

SUMMARIES

Vytyaz O.Yu.: **Prediction of conditions of longterm operated drill pipes failure** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

An experimental assessment of the force criterion for metal failure of longterm drill pipes operation was carried out. Defined were the conditions under which during tripping the failure of longterm operated drill pipes is possible when they contain an external or internal circumferential transverse crack. The interrelation of critical external or internal circumferential transverse cracks in drill pipes to the drilling string weight was established. It was shown that the internal cross cracks during drilling string tripping at depths exceeding 3000 m are more dangerous than the external ones, whereas within the range of 1000–3000 m the external circumferential transverse cracks are more dangerous.

Keywords: critical stress intensity factor, critical size of the external or internal circumferential transverse cracks, typical depth of external or internal circumferential transverse crack

Rychlicki S., Stopa J.: **Prospects for development of the oil market in the world** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Crude oil and natural gas were in the twentieth century and are still the most important strategic resources, which determine many aspects of politics and the world economy. The price level and the availability of oil and gas has a huge impact on the economic situation of all countries of the world. The developments in the oil market were the cause of many wars. The use of oil on an industrial scale it was observed at the end of the nineteenth century and once was considered the most effective source of energy for universal use. Since then, a steady increase of its share in the energy balances of the World. Growing automotive industry in the early twentieth century was also an important factor in increasing the use of oil, which is then processed in many emerging refineries. All this led to the development of the oil industry, which has become an alternative to coal as the main fuel so far. However, a major breakthrough in the use of oil occurred only after the Second World War, when began to rapidly develop such industries as chemical-based oil or plastics industry. This article presents information on traditional and prospective areas where oil deposits in the world and its resources as well as international trade, price formation in the market and prospects of development of the oil market in the world.

Keywords: oil, oil resources, oil trade, oil prices

Janiga D., Czarnota R., Stopa J., Wojnarowski P.: **Microscale modeling of CO₂-EOR process in coupling with laboratory measurements** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Application of enhance oil recovery methods (EOR) as carbon dioxide injection (CO₂-EOR) can increase technological or economical production indicators. For the evaluation of process effectiveness, full scale simulation model is used. Numerical models require large number of high quality geological and production data. However, the necessary data may be uncertain therefore microscale laboratory experiment and modeling can provide a knowledge to understand the fluid flow phenomena. In this paper the authors propose an integrated decision model coupling laboratory measurements of displacement with the numerical simulation of flow. First step consists of routine rock properties determination, after that core sample geometry, porosity and permeability were reconstructed in numerical reservoir simulator. Simple core model

was combined with relative permeability measurements for oil – water and oil – carbon dioxide as well as fluid properties. Calibrated to laboratory measurements simulation model was used to analyze the process of CO₂-EOR and evaluation of its effectiveness depending on technological parameters.

Keywords: CO₂-EOR, microscale simulation, relative permeability

Kosowska K., Kosowski P.: Russian oil and gas industry on the eve of changes • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

In 2016 Russia's oil and gas industry celebrated 150th anniversary of its creation. It was a breakthrough moment in the history of Russian economy's development due to two main reasons: firstly, it was a strong impulse to develop the national oil industry, secondly, a proof of huge technological potential of Russia. Today, when oil industry is at its best technological revolution, Russian oil sector loses to its competitors due to the lack of any reforms for two decades. But it is still the most important part of Russian economy – income from export of raw materials (mainly crude oil) has been a crucial part of federal budget (around 50%) which allows to subsidize other branches of economy. In the coming years Russia's oil sector will have to face many challenges, both external (low oil price, sanctions) and internal (reducing production level, tax reforms). It is highly probable that despite negative experience of economic crisis, Russia's authorities will not resign from the perception of oil sector as a driving force of the national economy. But Russia should find and develop other tradable industries or its long-term economic prospect will not be optimistic.

