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Contents

THE 75TH ANNIVERSARY OF THE FEDERAL AUTONOMOUS ENTERPRISE "25TH STATE SCIENTIFIC RESEARCH INSTITUTE OF CHEMMOTOLOGY OF THE MINISTRY OF DEFENSE OF RUSSIAN FEDERATION"

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Основные этапы развития, итоги и направления научной деятельности

В статье изложены этапы становления и развития 25 ГосНИИ МО РФ. Рассматриваются основные перспективные задачи, требующие решений и состояние научного потенциала института. Приводятся направления и итоги научной и практической деятельности института в связи с 75-летним юбилеем со дня его формирования, перечислены действующие научные химмотологические школы. Статья содержит многоплановую интересную информацию об институте, Особое внимание уделяется созданной в стенах института новой прикладной науке – химмотологии и организации семинаров и конференций по результатам исследований в области этого, относительно нового научного направления. В статье отражено много интересных фактов и цифр, характеризующих активную позицию коллектива научного учреждения в области рационального применения нефтепродуктов в технике, приведен анализ динамики развития института в соответствии с развитием научно-технического прогресса и изменением отечественного геополитического положения.

Ключевые слова: научно-исследовательский институт, становление, химмотология, научные школы, горюче-смазочные материалы, технические средства службы снабжения горючим, вооружение, военная и специальная техника, испытания, внедрение, эксплуатация.

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Становление и перспективы развития химмотологии

Рассмотрены предпосылки формирования химмотологии как новой прикладной науки о рациональном и эффективном применении топлив, смазочных материалов и специальных технических жидкостей в технике, устанавливающей зависимости между составом, качеством ГСМ и показателями надежности, эффективности и другими характеристиками работы техники. Изложены ее методические основы и направления развития.

Ключевые слова: химмотология, горюче-смазочные материалы, химмотологическая система, эксплуатационное свойство, химмотологический процесс.

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Deployment and Prospects for Chemmotology Development

Requisites for deployment of chemmotology as a new field of applied science focused on rational and efficient application of fuels, lubricants and special-purpose fluids in equipment that traces dependencies between

composition, POL qualities and levels of reliability, efficiency and other characteristics of equipment performance, have been considered. Methodological background and growth options have been presented.

Key words: *chemmotology; petroleum, oils and lubricants, chemmotology system, performance property, chemmotology process.*

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Формирование требований к уровню эксплуатационных свойств топлив и смазочных материалов при их разработке

Метод формирования требований к уровню эксплуатационных свойств топлив и смазочных материалов, основанный на выражении общих требований к ним через значения точечных и интегральных показателей свойств, полученных по результатам испытаний на лабораторных установках, позволяет повысить оперативность и достоверность оценки их качества при снижении материальных затрат.

Ключевые слова: требования к эксплуатационным свойствам горючего, модель химмотологического процесса, модельная установка, теория планирования эксперимента, точечная и интегральная оценка свойств горючего.

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Substantiation of Requirements to the Level of Performance Properties of Fuels and Lubricants while Their Development

The method of development of requirements for the level of performance properties of fuels and lubricants based on the general requirements for them by means of values of point and integral indicators of properties obtained from the tests results at laboratory units makes it possible to increase the efficiency and reliability of evaluating their quality while reducing material costs.

Key words: *requirements for performance properties of fuel, model of chemmotological process, model unit, theory of experimental design, point and integral assessment of fuel properties.*

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Оценка топливопроницаемости стеклопластиковых труб и концептуальные пути решения проблемы обеспечения герметичности композитного сборно-разборного трубопровода

С использованием системного подхода установлены виды возмущений, возникающих в трубном линейном элементе при функционировании, и их последствия, приводящие к нарушению герметичности композитных труб. Предложена физическая модель процесса проницаемости, в которой стенка трубы рассматривается

как пористая среда, пронизанная параллельными друг другу капиллярами, приведены результаты оценки проницаемости стенки композитной трубы неравновесной спирально-винтовой намотки по критерию герметичности. Аргументированы концептуальные подходы к решению проблемы герметичности композитных трубопроводов.
Ключевые слова: сборно-разборные трубопроводы, герметичность композитных труб, топливопроницаемость, критерии оценки, структура намоточного стеклокомпозита, поток моторных топлив, микротрещины структуры, капилляры проницания.

