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INNOVATIVE TECHNOLOGIES OF OIL AND GAS

Synthesis Gas Production from Unconventional Hydrocarbon Stock

L. A. Gulyaeva, N. Ya. Vinogradova, G. V. Bitiev, E. G. Gorlov, and A. V. Shumovskii

Test trials of a plant were conducted to study the process of gasification of heavy oil resids blended with carbonaceous shales. The possibility of steady operation of the plant in gasification mode with production of synthesis gas is shown. The process efficiency was about 80% and the yield of dry synthesis gas was 5.9 m3/kg of the feedstock.

Key words: gasification, carbonaceous shale, heavy oil resids, synthesis gas.

Modeling and Modernization of Industrial Desulfurizing Packed Columns at Refineries

A. G. Laptev, T. M. Farakhov, and M. M. Basharov.

The process of mathematical modeling of mass transfer in a random packing layer under conditions of turbulent gas motion and countercurrent laminar wavy flow of a liquid film is studied. The packing layer is depicted as a set of equivalent channels with a correction for sinuosity. P. Kapitsa's idea of depicting waves on a mesophase film surface upon interaction with a gas stream as elements of roughness is used. The component concentration profiles are found by solving differential mass transfer equations for a cylindrical channel with a volume mass source. The results of solution of the equations system are presented and compared with experimental chemisorption data.

Key words: desulfurization, mass transfer, chemisorption, packed column, packing, two-liquid model.

Production of motor fuels for cold climates with simultaneous refining of vegetable and crude oil stock

L. A. Gulyaeva, O. I. Shmel'kova, V. A. Khavkin, L. A. Krasil'nikova, and R. É. Boldushevskii

The feasibility of involving synthetic oil produced by Fischer-Tropsch process from synthesis gas of wood biomass gasification process in production of K5 class of alternative low-pour-point fuels by processing in a blend with straight-run diesel distillate employing a two-stage scheme (the first stage - hydrofining in the presence of the conventional hydrofining catalyst Co-Mo/Al2O3, the second - hydroisodewaxing) is investigated. It is shown that the nickel-molybdenum-containing hydroisodewaxing catalyst based on binary mixture of zeolites (high-silica low-alkali zeolite TsVN of the pentasil structure and mordenite) allows production of diesel fuel for Arctic conditions (limit filterability temperature -45°C) and in aviation kerosene with initial crystallization temperature of -63°C. A mixture of boron and lanthanum oxides was used as the promoter and a mixture of amorphous aluminum silicate and g-alumina, as the binder.

Keywords: low-pour-point motor fuels, wood biomass gasification, synthetic oil, Fischer-Tropsch synthesis, straight-run diesel distillate, hydrofining, hydroisodewaxing.

Efeect of Carbon-Nanotube-Based Additives on Rheological Properties of Liquid Boiler Fuel

E. R. Zvereva, O. S. Zueva, R. V. Khabibullina, G. R. Mingaleeva, G. R. Akhmetvalieva, D. R. Salikhzyanova, and Z. F. Khatmullina.

To improve the quality of heavy oil fuel having a large proportion of residual fractions, we studied the effect of addition to it of additives based on carbon nanotubes, which are versatile additive nanomaterial for producing substances having fundamentally new or significantly altered physicomechanical and physicochemical properties. The results of the studies of rheological properties of furnace fuel oil and water-oil emulsions mixed with suspensions of domestic carbon nanotubes in surfactant dispersions are presented. The mechanisms of the action of carbon nanotubes on the dynamic viscosity of the fuel oil are studied. It is shown that energy-saving and resource management problems can be solved by reducing the cost of meeting the needs of plants and boiler houses while incorporating carbon nanotubes in the boiler fuel.

Key words: oil fuel, residual fuel oil, water-fuel emulsion, carbon nanotubes, dynamic viscosity, dispersion.

Effect of calix[n]arene derivatives on oxidation resistance of plastic lubricants

L. A. Khamidullina, A. S. Gusak, E. A. Ivanova, O. A. Trofimova, P. E. Prokhorova, and Yu. Yu. Morzherin

The effect of the nature of calix[n]arenes [n = 4, 6, 8] added to a plastic lubricant on the oxidation resistance of the lubricant at high temperatures is studied. Such characteristics as the quantity of phenolic fragments in the calixarene structure, presence of tert-butyl groups on the upper ring of the calix[n]arene, and presence of an O-alkyl substituent on the lower ring are examined. It is shown that calix[8]arenes are capable of inhibiting high-temperature oxidation of plastic lubricants, regardless of the presence of a tert-butyl substituent on the upper ring and an alkyl substituent on the lower ring.

Keywords: calixarenes, plastic lubricants, antioxidative properties, acid number.