Keywords: Russia, oil industry, economy, reforms, fiscal policy

Podsobiński D., Stopa J., Wojnarowski P.: The use of computer simulations to assess the effectiveness of the revitalization of mature oil fields using the selected reservoir as an example • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

The decrease in new oil field discoveries over the years makes it necessary to return to the abandoned partially depleted oil fields. Due to remaining significant amount of geological resources, mature oil field can be important in the overall balance. The production rate can be increased using various recovery methods. This paper presents a method of revitalizing mature oil fields used in Poland and wide world as well as screening criteria were presented. This article indicate the role of computer simulation as a tool in planning process of revitalization works in case of mature oil fields exploration and management. A recovery methods would be proposed, using computer simulation for the selected reservoir in south – eastern Poland as an example. The effectiveness of the recovery method would be determined through forecast of future production. An preliminary economic analysis would be performed to determine the feasibility of the selected method taking into account the initial investment costs and different oil prices.

Keywords: revitalization, mature fields, reservoir simulations

Maruta M., Zakrzewski A.: Geochemical characteristics of Neogene methane-bearing lignite of the Bełchatów region • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Coal beds could contain various amount of methane. This attribute might be dangerous in shafts or quarrying. Among other things, the works in the coal beds, including drilling, potentially there is a risk of exceeding the methane lower explosive limit. But on the other hand it is a source of unconventional hydrocarbon accumulations. In this paper geochemical characteristic of organic matter of tertiary brown coal from central part of Poland were performed. Geochemical surveys helps to know about genesis

of methane from study area. The analysed samples contain various quantity of organic carbon, from 20,74 to 71.93 wt. %. Lignite from examine samples have weak hydrocarbon potential. In tertiary sediments prevails III type of kerogen with admixture of II type of kerogen. The thermal maturity of the tertiary organic matter changes within the interval from 354 to 419 in T_{max} scale. Organic matter is immature. The composition of bitumens is different in various part of study area. Elemental analysis confirm that brown coal was comprised mostly by humic-group macerals. Coal samples contain methane with mixed genesis.

Keywords: *tertiary lignite, geochemical analysis, palaeoenvironment, methane*

Gaczol M.: Influence of ionic hydration inhibitors on triple inhibition system mud properties – technological parameters • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Clay rock hydration is primary reason of borehole wall instability during drilling. In correspondence to this fact, it is substantial to counteract abovementioned phenomenon. It can be achieved e.g. applying ionic hydration inhibitors in the drilling mud formula. From the point of view of drilling effectiveness, the most practical is water based inhibitive mud. Its stabilizing properties are partially effect of soluble salts and low concentrations of polymer. This type of the mud exhibits good rheological properties and causes, in most of cases, increased rate of penetration (ROP). Ionic inhibition contribute to reduction of both dispersion and hydration of clay rock due to decreased instability of shales containing swelling clays. Hydration degree depends on the type and concentration of inhibitive ions in the drilling mud. This paper describes studies on influence of the chosen inhibitors (KCl, K_2CO_3 , HCOOK, $CaCl_2$) on technological parameters of the developed drilling muds with triple inhibition system. Obtained results indicate good parameters of the mud. For HCOOK and $CaCl_2$ increase of the inhibitor concentration causes major changes in mud parameters, however for K_2CO_3 and KCl those parameters do not change significantly.

Keywords: *drilling fluids, ionic hydration inhibitors, clays and shales*

Galves L., Miska S., Ozbayoglu E., Ziaja M.: Study of the performance of LCMs in fractured formations • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

This study focuses on modeling three phenomena that greatly affect the performance of lost circulation materials (LCMs) in sealing thief zones: the process of construction of the LCM seal, the final flow rate after its creation, and the fractability of this seal to the pressures inside the wellbore. To model them, concepts related to fluid mechanics, and geomechanics become of the utmost importance. To help the validation of the models presented in this work, an experimental facility to simulate lost circulation was constructed. The facility makes use of a real limestone core drilled with the Tulsa Drilling Research Projects (TUDRP) drilling rig. This experimental setup represents progress in the reproduction of overall field conditions in comparison with other setups found in the literature. Several tests were performed with walnut at different sizes and concentrations, as well as with distinct fracture openings, inclinations, and orientations. As a result, a D90 as large as the size of the fracture aperture ends up to being effective in the plugging process. In addition, a D50 the size of 1/3 of the fracture opening also provides of a good seal. Depending on the concentration, smaller sizes can be applied – the smaller the size is, the larger the concentration must be. Finally, a computer program has been developed. Estimations of particle size distribution (PSD), plug time, and flow rate after seal formation are outcomes. This method of LCM selection can be used to assess the performance of different LCMs in the field. Hence, cost, time, and energy can be saved in dealing with lost circulation.