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Assessment of Fuel Permeability for Fiberglass Pipes and Conceptual Approaches to Solving Problems Related with Metal-Composite Sectional Pipeline Leak Tightness
As the system concept has been adopted, some disturbances arising in a pipe linear element have been found during operation, as well as their effects, causing leakproofness breakdown of the composite pipelines. The authors suggested a physical model for permeability process, in which the pipe wall is considered to be porous capillary medium; the evaluation results for non-equilibrium spiral-screwed wound composite pipe wall permeability have been disclosed with respect to the leakproofness criteria. Conceptual solutions for composite pipeline leakproofness have been reasoned.
Key words: *sectional pipelines, composite pipeline leakproofness, fuel permeability, estimation criteria, filament-wound fiber-glass composite structure, motor fuel run, structure microcracks, permeability capillary.*

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Методика имитационного моделирования химмотологических процессов для оценки и прогнозирования эксплуатационных свойств горюче-смазочных материалов
В работе представлена методика моделирования химмотологических процессов, позволяющая по результатам испытаний горюче-смазочных материалов (ГСМ) на физических моделях объектов применения ГСМ строить с использованием ЭВМ математические и имитационные модели процессов и на их основе оценивать и прогнозировать эксплуатационные свойства ГСМ с учетом вероятностных характеристик (законов распределения) состава ГСМ, реальных режимов работы и условий эксплуатации техники. Приведены результаты апробации методики применительно к свойствам моторных топлив.
Ключевые слова: горюче-смазочные материалы, эксплуатационное свойство, химмотологический процесс, имитационное моделирование, математическая модель, прогнозирование.

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Method of Simulation Modeling of Chemmotological Processes
for Fuels and Lubricants Performance Properties Evaluation and Forecasting

Method of simulation modeling of chemmotological processes that is aimed at construction of mathematical and simulation computer models of the in-equipment operation processes is proposed. Application of the suggested simulation modeling of chemmotological processes will allow the fuels and lubricants performance properties evaluation and forecast that represent probabilistic characteristics (laws of probability distribution) of fuels and lubricants composition as well as real world equipment operational conditions, to be easily obtained. The examples of advantages of the new method are provided when estimating the properties of motor fuels.

Key words: *fuels and lubricants, performance property, chemmotological process, simulation modeling, mathematical model, forecasting.*

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Исследование осадкообразования в реактивных топливах при обводнении
с использованием методов молекулярной механики

Приведены результаты исследования процессов формирования и структурирования дисперсных систем топлив для реактивных двигателей в условиях контакта топлива ТС-1 с противоводокристаллизационными жидкостями и без них с водой, а также образования агрегированной дисперсной фазы, являющейся одной из причин отказов топливных систем авиатехники.

Ключевые слова: дисперсная система, агрегированная дисперсная фаза, сложная структурная единица, межмолекулярные взаимодействия, стерическая энергия, функции силового поля.

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Study of Sedimentation in Jet Fuels Due to Watering
Using Methods of Molecular Mechanics

The research results of the formation and structuring of dispersed jet fuel systems in contact of fuel TS-1 with icing inhibition liquids and without them with water, as well as the formation of the aggregated dispersed phase, which is one of the causes of fuel system failures of aircraft, are presented.

Key words: *dispersed system, aggregated dispersed phase, complex structural unit, intermolecular interactions, steric energy, force field functions.*

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Применение планирования эксперимента для оптимизации условий испытания при оценке противоизносных свойств авиакеросинов

Предложено использовать математическое планирование эксперимента для оптимизации условий испытания, при которых обеспечивается максимальная разрешающая способность метода оценки противоизносных свойств авиационных керосинов. В качестве критерия оптимизации выбрана абсолютная разность между значениями определяемого показателя «ширина дорожки износа» для топлив с различным уровнем противоизносных свойств.

Ключевые слова: авиационный керосин, противоизносные свойства, подобие, моделирование, планирование эксперимента, испытания, оптимизация.

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Application of Experiment Planning for Optimization of Test Conditions when Evaluating Anti-Wear Properties of Aviation Kerosene

It is proposed to use the mathematical planning of the experiment to optimize the test conditions which provide the maximum resolution of the method for assessing the anti-wear properties of aviation kerosene. The absolute difference between the values of the determined indicator "wear-track width" for fuels with different levels of anti-wear properties is selected as the optimization criterion.

