SUMMARIES

Czarnota R., Janiga D., Stopa J., Wojnarowski P.: **Predicting relative permeability from experimental capillary pressure porous plate test for two phase flow** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Relative permeabilities relationships as a function of fluids saturation are one of the most important parameters for describing multiphase flow processes in reservoir rocks. When direct laboratory tests are not available for investigating oil-water multi-phase flow in rocks, then indirect prediction techniques using relative permeability functions are widely used, e.g. from capillary pressure test. In this study the measurement of capillary pressure was performed on rocks plugs with different characteristics at reservoir conditions using porous plate method. During measurement semi-permeable membrane was used with 15 bar threshold pressure, what allowed to register formation water saturation, at changing differential pressures steps. Desaturation at each pressure stage was continued until no more produced liquid was observed. Water saturation point at maximum capillary pressure applied is assumed to be final irreducible water saturation. Application of porous plate method provides sufficient stabilization time, allowing to achieve uniform saturation distribution. In this research, Brook–Corey model was used to predict relative permeability from experimental measured capillary pressure data for oil-water phase flow in porous media. As a result, it is possible to obtain more accurate capillary pressure outcomes, and relative permeability curves for the two-phase system, than other methods used in practice. Performing capillary pressure measurements at reservoir conditions, allows to restore the processes occurring in the reservoir.

Keywords: *capillary pressure, relative permeability, crude oil, multiphase flow*

Kremieniewski M., Stryczek S., Wiśniowski R., Rzepka M., Gonet A.: **Influence of bentonite addition on parameters of fresh and hardened cement slurry** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The recipe of cement slurry contains a number of additives and admixtures used for obtaining appropriate technological parameters. Some of these agents have a loose form and their density is higher or lower than that of working water, which may result in sedimentation of solid phase. For the sake of eliminating this effect, the viscosity of the working fluid should be increased to keep the fine solids over the entire volume of the slurry. This can be done with the use of appropriate high-molecular polymers. However, bearing in mind the cost of the polymers, bentonite is most frequently applied. Bentonite (montmorillonite) has a packet build and the resulting higher water-demand causes an increase of viscosity of working fluid. It is most frequently used to improve the sedimentation stability, though the presence of this additive is not neutral for the technological parameters of the slurry.

During research works aimed at analyzing the influence of montmorillonite on the parameters of fresh and hardened cement slurry predefined quantities of bentonite were used in proportion to the working water. Reference recipes of slurries were worked out to trace the changes. The following properties of the slurry were defined: rheological parameters, filtration, thickening time, water settling, sedimentation stability. For hardened cement samples the bentonite addition was analyzed in view of its influence on the mechanical properties (compressive strength), physicochemical parameters (adhesiveness to steel pipes and adhesiveness to rock formation). Additionally, hardened cement slurry underwent analyses describing the microstructure of the sample porosity and permeability tests). For the sake of determining the influence of mineral additives on parameters of slurry and the hardened slurry there were performer tests for recipes of slurries to be used in wellbore conditions at temperature from 30°C to 90°C and pressure from 5 MPa to 35 MPa.

Keywords: *cement slurries, bentonite*

Fąfara Z., Mazur R., Matuła R.: **The study of unsteady operation mode of the crude oil trunk pipeline in case of a sudden stop flow** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Media pipeline transportation, in particular energy commodities has a very high share in the world economy. It has many advantages over other methods of transmission of the products on land but there are concerns about the safety of the pipeline system. When we are designing the pipeline, we take into consideration maximal discharge pressure of medium, but any change in pumping parameters results the appea rance of an unsteady (transient) process, which in some cases may lead to a rapid increase in pressure. The largest increase in pressure in the pipeline comes at a time of a complete stop fluid flow. There is formed a water hammer, which may cause a major accident up to pipeline leaks inclusive. Subject of considerations in the paper is the analysis of changes in pressure over time in the pipeline obtained in 12 experiments of stop oil pump unit in the trunk pipeline for different pumping parameters and properties of the medium. Based on the recorded changes of pressure in measurement points were fitted regression models allowing to forecast an increase in pressure along the pipeline route caused by water hammer.