Keywords: *lost circulation, concentration and particle size distribution of LCMs, plug time and seal fractability modeling*

Śliwa T., Jaszczur M., Kruszewski M., Sapińska-Śliwa A., Bieda A., Kowalski T., Zlotkowski A.: **A study of hydraulic characteristic for borehole heat exchangers** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Thermal Response Test (TRT) is a standard test performed in borehole heat exchangers (BHE), which provides thorough understanding of thermal parameters of surrounding rock mass. Following work consists of calculations for hydraulic power and pressure losses along the BHE's length. Analysis was carried out in eight BHE's with different diameters, lengths and heat carriers in various areas throughout Poland. In accordance with TRT results, potential power exchanged between BHE and rock mass was determined. In order to find relations between pressure losses and volumetric flow rate, hydraulic tests in average static temperature of rock mass and during heating period were investigated. Proportions between hydraulic power and total power exchange with rock mass are also presented in following research.

Keywords: thermal response test, borehole heat exchanger, hydraulic characterization

Kowalski T., Ruvceska A., Śliwa T., Bieda A.: **Comparative analysis of using borehole heat exchangers in Macedonia and in Poland** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Using borehole heat exchangers for heating and cooling in different climate conditions were analysed and compared in this paper, considering the heating and cooling modes of the heat pump. Economic analysis were made according to the energy demand for heating, cooling and hot tap water with borehole heat exchangers for a typical family house. The costs for running borehole heat exchangers in Macedonia and Poland were also based on the average monthly temperatures and geological profile of the location.

Keywords: borehole heat exchangers, geothermal energy, heat pump, hot tap water

Budzowski R., Janiga D., Czarnota R., Wojnarowski P.: **Hydraulic fracturing optimization framework based on PKN and Cinco-Ley methods** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

In an era of decreasing number of discoveries of conventional hydrocarbon reservoirs, in the global oil and gas industry we can observe growing interest in unconventional resources. Conducting effective production from this type of reservoirs is associated with carrying out the intensification processes of production, among which hydraulic fracturing is the most popular. Fracturing project design consist of several technological parameters, i.e. the type of fracturing fluid and quantity of proppant, which have a direct impact on the process effectiveness. The actual shape of the fracture is difficult to predict due to the local heterogeneity of the reservoir and the superposition of the phenomena occurring during stimulation treatment. In this paper optimization model was proposed, which allows for selection appropriate parameters of fracturing technology. Developed optimization algorithm is based on two-dimensional PKN fracture model and Cinco-Ley analytical method. Optimization method used in this paper based on nature – inspired algorithms which were compared with gradient method.

Keywords: optimization, hydraulic fracturing, nature – inspired optimization algorithms

Wiśniowski R., Skrzypaszek K., Kiebzak P.: **ECD optimization with specially designed low rheology drilling fluids** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

This article presents a method in which low rheology drilling muds are used as a solution for demanding wellbore pressure management and high Equivalent Circulating Density (ECD) values. In order to investigate this problem series of numerical simulations were conducted. Real, field data from two already accomplished wells was used to recreate actual wellbores conditions in Halliburton Landmark Drilling Software and to calculate ECD values. In order to check and confirm the program's results accuracy, the outcomes were compared with pressure while drilling (PWD) equipment surveys results made during drilling operations. Next, simulations were made in order to check how low rheology parameters of drilling muds will impact overall ECD values. Additionally in the article are included field tests results from Hibernia Platform, prepared by Bolivar, Joung et al. in 2007 where specially treated (TMSB) low rheology drilling fluids was used to mitigate lost circulation issues and extensive ECD values. Both researches' results indicate that low rheology drilling muds may solve ECD optimization problems while still maintaining required properties and executing tasks of drilling fluids.

