпейв.

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Development of Restoring Rubber-Containing Additives

for Old Road Bitumen

Modern ideas about the aging process of road binders and the principles of restoring their properties and structure are given. The technology of production of standard restored road binders (bitumen and polymer-bituminous materials) using devulcanizate rubber crumb (RK) obtained in the process of crushing waste tires, elemental sulfur, oil dispersing agents (asphaltite process of deasphalting tar and heavy gas oil catalytic cracking) and polymer - thermoplastic elastomer. In addition, this technology provides the skillful use of elemental sulfur, asphaltite – waste

process deasphalting tars, and naphtha tar, surplus for many refiners. In the carried out work physical and chemical properties of the restored road binders on compliance to their requirements of the Russian and American standards were analyzed.

Key words: *aged bitumen, reducing additive, rubber crumb from spent tires, road binders, polymer-thermoplastic elastomer, asphalt, catalytic cracking gas oil, elemental sulfur, tar, Superpave system.*

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Структурно-механические свойства полимерно-парафиновых композиций

Исследованы деформационно-прочностные (прочность и пластичность) и dilatометрические (контракция или объемная усадка) свойства бинарных композиций пищевого парафина П-1 с полимерами: полиэтилен низкого давления, полиэтиленовые воски, атактический полипропилен и сополимеры этилена с винилацетатом. Построены графические зависимости структурно-механических свойств полимерно-парафиновых композиций от состава. Установлены сравнительные зависимости этих свойств от содержания модифицирующего компонента в композициях с парафином П-1.

Ключевые слова: полимеры, нефтяной парафин, композиционные смеси, прочность, пластичность, объемная усадка.

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Structural and Mechanical Properties of Paraffin Wax Composites

The deformation-strength (strength and plasticity) and dilatometric (contraction or volume shrinkage) properties of binary compositions of food paraffin P-1 with polymers (low-pressure polyethylene, polyethylene waxes, atactic polypropylene and ethylene copolymers with vinyl acetate) are investigated. Graphic dependences of structural and mechanical properties of polymer-paraffin compositions on the composition are constructed. Comparative dependences of these properties on the content of the modifying component in compositions with paraffin P-1 are established.

Key words: *polymers, oil paraffin, composite, composition, strength, plasticity, volume shrinkage.*

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Исследование свойств нефтяных и синтетических масел как основы противокоррозионных материалов

Определены свойства нефтяных и синтетических масел для их использования в качестве основы противокоррозионных материалов. Установлено, что вязкостно-температурные характеристики определяют технологичность нанесения масляных покрытий. Получены уравнения регрессии, позволяющие рассчитать толщину формирующейся защитной пленки как функцию вязкости масла. По результатам оценки смачиваемости определено, что поверхность масла гидрофильна. Установлено, что масляные пленки проницаемы для воды, стимуляторов и ингибиторов коррозии. Показано, что пленки исследуемых масел тормозят анодное растворение стали и несколько ускоряют катодное восстановление кислорода. Установлено, что при введении антикоррозионных присадок Эмульгин или Мобиил-3 в концентрации не менее 15% мас. природа масляной основы незначительно влияет на защитную эффективность.

Ключевые слова: нефтяные масла, синтетические масла, коррозия, защитная эффективность.

V. I. Vigdorovich, L. G. Knyazeva, L. E. Tsygankova, V. V. Ostrikov, A. I. Petrashev.

Research of Properties of Petroleum and Synthetic Oils as Bases of Anti-Corrosion Materials

The properties of petroleum and synthetic oils for their use as a basis for anti-corrosion materials are determined. It is established that the viscosity-temperature characteristics determine the manufacturability of the application of oil coatings. The regression equations, allowing to calculate the thickness of the emerging protective film as a function of oil viscosity, are obtained.

It was determined that the surface of the oil is hydrophilic based on the results of wettability assessment. It is established that oil films are permeable to water, stimulants and corrosion inhibitors. It was shown that the films of the studied oils inhibit the anodic dissolution of the steel and somewhat accelerate the cathodic reduction of oxygen. It is established that with the introduction of anti-corrosion additives Emulgin or Mubiin-3 in a concentration of at least 15 wt.%. The nature of the oil base slightly affects the protective efficacy.

