

Chemistry and Technology of Fuels and Oils

2⁽⁵⁹⁴⁾'2016

Head Editor

A. I. Vladimirov – Cand. Eng. Sci., prof.

Associate Editor

B. P. Tumanyan – Dr. Eng. Sci., prof.

Editorial Board

S. N. Volgin – Dr. Eng. Sci., prof.

I. B. Grudnikov – Dr. Eng. Sci., prof.

Yu. L. Ishchuk – Dr. Eng. Sci., prof.
(Ukraine)

I. P. Karlin – Dr. Chem. Sci., prof.

V. L. Lashkhi – Dr. Eng. Sci., prof.

A. Luksa – Dr. Eng. Sci., prof. (Poland)

A. M. Mazgarov – Dr. Eng. Sci., prof.

E. D. Radchenko – Dr. Eng. Sci., prof.

V. A. Ryabov – Director General of the Oil Refiners and Petrochemists Association

E. P. Seregin – Dr. Eng. Sci., prof.

Publisher— ICST «TUMA Group» LLC

Редактор

В. С. Дмитриева

Ответственный секретарь

О. В. Любименко

Графика и верстка

В. В. Земсков

Подготовка материалов

Н. Н. Петрухина,

С. О. Бороздин

Адрес редакции:

119991, ГСП-1, Москва, В-296,
Ленинский просп., 65. РГУ нефти и газа
им. И. М. Губкина, редакция «ХТТМ»

Телефон/факс: (499) 507-80-45
e-mail: htm@list.ru

Материалы авторов не возвращаются.

Редакция не несет ответственности
за достоверность информации
в материалах, в том числе
рекламных, предоставленных
авторами для публикации.

Формат 60 84 1/8.

Печать офсетная.

Усл. печ. л. 7.

Тираж 1000 экз.

Отпечатано ООО «Стринг»

E-mail: String_25@mail.ru

Contents

CHEMICAL ENGINEERING AND EQUIPMENT

Ch. D. Murshudli and G. A. Mamedov. 3
Extraction of Petroleum Acids from Diesel Fuel with Ammonia Water.
Hydrodynamic Characteristics of Extractor Plate

CHEMMOTOLOGY

L. V. Zheleznyi, Yu. V. Veligorskaya, A. A. Papeikin, and I. A. Venger. 7
Structure and Properties of Natural Surfactant Based Oleogreases

RESEARCH

V. A. Lyubimenko, V. I. Frolov, M. P. Krestovnikov, and S. V. Lesin. 12
Mathematical Modeling of Thermal Cracking of Oil Sludge Activated
by Electromagnetic Radiation

Li Nianyin, He Dailan, Zhao Liqiang, and Liu Pingli. 16
An Alkaline Barium and Strontium Sulfate Scale Dissolver

*G. P. Kayukova, A. M. Kiyamova, I. P. Kosachev, S. M. Petrov,
G. V. Romanov, L. M. Sitdikova, I. N. Plotnikova, and A. V. Vakhin.* 21
Generation of Hydrocarbons by Hydrothermal Transformation
of Organic Matter of Domanik Rocks

*A. P. Semenov, V. I. Medvedev, P. A. Gushchin,
V. S. Yakushev, and V. A. Vinokurov.* 29
Study of Inhibiting Properties of Polymer + Methanol Composite
in Gas Hydrate Formation Process

*A. P. Glotov, S. V. Kardashev, S. V. Egazar'yants, S. V. Lysenko,
V. A. Vinokurov, and E. A. Karakhanov.* 34
Catalytic Cracking of Petroleum Feedstock in Presence
of Additives Based on Crosslinked Mesoporous Oxides
That Reduce Sulfur in Liquid Products

Yang Yang, Liu Huiqing, Xie Ling, and Zhang Meng. 36
Experimental Investigation of Non-Darcy Flow Coefficients
in Artificial Frac-Vuggy Media

Yang Hao. 41
Borehole Wall Stability in Shale and Coal Seams in Daniudi Gas Field

METHODS OF ANALYSIS

L. V. Markova, N. K. Myshkin, and V. M. Makarenko. 46
Fluorescence Method for Quick Transformer Oil Monitoring

*G. M. Balak, A. N. Privalenko, A. V. Oreshenkov,
L. V. Krasnaya, V. D. Zueva, and I. A. Smirnova.* 51
Determination of Elemental Composition of Precipitates Formed
During Use of Petroleum Products by Flame Atomic Absorption Spectroscopy

INNOVATIVE TECHNOLOGIES OF OIL AND GAS

Sun Tengfei, Zhang Hui, Gao Deli, and Zhou Jianliang. 57
Calculation of Open-Hole Extended-Reach Limit Length