Residual fuel oil cracking using alumium plant sludges as catalysts

L. M. Mirzoeva and I. A. Khalafova

Cracking residual fuel oil separated from a mixture of Azerbaijan crude oils using catalysts based on aluminum plant sludges containing up to 50-70% Fe2O3 is investigated. It is shown that the yield of liquid products, including motor fuels, upon residual fuel oil cracking at 550°C rises to 80 and 70 wt. %, respectively. Steam gasification of carbonized and partially reduced catalyst allows production of gas with a hydrogen content of up to 72.84 vol. %.

Keywords: residual fuel oil processing, catalytic cracking, aluminum plant sludges, hydrogen-containing gas, distillate fractions.

Calculation of thermodynamic parameters of the process of high-octane component production from butane-butylene fraction based on thermobaric dependencies and informative model

E. F. Trapeznikova, Yu. A. Khamzin, R. R. Shiriyazdanov, A. R. Davletshin, O. N. Makhmutova, F. Sh. Vil'danov, and M. N. Rakhimov

The thermodynamic parameters of the process of oligomerization of butane-butylene fraction based on thermobaric dependencies and informative model, which can be used further for mathematical evaluation and prediction of the possibility of occurrence of reaction, are calculated. The variations of equilibrium constants and Gibbs free energy as a function of process temperature are presented graphically.

Keywords: oligomerization, butane-butylene fraction, thermodynamic parameters, equilibrium constant, Gibbs energy.

Hydrocracking of vacuum gas oil on bimetallic NI-MO sulfide catalysts based on mesoporous aluminosilicate AL-HMS

A. V. Vutolkina, A. P. Glotov, S. V. Egazar'yants, M. Yu. Talanova, N. A. Sinikova, S. V. Kardashev, A. L. Maksimov, and É. A. Karakhanov

The activity and selectivity of bimetallic Ni-Mo sulfide catalyst based on mesoporous aluminosilicate Al-HMS with Si/Al ratio of 10 in vacuum gas oil hydrocracking process in a reactor with a fixed catalyst bed is studied. The dependence of the activity and selectivity of the NiS-MoS_2/Al-HMS (Si/Al = 10) catalyst on the process parameters (temperature, hydrogen pressure, volume stock feed rate, etc.) is investigated. It is shown that in the 380-450°C range and at 5 MPa hydrogen pressure the noted catalyst ensures conversion of the heavy part of the hydrocarbon stock to fuel fractions with high middle distillate selectivity and allows reduction of sulfur content in the liquid hydrocracking products.

Keywords: hydrocracking, hydrofining, mesoporous materials, vacuum gas oil, middle distillates.

Effect of group chemical composition of mixture of West Siberian oils on road asphalt quality

V. E. Somov, G. D. Zalishchevskii, A. G. Brusnin, I. V. Ryabinin, V. V. Vasil'ev, E. V. Salamatova, I. A. Sadchikov, and E. E. Nikitin

It is shown that the group chemical composition of oil fractions refined at OOO Kinef (Kinef Ltd.) changes with time and that with increase in penetration of heavy resid the oxidation rate and penetration index of the asphalt obtained from it increases. The extensibility of road asphalt decreases markedly with increase in paraffin content. Road asphalt meeting the PNST 1-2012 specifications was produced by compounding asphalts oxidized to different degrees.

Keywords: group chemical composition, oil fraction, road asphalt, heavy resid penetration, paraffin, asphalt extensibility.

Impact of imbibition on lost gas content of gas shale

Shen Yinghao, Ge Hongkui, Su Shuai, and Yang Zhihui

Field desorption method is an important means of estimating total gas content of gas shale. Accurate calculation of total shale gas content is difficult, the lost gas content being the main source of error in the calculation. Because of ultra-low water saturation and high micro-nano capillarity, the water absorption ability of shale deposit is strong and the drilling fluid percolates into the core pores under imbibition effect, which, in turn, affects gas occurrence. This effect is not considered currently in calculation of gas content loss of gas shale. In this article, the mechanisms of shale imbibition process is studied for different drilling fluid properties with reference to Chang-7 shale of the Yanchang Region of the Erdos Basin to ascertain the impact of imbibition of drilling fluid filtrate on gas yield and to calculate the lost gas content of shale. It is shown that capillary imbibition of drilling fluid occurs in three stages: early stage, which is controlled mainly by fracture and has a high imbibition rate; middle stage, which is controlled mainly by shale matrix and has a low imbibition rate; late stage is a diffusing stage and is the longest. Capillary imbibition enhances shale gas dissipation rate and its effect differs if the drilling fluid properties and the adopted desorption methods are different, causing a 10-20% error in the calculation of the lost gas content of shale.