Keywords: ECD, drilling, rheology, drilling fluids

Wiśniowski R., Skrzypaszek K., Kiebzak P., Kański M.: **Wellbore trajectory impact on equivalent circulating density** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Undermentioned article presents how wellbore trajectory changes may impact mud flow pressure losses in wellbore annulus and overall Equivalent Circulating Density (ECD) value. In order to investigate this topic, there were conducted two series of tests. In the first round actual, field data from six previously drilled wells was used to recreate real wellbores conditions in Halliburton Landmark Drilling Software and to calculate ECD values. In order to check and confirm the results accuracy, the outcomes were compared with pressure while drilling (PWD) equipment surveys' results made during drilling operations. Next it was analyzed how ECD parameter's values change in particular sections of vertical and horizontal wellbores, due to trajectory angle modifications. With aim of expanding scope of the work, the second group of tests was made in Drilling Fluids Laboratory at Faculty of Drilling, Oil and Gas. Using Grace Sagging Tester M8500 Ultra HPHT it was examined how in wellbore conditions (high pressure and temperature) wellbore trajectory angle modifications may impact solids sedimentation process and fluid density changes in the annulus thus ECD value as well. The results indicate that there is a relationship between wellbore trajectory angle changes and ECD value shifts. In addition there are included field tests outcomes prepared by K&M Technology Group which confirm presented assumption.

Keywords: drilling, drilling fluids, rheology

Uliasz-Misiak B., Lewandowska-Śmierchalska J., Matuła R.: **Ecological risk associated with the onshore hydrocarbon deposits exploration** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Oil and natural gas exploration is performed using geophysical methods and drilling works. In areas initially identified as prospective for the occurrence of accumulation oil or natural gas based on the analysis of geological data carried out geophysical surveys. The aim of this works is to identify geological structures that could constitute hydrocarbons traps. In the case of finding the appropriate structures, the next stage of exploration work is drilling well for further recognition of the structure. These works allow to explore not

only the geological profile but also the physico-chemical properties of drilled rocks and reservoir fluids. Geophysical (mainly seismic) surveys and drilling works can affect the individual elements of the environment: the atmosphere, underground and surface water, ground surface and land and rock environment in different degrees.

In order to estimate the risks, threats to all elements of the environment related to the prospection of hydrocarbon deposits have been analyzed (seismic and drilling works). Environmental risk is estimated based on a modified methodology contained in the norm PN 18002. For risks associated with the exploration referred to the consequences of adverse events in relation to the individual elements of the environment and the frequency thereof (by determining the probability of their occurrence). The risk was estimated by multiplying the weight of the likelihood of adverse events weights and consequences. Risk evaluation, indicating danger tolerated, acceptable and unacceptable was also evaluated

Keywords: *hydrocarbon deposits, seismic surveys, drilling works, ecological risk*

Gonet A., Stryczek S.: Protecting Wieliczka Salt Mine against water hazard on the example of the Mina traverse • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Water surrounding every salt mine creates catastrophic hazard for that place. One of such cases is uncontrollable flooding of the Wapno Salt Mine, near Innowrocław (see article Kortas G. and Maj A., *Przegląd Solny*, 10, 2014). The causes of catastrophic water fluxes to the Mina traverse located in level IV at a depth of 170 m b.s. in the historical Wieliczka Salt Mine is presented in this paper. The complex geological build of the immediate neighborhood of the Mina traverse was described, paying attention to the evidently disadvantageous hydrogeological conditions in the northern part of the salt dome. The most important actions aimed at limiting the water hazard in Wieliczka Salt Mine concentrated on managing and so liquidating the disastrous flux of water and solids to the Mina traverse, which started in 1992. A unique solution was proposed to solve this problem, i.e. an internal safety pillar was construed with the use of dedicated unique technologies.

Keywords: *salt mine, water hazard, Wieliczka*

Turkiewicz A., Falkowicz S., Kapusta P.: Laboratory tests for the application of nitrate-based inhibitor against H₂S formation • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

This article discusses two series of the efficiency tests of nitrate-based inhibitor in the contaminated media. Nitrate-based treatments are the new methods of biogenic hydrogen sulfide elimination in the reservoir conditions. The first series concerned the tests of the contaminated medium, i.e. the mixture of formation water and sulfate-reducing bacteria suspension. The second series included the results of tests on natural formation water (without additional microbiological contamination). Moreover, a series of tests was performed in order to evaluate the influence of the tested material on reservoir rock samples represented by sandstone. The results of tests were presented in the form of tables and the formulated conclusions may be in the future useful for the oil and gas industry.