*Lin Dan, Zhang Tingshan, Liao Jijia, Liao Mingguang,
Geng Dan, Ren Xiaocong, and Chen Yuliang.* 61
Mineral Composition and Brittleness Analysis
of Lower Paleozoic Shale

Li Cheng-yong, Zhou Jun, Luo Yi, and Zhang Ran. 65
Nonlinear Gas Flow Model for Volume-Fractured Horizontal Wells
in Shale Gas Reservoirs

Extraction of petroleum acids from diesel fuel with ammonia water. Hydrodynamic characteristics of extractor plate

Ch. D. Murshudli and G. A. Mamedov

E-mail: 2040336@gmail.com

The physicochemical properties of substances taking part in processes of diesel fuel cleaning with ammonia water and washing with water are studied. It is shown that ammonia water containing ~2 wt. % of petroleum acids should be used as the reagent. For steady operation of the plate column, the optimal rates of fuel discharge through the plate holes are found to be 0.15 m/sec for cleaning and 0.30 m/sec for washing of the fuel. In this case, the disperse phase layer heights under the plate are 12-16 mm and 75-85 mm, respectively.

Keywords: petroleum acids, extraction of petroleum acids, diesel fuel, ammonia water, fuel acidity, plate column, hydrodynamic characteristics.

Structure and properties of natural surfactant based oleogreases

L. V. Zheleznyi, Yu. V. Veligorskaya, A. A. Papeikin, and I. A. Venger

E-mail: veligorskaya21@mail.ru

The results of study of the structure and properties of high-temperature oleogreases containing in the thickener components that can be derived from renewable natural materials are presented. The constitution of the primary structures of the oleogreases prepared by using calcium soaps of fatty acids of poultry fat and palm oil as the organic component of the thickener is established. It is proved that the distinctive properties of the oleogreases are ensured by the thickener system based on calcium carbonate and natural surfactant dispersion. In bulk-mechanical, antioxidative, tribological, and protective properties, the obtained oleogreases are not inferior to commercial superalkaline sulfonate lubricant.

Keywords: oleogreases, renewable material, calcium carbonate, calcite, faterite, palm oil.

Mathematical modeling of thermal cracking of oil sludge activated by electromagnetic radiation

V. A. Lyubimenko, V. I. Frolov, M. P. Krestovnikov, and S. V. Lesin

E-mail: fvi209@mail.ru

The results of modeling of thermal cracking of oil sludge activated by electromagnetic radiation are reported. An experimental-statistical model of dependence of wide gas oil fraction yield on radiation frequency, electromagnetic radiation power, and oil sludge activation time is obtained to optimize the cracking process conditions.

Keywords: oil sludge, electromagnetic activation, thermal cracking, mathematical modeling.

An alkaline barium and strontium sulfate scale dissolver

Nianyin Li, Dailan He, Liqiang Zhao, and Pingli Liu

E-mail: lnyswpu@163.com

At present, most oilfields are developed by applying water flooding technology. But due to incompatibility between injection fluid and formation water, and other reasons this technology is often accompanied by inorganic scale deposition on water and oil pipe and equipment walls. Barium and strontium sulfates are highly resistant to the acids that are generally used as scale dissolvers. In this work, a new chelating-agent-based alkaline barium and strontium sulfate scale dissolver named SA-209 has been developed and many of its important parameters, such as salt concentration, reaction time, pH value, temperature, etc. that affect descaling efficiency, are evaluated by experiments and analysis. This dissolver has high descaling rate and low equipment and pipe corrosion, is environment-friendly, and so would have promising application in oilfields.

Keywords: inorganic well scale, scale dissolver, barium sulfate, strontium sulfate.

Generation of hydrocarbons by hydrothermal transformation of organic matter of domanik rocks

G. P. Kayukova, A. M. Kiyamova, I. P. Kosachev, S. M. Petrov, G. V. Romanov, L. M. Sitdikova, I. N. Plotnikova, and A. V. Vakhin

E-mail: kayukova@iopc.ru

The distinctive properties of products of hydrothermal transformations of organic matter of bituminous rocks from Upper Devonian Domanik carbonate-argillaceous deposits of Romashkino field, which were formed due to generation of bituminous components present in the rock in free state as well as of hydrocarbons and high-molecular heteroatomic compounds in the insoluble kerogen degradation process, are determined. It is shown that, among the n-alkanes, homologs with even number of carbon atoms dominate in the kerogen degradation products and that the asphaltenes contain two solid disperse phases differing in aromaticity, heteroatom, microelement and vanadium porphyrin complex contents, free radical concentration, and solubility in organic solvents. The sequence of leaching out of hydrocarbons, heteroatomic compounds, resins, and asphaltenes from the rock by vapor-gas mixture is studied. The migration and adsorption capacity of n-alkanes with even and odd number of carbon atoms is shown to be diverse. Changes in the microstructure of Domanik rocks upon hydrothermal transformations are studied.