Keywords: shale gas, gas content, lost gas content, imbibition effect.

A novel method for determining the degree of clay swelling in a clay—polymer—water system

Gang Xie, Pingya Luo, Mingyi Deng

The effectiveness of various clay-shale swelling inhibitors was evaluated and the hydration mechanism was studied using information on the contents of adsorbed water in a clay—polymer—water system. Quantitative analysis used a UV photodetector and thermogravimetric analysis. The evaluation of the degree of shale hydration could provide new ideas for well designs and the most effective and ecologically friendly swelling inhibitors.

Keywords: clay shale, clay shale swelling inhibitor, thermogravimetric analysis, UV photodetector

Distinctive features of express-functional method of magnetic monitoring of ferroimpurities in fuels and lubricants

D. A. Sandulyak, A. V. Sandulyak, P. N. Shkatov, and M. A. Kononov

Systematized information about standardizable parameters and methods of monitoring mechanical impurity contents in lubricant coolants, industrial and motor oils, and gasoline is provided. Considering that in most cases metallic impurities possess ferromagnetic properties, magnetic methods are preferred for monitoring iron-containing impurities. The basic aspects of the relatively new experimental-computational method approved for a number of fuels and lubricants, which, contrary especially to the experimental method, allow more accurate monitoring of ferroimpurity content, are expounded. The

suitability of the model of exponential ferroimpurity absorbing screen for this monitoring method is confirmed with reference to gasoline, diesel fuel, and industrial and motor fuels. Based on the results of the proposed magnetic monitoring method, a notable demerit of one of the most popular variants of magnetic monitoring used for ferrography is pointed out.

Keywords: fuels and lubricants, lubricant coolants, iron-containing impurities, magnetic monitoring, experimental-computational model.

Analysis of Rocket-Kerosene Components by Comprehensive Two-Dimensional Gas Chromatography/Time-of-Flight Mass Spectrometry

Guang-you Zhang, Qing-tao Peng, Li Wang

Rocket-kerosene components were analyzed by comprehensive two-dimensional gas chromatography/time-of-flight mass spectrometry. Qualitative analysis identified chromatographic peaks for various compound classes. Quantitative analysis estimated the corresponding characteristic peak areas. The kerosene was found to consist of paraffins, cycloalkanes, bicyclic and tricyclic alkanes, alkenes, and aromatic and oxygenated compounds. It was demonstrated that this analytical method had several advantages over traditional methods for determining rocket-kerosene compositions.

Keywords: comprehensive two-dimensional gas chromatography, time-of-flight mass spectrometry, rocket fuel, rocket kerosene.

Effect of type of treatments on uniaxial compressive strength parameters of rock core

Yang Hao

Uniaxial compressive strength, Poisson's ratio, and modulus of elasticity of various artificial rock cores differing in mineral composition, particle size distribution, permeability, porosity (void ratio), etc. and submitted to different types of treatments are measured. The results indicate that water saturation of the rock core under vacuum and subsequent oil and gas injection under a pressure that simulates the formation pressure is the best way to prepare the core for performing the measurements.

Keywords: rock core, uniaxial compressive strength, Poisson's ratio, elasticity modulus.

A modified multiple mixing cell method for minimum miscibility pressure calculation

Chenshuo Zhang, Zifei Fan, Anzhu Xu, and Lisha Zhao

The existing methods of determination of minimum miscibility pressure (MMP) are reviewed in brief. A modified multiple mixing cell method is proposed to calculate MPP based on variation of tie lines at various pressures. First, the algorithm of classical multiple mixing cell method is used to calculate the length of the tie line, its structure is studied, and the pressure-dependent critical points are found. Then, a detailed procedure is proposed to improve the existing algorithm of the mixing cell method. Finally, the

method is validated by comparing the results of the modified method, analytical method, and slim tube experiment in four cases. It is shown that the proposed novel algorithm can be used to solve the complex problem of finding the precise MMP.

Keywords: oil displacement by mixing agents, minimum miscibility pressure, multiple mixing cells, fraction-wise calculation, flash calculation, estimation method.

Effect of ultrasound on nominal viscosity of water-asphalt emulsions

A. I. Abdullin, M. R. Idrisov, and E. A. Emelyanycheva

The results of study of the effect of ultrasound on the viscosity properties of water-asphalt emulsions stabilized by nonionogenic surfactants are presented. The viscosity properties of emulsions depend on the emulsifying agent concentration and ultrasonic emulsion treatment time. Competing processes of dispersion and coagulation of particles, which affect the ultimate properties of the emulsion, occur in the course of the ultrasonic action. This fact dictates the need for selecting the optimum ultrasonic action time for ensuring high dispersity of the asphalt emulsions such that the emulsions approach the multidisperse state.