Key words: oils, petroleum, synthetic, inhibited, corrosion, protective effectiveness.

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Особенности методов добычи вязкой нефти подгазовых оторочек сеноманского горизонта Экспериментально исследованы методы добычи вязкой нефти подгазовых оторочек сеноманского горизонта (пласты ПК). Показано, что пар способствует набуханию и диспергированию глинистых компонентов породы, т. е. термические методы не могут быть рекомендованы для применения. Исследовано влияние нефти на свойства породы пластов ПК и показано, что проницаемость, смачиваемость и степень вытеснения нефти минерализованной водой зависят от нефтенасыщенности и переход породы от гидрофильности к гидрофобности происходит при нефтенасыщенности более 75%. Щелочное заводнение и использование неионогенных поверхностно-активных веществ не эффективны для повышения

нефтеотдачи пластов ПК. Для вытеснения нефти рекомендуется применять водогазовую смесь или последовательную закачку растворителя и воды (или ВГС).

Ключевые слова: вязкая нефть, сеноманский горизонт, пар, повышение нефтеотдачи.

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Features Viscous Oil Production Methods from Oil Leg Reservoir of the Cenomanian Horizon

The methods of extracting viscous oil from oil leg reservoir of the Cenomanian horizon are experimentally investigated (PK layers). It was found that steam contributes to the swelling and dispersion of clay components of the rock, i.e. thermal methods cannot be recommended for use. The effect of oil on the rock properties of PK layers was investigated. It was shown that permeability, wettability and degree of oil displacement by saline water depend on oil saturation and the rock transition from hydrophilicity to hydrophobicity occurs at oil saturation more than 75%. Alkaline flooding and the use of non-ionic surfactants are not effective for enhancing the recovery of PK layers. To displace oil, it is recommended to apply a water-gas mixture or sequential injection of solvent and water.

Key words: viscous oil, oil production methods, nonionic surfactants, PK layers, water-gas mixture.

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Влияние типа модели нефти при вытеснении легкой нефти газом на их смесимость

Исследовано применение дегазированной нефти вместо рекомбинированной модели нефти в методике slim tube. Показано, что применение дегазированной нефти не рекомендовано для моделирования и исследования смесимости газа и нефти по методике slim tube в типичных условиях для месторождений Западной Сибири. При использовании рекомбинированной модели нефти или дегазированной нефти подтверждена ранее установленная смесимость легкой нефти и попутного нефтяного газа в результате постепенного перехода от режима несмешивающегося вытеснения к режиму ограниченно-смешивающегося вытеснения нефти и затем к режиму полной смесимости в результате их массообмена.

Ключевые слова: slim tube, модель нефти, нефть, попутный нефтяной газ.

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Influence of The Type of Oil Model at a Displacement of Light Oil by Gas on Their Miscibility

The application of degassed oil instead of recombined oil model for a slim tube technique was investigated. It is found that using of degassed oil is not recommended for modeling and studying of gas and oil miscibility under typical

conditions of Western Siberia deposits. The previously estimated mixability of light oil and associated gas was confirmed in case of application of recombined oil model or degassed oil at displacement from a slim tube. This occurs because of a gradual transition from the mode of immiscible displacement to the mode of limited-mixing displacement of oil and further to the mode of complete mixing as a result of the mass exchange of light oil and associated gas.

Key words: slim tube, oil model, oil, associated gas.

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Анализ аспектов культуры безопасности на объектах нефтегазового комплекса

В статье проведено исследование влияния различных факторов на компоненты культуры безопасности путем математической обработки результатов анкетирования 344 работников компании транспорта газа. Определен уровень культуры безопасности в компании. Выявлены наиболее часто встречаемые нарушения требований безопасности работниками структурных подразделений компании на основе построенной лепестковой диаграммы по результатам обработки 242 отчетов поведенческого аудита безопасности, проведенных во всех структурных подразделениях компании в период апрель–май 2019 г.

Ключевые слова: охрана труда, промышленная безопасность, поведенческий аудит безопасности, компоненты культуры безопасности, анкетирование.