Keywords: Domanik rock, carbonate-argillaceous rock, organic matter, kerogen, heavy crude oil, hydrothermal transformations.

Study of inhibiting properties of polymer + methanol composite in gas hydrate formation process

A. P. Semenov, V. I Medvedev, P. A. Gushchin, V. S. Yakushev, and V. A. Vinokurov

E-mail: semyonovanton@mail.ru

The results of study of inhibiting properties of the composite 0.5% polymer kinetic inhibitor (KI) + 10.0% thermodynamic inhibitor (methanol, TI) in the process of formation of methane hydrate (Class I) and hydrate of 95.66 mol. % CH₄ + 4.34 mol. % C₃H₈ (methane-propane) mixture (Class II) are presented. The inhibiting properties of the composite are determined by isothermal method and method of cooling at a constant rate using a GHA350 autoclave. It is shown that methanol has an adverse effect on the inhibiting properties of polymer KI with respect to both methane hydrate and hydrates of C₁–C₃ hydrocarbons. The decline in inhibiting capacity of polymer KI in the presence of CH₃OH is expressed as a decrease in the supercooling degree attainable in the system without absorption of hydrate forming gas by 1.5-2.5°C compared with a system containing no TI. The induction time is shown to depend on the supercooling degree in the system in the process of inhibition of Class I hydrate and Class II hydrate of the 0.5% KI + 10.0% TI composite.

Keywords: kinetic hydrate formation inhibitors, thermodynamic hydrate formation inhibitors, methanol, methane hydrate, methane-propane hydrate, supercooling degree, induction time.

Catalytic cracking of petroleum feedstock in presence of additives based on crosslinked mesoporous oxides that reduce sulfur in liquid products

A. P. Glotov, S. V. Kardashev, S. V. Egazar'yants, S. V. Lysenko, V. A. Vinokurov, and É. A. Karakhanov

E-mail: kar@petrol.chem.msu.ru

Sulfur-reducing La/MCM-41/ γ -Al₂O₃ additives to commercial zeolite-containing cracking catalyst, which are based on MCM-41/ γ -Al₂O₃ carrier with various component contents, are evaluated. It is demonstrated that vacuum gas oil cracking at 500°C in the presence of the additives in the amount of 10 wt. % of the catalyst reduces sulfur in the liquid products by 20-31%.

Keywords: catalytic cracking, desulfurizing additives, mesoporous materials, vacuum gas oil, oil sludge.

Experimental investigation of non-darcy flow coefficients in artificial frac-vuggy media

Yang Yang, Liu Huiqing, Xie Ling, and Zhang Meng

E-mail: whitesheep00@163.com

Fracture and vug of various sizes (mm- to cm-scale) are quite common in carbonate reservoirs. Non-Darcy flow regime, which is a key parameter for correct prediction of production performance and behavior of such reservoirs, is investigated with reference to pure water and water-oil flow through an artificial carbonate core. The results indicate that both Darcy and non-Darcy flow may occur in fractured-vuggy media. Based on calculation of inertial coefficient at various fracture widths and vug diameters by rewriting the Forchheimer equation and experimental determination of the correlation between fracture width, vug diameter, fracture porosity, vug porosity, total porosity, permeability, and inertial coefficient, a method is proposed to determine Darcy and non-Darcy oil-water two-phase flow applying fractal theory.

Keywords: non-Darcy flow, Forchheimer equation, inertial coefficient, frac-vuggy media.

Borehole wall stability in shale and coal seams in daniudi gas field

Yang Hao

E-mail: yanghao@cugb.edu.cn

While constructing horizontal well in Daniudi gas field, accidents of the blocking type occurred near the horizontal section because of serious borehole collapse in the mudstone section of Shilezi formation and the coal seams of Shanxi or Taiyuan formation. To study the sidewall instability mechanism, the mud density window for horizontal well in complex formations was studied using logging data. Based on mud density window calculation results, it is found that in shale formations this density decreases with increase of well inclination (zenith) and azimuth angle, while in coal seams it was negative. Collapse and expansion are proved to be conducive to borehole stability and the mud density window can be positive only if the borehole collapses. It is therefore necessary to increase mud density window from 1.2 to 1.4 g/cm³ and to use drill pipe of minimally possible diameter for maximally possible time. In this case, the borehole trajectory should be determined in keeping with the seam location and mud density.

Keywords: Daniudi, mudstone, shale seam, coal seam, borehole stability.