Keywords: water-asphalt emulsion, ultrasonic treatment, viscosity properties.

Modifying complex additive for asphalt binder

I. N. Galimullin, N. Yu. Bashkirtseva, and I. I. Mukhamatdinov

The effect of modifying complex additives on the physicochemical properties of asphalt is studied. It is shown that complex additives based on cellulose fibres having surfactants adsorbed on their surface possess cross-linking effect and improve heat and frost resistance of the asphalt binder and adhesive and cohesive strength.

Keywords: road asphalt, gravel-cement asphalt concrete, modifier, stabilizer, complex additive, cellulose fibre.

Study of heavy hydrocarbon stock separation by single-pass flash vaporization

S. M. Petrov, A. I. Lakhova, S. D. Molodtsov, É. A. Galiullin, R. Z. Fakhrutdinov, and I. N. Diyarov

This work is aimed at solving the scientific problem relating to development of an energy-saving technology of primary heavy hydrocarbon stock processing based on single-pass flash vaporization. Single-pass flash vaporization process is based on atomization of heated stock in the apparatus. In this process, the phase interface increases several folds, making supramolecular convective mass transfer comparable with diffusional transfer, which ensures more than threefold
increase in yield of distillate in the heavy oil treatment process with weighting of the residual product.

Keywords: heavy oil, single-pass vaporization, atomization, distillate, oil residue.

Role of paraffinic hydrocarbons in formation of dispersed structure of petroleum asphalt

I. N. Frolov and A. A. Firsin

The structural and thermal properties of petroleum asphalt and paraffinic hydrocarbon fractions are analyzed by temperature-modulated differential scanning calorimetry. It is shown that macrocrystalline waxes play the key part in the formation of the dispersed phase of colloidal size, creating the dispersed structure of asphalt.

Keywords: temperature-modulated DSC, petroleum asphalt, waxes, dispersed colloidal structure.

Synergy effect of use of blends of oxygenates and amines as straight-run gasoline additives

A. V. Sharifullin, L. R. Baibekova, and A. I. Dusmetova

The effectiveness of use of binary and ternary composites of alcohols and nonaromatic amines as antiknock additives to straight-run gasoline is studied. Their synergy effect is ascertained and the gum formability of fuels with such additives is studied. It is shown that the increase in gum formability does not obey the additivity law.

Keywords: straight-run gasoline, additive, oxygenates, octane number, gum formability, actual resins, antiknock properties.

Solvents of asphalt-resin-wax deposits based on aliphatic dialkyl disulfides

O. M. Kornetova, A. V. Sharifullin, F. A. Korobkov, A. F. Vil'danov, and L. R. Baibekova

The structural-group composition of the studied specimens of asphalt-resin-wax deposits (ARWD) is determined. It is proved that they are of wax-rich type. The effectiveness of disulfide oil as an ARWD solvent is studied and it is shown that in pure state disulfide oil is not effective enough for removing the most difficultly degradable wax-rich deposits. Addition to disulfide oil of nonionogenic surfactants (0.1-0.5 wt. %) and aromatic hydrocarbons (liquid pyrolysis products, Bentol) in a quantity of more than 40 wt. % markedly enhances the effectiveness of disulfide oil (up to 80-90 wt. % in the 20-50°C range), which makes its use commercially justified.

Keywords: asphalt-resin-wax deposits, solvent, disulfide oil, liquid pyrolysis products, Bentol (benzene-toluene) fraction.

Steam-air conversion of heavy oil in presence of nano-sized particles of metal oxides

S. M. Petrov, G. P. Kayukova, A. I. Lakhova, R. R. Soldatova, and D. A. Ibragimova

The effect of suspended nano-sized magnetite and hematite particles on thermal degradation of heavy oil at 360°C in steam-air atmosphere at various pressures in the system is studied. It is shown that mainly the high-molecular components of the oil undergo degradation, which leads to a decrease in the oil viscosity. The effect on the process of aluminum and zinc oxides used as additives that initiate breaking of hydrocarbon bonds is studied. The mechanisms of change in component composition of the conversion

products relative to the initial oil are disclosed. Implementation of the process in the presence of additives at 11 MPa pressure facilitates reduction of aromaticity of the end products with increased yield of hydrocarbons of the oils and formation of gaseous products. Also, asphaltic-resinous matters are found to decrease due to conversion in the presence of additives. Rheological curves of the conversion products are constructed and they are used to show the peculiarities of change in the viscosity-temperature characteristics.

Keywords: high-viscosity oil, nano-sized particles, iron oxides, component composition of oil, rheological curves.