Key words: *aviation kerosene, anti-wear properties, similarity, simulation, experiment planning, testing, optimization.*

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A New Wellbore Stability Model for Shale Gas Horizontal Wells With Effects of Bedding Planes and Water Content

The exploration and development of shale gas has been a hot spot in natural gas industry, while wellbore instability is always problem during the drilling of horizontal shale gas wells. In this paper, based on the circumferential stresses analysis of horizontal wells and analysis of geometrical relationships of bedding planes and wellbore, a new horizontal wellbore stability model considering the effect of bedding planes is introduced when water contents are taken into the strength parameters of shale; then a comparison with the wellbore stability model for intrinsic rocks is made based on actual field data of a shale gas well, results of which show that existence of bedding planes make wellbore more unstable. Meanwhile, the maximum and minimum value of collapse pressure density at different azimuths of wellbore linearly increase with increasing water contents. Besides, results also show that factors like azimuths of wellbore, dip angles and dip directions of bedding planes have significant impact on wellbore stability of horizontal shale gas wells.

Key words: wellbore stability, bedding planes, water content, shale gas, horizontal wells, collapse pressure.

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Research on the Fluid Flow Characteristics in the Process of Pump Closing in Cementing

In the process of cementing for formations with narrow density window, due to the instantaneous change of displacement at the time of closing the cementing pump, the fluctuation of flow and pressure are produced in the wellbore, which is bound to affect the wellbore pressure safety and annulus wellbore stability. Therefore, it is very important to study the flow characteristics of wellbore fluid in the process of closing the cementing pump. The control equations for wellbore fluid flow in the process of instantaneous cementing pump closing are established, the solving method and boundary conditions are determined, the corresponding calculation software is developed, and the flow characteristics of wellbore fluid in the process of closing the cementing pump are analyzed based on the practical calculation. This research has important practical significance for optimizing the operation of closing a cementing pump.

Key words**:** control equation, solvingmethod, boundary condition, practical calculation.

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Development and Dynamic Analysis of Torsional Vibration Damping Tool for PDC Bit

It is generally recognized that the stick-slip motion of Polycrystalline Diamond Compact (PDC) bit is responsible for the low rate of penetration (ROP) and premature failure of the PDC bit in drilling hard rock formations. To solve this problem, a torsional vibration damping tool was developed. A working principle model of the tool and a calculation model of the optimal spiral angle of the tool were established. The stability of the tool was analyzed, and the parameter range of spiral guideline thread stability was determined. Theoretical analysis revealed that the tool can automatically adjust the WOB and the rotary speed of the PDC bit through the spiral guide and the disc spring, which could suppress the torsional vibration of the PDC bit and convert part of the vibration load into cutting torque for rock breaking and thus to improve the rate of penetration (ROP). The optimal spiral angle of the tool is proportional to the axial stiffness, bit diameter and rock hardness of the drill string system and inversely proportional to the torsional stiffness of the drill string system and the reclining angle of the PDC bit. The stability of the tool is related to the spiral angle, length and friction angle of the spiral guide. The tools were applied in test wells, the results indicate that the torque fluctuations are significantly decreased and effectively extend the service life of the PDC bit. During the test process, the tool exhibits steady performance, the feasibility of the tool calculation model was verified. It is anticipated that the presented results will make such drilling a more feasible method for well services.

Key words**:** torsional vibration, stick-slip, WOB, PDC bit, ROP.

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Study on Mechanical Behavior of Production String in High Temperature and High Pressure Wells

High temperature and high pressure wells are facing a lot of problems such as complicated stress on production string, severe deformation and annular pressure, which seriously restrict the pace of drilling and development of high temperature and high pressure oil and gas resources in China. In this paper, theoretical analysis and software calculation are combined to study stress and deformation of high temperature and high pressure well string. Through this research, the flow and method of mechanical analysis of high-temperature and high-pressure wells are established, which can effectively guide the mechanical analysis of high-temperature and high-pressure wells in the future. At last, this paper describes the analysis flow and calculation method of string mechanics according to an example, and calculates the force, deformation and trap pressure of string and packer under different working conditions. These calculation results can give some warning to the field operation in advance. Therefore, the research content of this paper can provide the analytical method and process for the mechanical analysis of production string in the development scheme design of high temperature and high pressure well.

Key words: high temperature and high pressure well, production string, force analysis, trap pressure.