Keywords: *hydrogen sulfide, nitrate-based treatment, permeability, reservoir rock, formation water*

Żurek R., Jamrozik A., Gonet A.: Toxicity evaluation of spent drilling mud and drilling waste • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

Spent of water based mud (WBM) were tested in this study. Bioassays were done on spent WBM, brine after filtration and solid phase (SP) after filtration on the press. As test organisms, green algae *Kirchneriella obesa* and *Botrydium granulatum* were used, along with the cladoceran *Simocephalus vetulus* and the plant

Lepidium sativum. Electrolytic conductivity was between 6.43 and 240 mS/cm. The liquid phase was toxic for *K. obesa* in the range of dilutions between 0.21 and 0.019, considered as LC₅₀. The parameter LC₅₀ in the category of dilutions was 0.125 to 0.0078 SPP for *S. vetulus*, 0.25 to 0.094 SPP for green alga *Botrydium granulatum* when diluted by brown soil and 0.56 to 0.039 SPP for *Lepidium sativum*. Maximum quantum efficiency (QY) of plants' photosystem II (PS II), growing on mixtures of drilling fluids with soil, did not depend on the kind of drilling fluid, whereas minimal fluorescence (F₀) did.

Rinsing the salt out of drilling fluids in a 1:1 proportion was effective only for bentonite mud in the test with *L. sativum*.

Keywords: *drilling waste, spent of drilling mud, toxicity of drilling waste*

Łaciak M., Włodek T.: **Innovative solutions in natural gas engineering** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

The role of natural gas increases in the world energy mix. Natural gas is an ecologic fuel and is used as an energy source in various industries, primarily in transportation. The increased role of natural gas causes the research for innovations and technology development. In modern industry technological innovations should not be presented only as a simple laboratory activities to develop a new tools, solutions and technological processes in natural gas sector. With the rapid development of the natural gas sector in the world in many countries the process of transformation of the national industrial base with the use of natural gas has begun. Natural gas can also be considered as an important bridge to other alternative sources of energy derived from fuel and effective for the environment. In this article the latest trends in the natural gas sector are collected and presented.

Keywords: *natural gas, natural gas sector, natural gas engineering, innovative solutions*

Śliwa T., Sapińska-Śliwa A., Gonet A., Jezuit Z., Bieda A., Kowalski T., Ozimek J., Złotkowski A.: **Specifying the number of borehole heat exchangers based on thermal response test and geoenergetic analysis** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

For the correct design, the number and the location of borehole heat exchangers, it is necessary to know thermal properties of rocks and the exchanger. This applies particularly to larger installations, more than 100 kW. One of the methods of determining these values is Thermal Response Test. This method is based on measurements in the first drilled borehole heat exchanger. Based on results of the TRT geo-thermal analysis is made. The analysis defines: the number of wells, the arrangement of wells, and the parameters of temperature of heat carrier after long-term use. This analysis based on calculations using specialist software.

This paper presents the determination of the number of borehole heat exchangers and working conditions (temperature of the heat carrier) of an underground heat reservoir accessed using borehole heat exchangers for the building of the Primary School in Myszków.

Keywords: *geoenergetics, borehole heat exchangers, geothermal heat pumps*

Cieślak T.: **Change in the structure of electricity generation in the USA, China, Japan and the EU, and a forecast of electricity consumption** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 1

This article analyses changes in the structure of electricity production in countries such as the USA, China, Japan, the EU and Poland. In China, a sharp increase in generation capacity and electricity production may

be noticed if the data from 2015 and 1990 is compared. The increase in China's electricity production is associated with a continuous growth in CO₂ emission, contrary to the situation in the United States, where, despite an increase in energy consumption and an increase in generation capacity, CO₂ emission has been falling since 2005. The largest decrease in CO₂ emission without inhibiting the growth of electricity production and electricity consumption can be seen in the EU. Models of consumption have been determined based on the collected data such as: temperature, dummy variables and electricity consumption per hour within three months. The aim was to establish the best regression model and compare it to the neural network models using mean absolute percentage error (MAPE).

Keywords: *electricity mix, emission, regression, forecasting, generation capacity in the energy sector*