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Analysis of Safety Culture Aspects at Oil and Gas Facilities

The article studies the influence of various factors on the components of safety culture by mathematical processing of the survey results of 344 employees of the Gas Transportation Company. The level of safety culture in the company is defined. The most frequent violations of safety requirements by employees of structural divisions of the company on the basis of the constructed radar chart by results of processing of 242 reports of behavioral safety audit are revealed. Behavioral safety audit was conducted in all structural divisions of the Company in the period April–May 2019.

Key words: occupational safety, industrial safety, behavioral safety audit, safety culture components, questionnaire.

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The Effect of Alkali on Reservoir Minerals and Deposition Characteristics

At present, alkali-surfactant-polymer(ASP) flooding in Daqing oilfield has entered into industrialized application stage and achieved better effects in increasing oil production and decreasing water-cut. However, a serious problem appeared at some blocks and wells. It is about the difficult injection of ASP system with strong base. Due to the influence of alkali on the formation, it brought a great challenge in the goals of maintaining oil production and improving oilfield recovery. So the authors carried out the research on the reaction between alkali and reservoir minerals, as well as its effects to seepage characteristic. The research was set the cores of typical block in Daqing oilfield as research object, pore structure of cores as comparison criteria, elements composition of core sample as analysis basis, resistance factor and residual resistance factor as evaluation indexes. Results show that the reservoir rocks of main blocks in Daqing oilfield contain alkali-sensitivity minerals. The degree of alkali-sensitivity damage is at mid-weak or weak level. Compared with weak base (Na_2CO_3), strong base (NaOH) could cause higher damage to reservoir. Moreover, alkali-sensitivity damage to reservoir mineral can lead to high injection pressure.

Key words: *strong base and weak base, alkali-sensitivity, injection pressure, ASP flooding.*

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Application of a New Method for Evaluating PDC Bit Anisotropy

Quantitative evaluation of PDC bit anisotropy is significant to well trajectory control and PDC bit optimization. Based on the structural parameters of PDC bits such as inner cone depth, outer structure height, back-rake angle, and gauge structure, the quantitative evaluation model for determining PDC bit anisotropy is established and a method for solving the model coefficient is given. This model was applied to evaluate bit anisotropy of PDC bit A in the well of the South China Sea, and on this basis, a new PDC bit, B, was optimized. When the PDC bit B was used in the 2450-2850 m section of offset well, the inclination control was satisfactory with inclination angle being controlled between 1.2 and 1.95°. Successful application of bit B in the offset well certifies the validity of this evaluation model. The model was applied to quantitative evaluation of PDC bit anisotropy, overcoming the shortcomings of laboratory test workload, high test conditions and poor applicability. Based on this model, the effect of structural parameters of PDC bits on the bit anisotropy index was discussed. We show that the bit anisotropy index increases as back rake angle, friction angle between the PDC bit and rock, and bit size increase, and decreases as outer structure height, inner cone depth, and friction surface of the gauge increase. When drilling with a pendulum bottom hole assembly, a PDC bit with large anisotropy index should be used to minimize the tendency for the well to build angle due to strata deviating forces.

Key words: *bit anisotropy, PDC bit, structural parameter, formation force, bottom hole assembly.*

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Study on Cementing Technology of Salt-paste Bed

After more than 100 years of development, cementing technology has been constantly improved and innovated to form many kinds of cementing technology, and the corresponding cementing technology has been developed for different well conditions. Since the exploration and development, some oilfields have formed the main cementing technologies, such as salt-gypsum layer cementing technology, liner tie-back cementing technology, double-stage cementing technology, leakage-proof cementing technology, gas-tight cementing technology, small-gap cementing technology and high-gradient cementing technology. This paper has analyzed the creep law and models of salt-gypsum layer, and supply the adaptability evaluation and suggestions of cementing Technology in Salt-gypsum layer.