Fluorescence method for quick transformer oil monitoring

L. V. Markova, N. K. Myshkin, and V. M. Makarenko

E-mail: lvmark@mail.ru

It is shown that in the mineral transformer oil oxidation process the fluorescence spectrum of the oil shifts to the long-wave region. This phenomenon lies at the foundation of the method of determination of the degree of electroinsulating oil oxidation in real time. The oxidation degree is determined by measuring the diagnostic parameter, i.e., the oxidation index that characterizes the magnitude of shift of the fluorescence spectrum of the oil upon its oxidation. The oxidation index is defined as the ratio of the fluorescence intensity measured in the longer-wave spectral range to the intensity measured in the shorter-wave spectral range. The results of measurement of the transformer oil oxidation degree by fluorescence method vis-à-vis other measurement methods, such as titration and IR spectroscopy, are presented. The proposed method can be used to determine the increase in oil oxidation rate at the earlier stage. The device for implementing the developed method can be a portable one or can be installed in the oil-filled system of the equipment.

Keywords: fluorescence method, transformer oil, oil oxidation, quick monitoring.

Determination of elemental composition of precipitates formed during use of petroleum products by flame atomic absorption spectroscopy

G. M. Balak, A. N. Privalenko, A. V. Oreshenkov, L. V. Krasnaya, V. D. Zueva, and I. A. Smirnova

E-mail: gmft@yandex.ru

The results of studies on development of flame atomic absorption method of determination element contents in precipitates formed during use of petroleum products are reported. The feasibility of application of this method for determining the elemental composition of the pollutants removed from the fuel and oil feed systems of the equipment and determination of the nature and causes of formation of these pollutants is demonstrated.

Keywords: petroleum products, precipitates, elemental composition, atomic absorption determination, resonance absorption, characteristic concentration.

Calculation of open-hole extended-reach limit length

Sun Tengfei, Zhang Hui, Gao Deli, and Zhou Jianliang

E-mail: zhanghui3702@163.com

Extended-reach drilling (ERD), especially of wells with a high horizontal displacement to vertical depth ratio, is an advanced drilling technology. In this paper, a model is proposed for calculating the length limit of open extended-reach wellbores. The model takes account of such factors as fracture pressure, static drilling fluid pressure, drilling fluid density, annular pressure loss, etc. The research results show that this model is more reliable and accurate than the existing ones. This paper also presents the results of analysis of the effect of various drilling parameters on the wellbore extended-reach limit. The calculations show that extended-reach limit length is inversely proportional to pump rates, drilling fluid density, and ROP, and proportional to formation fracture density.

Keywords: extended-reach limit, solid concentration, pressure loss, fracture pressure.

Mineral composition and brittleness analysis of lower paleozoic shale

Lin Dan, Zhang Tingshan, Liao Jijia, Liao Mingguang, Geng Dan, Ren Xiaocong, and Chen Yuliang

E-mail: zts_3@126.com

Organic-rich Lower Paleozoic Qiongzhusi, Wufeng, and Longmaxi formations in South Sichuan and North Yunnan areas are the main gas prospecting strata in China. XRD analysis technique is used to determine the mineral composition and brittleness indexes of three shale suites in these areas. These parameters are important for evaluating shale gas resources, analyzing reservoir-forming mechanisms, and prospecting planning. The investigation results indicate that the three shale suites have a mean quartz content of more than 27% and a mean clay mineral content of less than 37.27%, their sedimentary environment is euxinic, and they passed through telodiagenetic phase. The mean relative brittleness index of the samples from Qiongzhusi, Wufeng, and Longmaxi formations are 69.54%, 67.33%, and 60.44%, respectively. Such high relative brittleness indexes imply that the studied shale suites have good fracturability.

Keywords: South Sichuan and North Yunnan area, Lower Paleozoic, shale, mineral composition, brittleness.

Nonlinear gas flow model for volume-fractured horizontal wells in shale gas reservoirs

Cheng-yong Li, Jun Zhou, Yi Luo, and Ran Zhang

E-mail: zhoucudut2012@126.com

Due to the effects of desorption, diffusion, and seepage in shale, the flow characteristics of gas in dual-porosity shale gas reservoirs differ from the ones in conventional gas reservoirs. In this paper, we present

a mathematical model that describes gas flow from shale gas formations into volume-fractured horizontal wells. The basic solution of the model is obtained by applying Langmuir adsorption isotherm and Darcy law and combining Lord Kelvin's point-source function, Bessel integral function, and Poisson superposition equation. Type-curves of dimensionless pressure and pressure derivative are plotted in double logarithmic coordinates. The characteristics of gas flow from shale gas formations into volume-fractured horizontal wells and the factors influencing them are analyzed.

Keywords: shale gas, desorption, dual-porosity media, volume fracturing, horizontal well.