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Analysis of the influence of gas solubility on the gas flow characteristics of 0 in MPD operating

In consideration of gas solubility, gas slippage, volume coefficient of oil-based drilling fluid, the concept of annular 0 gas flow is put forward, and the model of residual gas is put forward. The calculation results show that in the process of continuous gas influx at the bottom of the well. The phenomenon of annular 0 gas flow can be produced by considering solubility. The increase of back pressure, the decrease of gas invasion rate and the decrease of oil-based ratio all increase the annular 0 gas flow well section. The invasion of carbonate gas at the bottom of the well, the back pressure is increased from 0.1MPa to 4.0Mpa, and the annular 0 gas flow section is increased from 1000m to 2700m, the maximum error of the annular void ratio is 21.22% without considering the 0 gas flow. When the CO_2 gas invades the bottom of the well, the oil base ratio is increased from 0.1 to 5, and the annular 0 gas flow section is increased from 1500 to 2250 m, the maximum error of the annular void ratio is 26.57%.

Key words**:** solubility, 0 gas flow, gas-liquid two phase, drilling, annulus.

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Prediction of shear-wave velocities in carbonate reservoir

Shear-wave velocities must be predicted to conduct AVO (amplitude variation with offset) inversion, interpret seismic converted-wave data, and match reservoir engineering information with seismic data in regions without shear-wave velocities. During CO_2 flooding and sequestration, the shear-wave velocity varies with the pressure that is caused by fluid injection. Predictions of how the shear-wave velocity changes with pressure can be used to interpret 4D seismic monitoring data during different stages of CO_2 injection. We use the characteristics of the Marly dolomite and Vuggy limestone units of the Weyburn Oilfield reservoir in Canada and Digby's model alongside Gassmann's equation to predict how the shear-wave velocity in this carbonate rock changes with pressure. We propose a new method for calculating the coordination number of the model and supplement the results with a shale correction, enabling our prediction to closely match the measured shear-wave velocities. Our method is verified by dipole sonic logging data and petrophysical test data from the Weyburn Oilfield. Our method is first applied to petrophysical test data, and the average error is below 5%. Then, our method is applied to well log data; the average error in the porous media is 3.014% in the Marly unit and 6.288% in the Vuggy unit.

***Key words*:** CO_2 sequestration, pressure-dependent shear-wave velocity, Digby model.

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Novel Method for Imbibition Production Mechanism Study Using NMR Technique

Tight volcanic reservoirs are characterized by strong heterogeneity, fracture development and difficult reservoir development. How to effectively develop such reservoirs is an important research work in oil and gas field development. The imbibition production is an important mechanism for oil recovery in tight reservoirs. In this paper, based on the poor development of horizontal wells in tight volcanic reservoirs, the mechanism of the imbibition production during fracturing fluid flowback in tight volcanic reservoir was studied using nuclear magnetic resonance (NMR) technology. First, the wire-cutting technique was used to simulate the fracture generated by the hydraulic fracturing development, and the core was filled with quartz sand. Last, the migration of fluid between small pores and

macropores during the imbibition process was studied by low-field NMR imbibition experiments. The research results show that the imbibition displacement of fracturing fluid with high pressure can effectively increase the degree of recovery, while the soaking time can affect the imbibition exchange of fluid between crack and matrix. Due to the small radius of the pores of the volcanic rock and the large resistance of the capillary, the imbibition stability time is longer. Furthermore, the pore size distribution of volcanic rock was analyzed quantitatively by NMR and mercury intrusion porosimetry. The dynamic imbibition process is mainly happened in pores less than 2 μm.
Key words: *volcanic reservoir, fracturing fluid flowback, imbibition production, NMR.*

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Method to Design and Check Tensile Coefficient in Ultra-deep Wells

Based on Casing Axial Load and Quality Reliability

It is very important to design safety factor to ensure the safety, reliability and economy of casing strings. According to the field practice, no casing failure happened in some deep and ultra-deep wells when the casing tensile coefficient is under the required range (1.6–2.0), but there is no adequate scientific basis. Based on the engineering experiences and available research, this paper analyzes the key influencing factors on the casing tensile coefficient and the types of axial loads. Related method is also carried out to accurately calculate the axial loads. Based on the reliability theory and processing quality reliability, a method is established to design the casing tensile coefficient. And then the value of casing tensile coefficient is obtained through the proposed method using the failure probability of casing tensile strength. This method is applied in the deep well of Tarim Oilfield, the results shows that the suitable casing tensile coefficient can reduced to 1.5 while the casing strength can keep reliable. The result has been applied and verified in Tarim Oilfield, thus providing technical support for the development of deep oil and gas.
Key words: ultra-deep well; casing strength reliability; tensile coefficient; design method; field application.