Key words: *Salt-gypsum layer, cementing, creep; adaptability.*

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Prediction of Fracture Width Using Logging Data and Optimization of Lost Circulation

In this study, the efficiency of fractures was evaluated, and their morphological characteristics estimated based on full-hole microresistivity and azimuth resistivity imaging logging. The lost circulation is mainly owing to the induced fractures in the ZW areas. The parameters of fracture aperture and porosity can be calculated using dual lateral logging information. The high-angle fracture parameters pertaining to lost circulation in the ZW3-x well include a fracture width in the range of 0.5–5 mm, permeability <15 mD, porosity 20%, and an extended fracture length of 3 m. The compressive strength of walnut shells and rigid particles in different circumstances is measured using a compressive strength instrument. The compressive performance of rigid particles is more stable than that of walnut shells. According to the different fracture sizes of the rigid particles, the optimal formula of drilling fluid is established. Theoretical calculations are carried out to obtain a reasonable combination of rigid particles, and follow drilling plugging agents that are used in drilling fluids during the drilling process with the use of slug-type follow-drilling plugging technology. This resulted in successful plugging using a small amount of drilling fluid and blocking time (0.5 h). Another major advantage is that this plugging technology can be effectively incorporated while drilling.

Key words: *lost circulation, fracture property, fracture parameters, rigid particles, plugging technology.*

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Rational Matching of Injection and Production Pump

for Rod Pump Injection-Production System

Based on the gas PVT theory and the principle of mass conservation, the gas volume equation of down well was established in this paper, and the calculation method of pump efficiency of single-well injection-production system was established, which was verified and corrected by 17 field test wells, with considering the influence of pump stroke loss and leakage. Combining the established mechanical model of the single-well injection-production system, aiming at the lowest water cut of the produced fluid, uses the enumeration method to design the reasonable matching of the production-injection pump and suction parameters, formulated the selection template of production-injection pump type and the selection of working system for the rod pump single-well injection-production system. It provides a basis for the process design of single-well injection-production system; and it provides technical support for the field application of the fourth generation oil recovery technology.

Key words: *rod pump, single-well injection-production system, pump efficiency, rational matching.*

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Plugging Ability of Ice Crystals in a Low Temperature Coal Rock Fracture

The key to temporary plugging by ice crystals in coalbed methane wells is whether sufficient ice formation plugging strength can be achieved. Ice crystal formation and plugging capacity test equipment was designed to test the plugging capacity of ice crystals in a low temperature coal rock fracture. The experimental results show that the plugging strength is above 20 MPa. The tensile strength of saturated coal rock under freezing conditions was tested by the Brazil disk split method in order to research the mechanism of sealing strength of ice crystals. The results show that tensile strength of frozen coal increases as the temperature falls beneath 0°C. Both of these results proved that the technology of temporary plugging using ice crystals in coalbed methane wells is feasible and rational.

Key words: *temporary plugging by ice, plugging capacity, tensile strength, coalbed methane.*

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Depth Image Super Resolution for 3D Reconstruction of Oil Refinery Buildings

Time-of-Flight (ToF) camera can collect the depth data of dynamic scene surface in real time, which has been applied to 3D reconstruction of refinery buildings. However, due to the limitations of sensor hardware, the resolution of the depth image obtained is very low, so it cannot meet the requirements of dense depth of scene in practical applications such as 3D reconstruction. Therefore, it is necessary to make a breakthrough in software and design a good algorithm to improve the resolution of depth image. We propose an algorithm of depth image super-resolution fusion multiple

progressive convolution neural networks, which uses a context-based network fusion framework to fusion multiple different progressive networks, so as to improve individual network performance and efficiency while maintaining the simplicity of network training. Finally, we have carried out experiments on the public data set, and the experimental results show that the proposed algorithm has reached or even exceeded the most advanced algorithm at present.

Key words: *depth image, 3D reconstruction, super resolution, progressive convolution neural network, oil refinery.*

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Transient Pressure Fluctuation Effect during Gas Drilling in Horizontal Well

The combination between gas drilling and horizontal well contribute to detect the oil and gas reservoir and improve production, which has been considered as a vast application prospect technology. However, when wellbore gas encountering high-press formation gas, the gas drilling will take huge risks. A theoretical model for pressure wave speed and attenuation coefficient of gaseous phase tube flow is established and is derived analytically by classic fluid-mechanics model and small perturbation theory. The simulation results suggest that the main factors affecting the pressure wave are angular efficiency, pipe diameter and original pressure. In addition, a pressure wave test device is established to validate the model. The experimental results fit well with the simulation results. The work presented in this paper can provide a theoretical foundation for gas drilling in horizontal section, and can also detect gas influx to ensure the safety of equipment and to prevent complicated accidents.

Key words: *gas drilling, horizontal well, pressure fluctuation, wave speed, attenuation coefficient.*