Keywords: *pipeline transportation of crude oil, rapid stopping the oil flow, water hammer*

Lewandowska-Śmierzchalska J., Uliasz-Misiak B.: **Application of AHP method to assess the possibilities of using of geological structures located in the aquifers as underground storage sites** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Decision-making problem with assessing of the suitability of geological structures located in aquifers in terms of their use for carbon storage, natural gas storage or waste injection is mainly connected with the necessity of taking into consideration a large number of criteria and analyze a lot of parameters. It also connected with making many independent decisions concerning geological, environmental, social, political, technical or legal issues.
This article shows the possibility of using the AHP method, ie. multi-criteria hierarchical methods to analysis of decision problems in assessment the potential of aquifers. AHP method allows to take reasonable decision. The article was divided into three parts. The first one includes a characteristics of geological structures located in aquifers, special attention was paid to the criteria describing these structures. In the second part, the basis for decision-making system based on the method of AHP, which was used to carry out the hierarchical scoping assessment of potential structures. Validation of decision-making system was realized on selected geological structures located on the Polish Lowlands. An assessment of the possibilities to use the two anticline in the Mesozoic aquifers was made. As a result, received the criteria ranking, rankings of decision variants to all criteria and global ranking of variants. Based on the results obtained can be determine which decision represents a priority way of use structure.

Keywords: *AHP method, decision-making system, aquifers, carbon storage, natural gas storage, waste injection*

Dubiel S.J., Rzyczniak M., Solecki M.L., Maruta M.: **Analysis of Drill Stem Test (DST) results at Osobnica oil field, in terms of sampling of selected technology parameters** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

In this paper results of DST tests obtained in two wells at Osobnica oil field are presented. At the same time there were analyzed and reinterpreted the conditions of these results from the selection of technological parameters and geological conditions. The results of this analysis have been developed in conclusions.

Keywords: *DST, oil field, Osobnica, analysis and reinterpretation*

Krzeczek P., Karasek P., Wojnarowski P.: **Analysis impact fracturing fluid acidity on structural strength of crosslinked gel complex** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Nowadays hydraulic fracturing is the most commonly used technique to stimulate the productivity of a well. The selection of a proper fracturing fluid is all about choices which strongly influence on effectiveness of the treatment. It should be carefully prepared, supported by lab analysis in order to match fluid to reservoir condition. This article concerns impact of fracturing fluid additives on fluid properties. In the paper crosslinking process has been shown and its importance on conventional reservoir rocks fracturing treatment. Provided lab examination shows fluid pH impact during creation crosslinked gel complex including influence to crosslinking time in the surface condition. The lower linear gel pH caused lower crosslinking time of fracturing fluid.

Keywords: *hydraulic fracturing, fracturing fluid, linear gel, crosslinking*

Ślizowski J., Smulski R., Nagy S., Burliga S., Polański K.: **Tightness of hydrogen storage caverns in salt deposits** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The problem of rock salt massif tightness concerns all stored media. It is particularly important in the case of hydrogen, because of the small size of its molecules. Preliminary results of selected permeability tests performed under the project Hestor are discussed in the paper. The results of numerical calculations determining a potential range of gas leakage are also presented.

Keywords: *rock salt, tightness of rock salt, hydrogen storage*

Knez D., Ziaja J., Piwońska M.: **Computer simulation of the influence of proppant high diameter grains damage on hydraulic fracturing efficiency** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Throughout the past two decades, there has been a great intensification of research on processes related to hydraulic fracturing. One of the most significant issues is the behavior of proppants under reservoir conditions. It clearly influences the oil production from the stimulated borehole. Quick loss of a fracture conductivity after hydraulic fracturing may be caused by migration of particles into the porous area of the fracture. Another effect is creation of small solid particles as a result of proppant crushing. Mineral sedimentation may occur on grains propping the fracture because of chemical reactions at the area of contact between the proppant and the mixture of reservoir water and the fracturing fluid. The effect of these reactions is changes in the porosity of the proppant package and conductivity of the fracture. The article presents results of a computer simulation of parameter changes of the proppant in reservoir conditions and their influence on oil production. One of paramount factors is proppant grains damage. As a result of a computer simulation, using Fracpro software, the level of decreased conductivity of the fracture was determined. It was also defined that the influence of this phenomenon on lower production in comparison to the situation where proppant damage is not accounted for.

Keywords: *hydraulic fracturing, proppant, computer simulation*

Macuda J., Styrkowiec E.: **Many years' extraction of groundwater in the context of established usable groundwater reserves** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The operation of water supply networks basically relies on the ability of supply water, which in the case of groundwater intakes, is defined by usable reserves offered by the wells involved. Their establishing is

the last stage of an investment, i.e. building of groundwater intakes, and their value determines the type of infrastructure and technological hardware in the wells. Owing to the fact that the usable groundwater reserves are conditioned by a number of factors (economic, technological, environmental) their correct determining depends on the correct definition of the number and quality of measurements and hydrogeological observations. In practice, these measurements tend to be shortened to minimum (test pumping) or discarded (diagnostics of well construction) for financial reasons. As a result the user obtains either over- or underestimated information about the intake parameters. Exploitation of a well with overestimated capacity brings about serious technological and economic consequences, starting from the lowered productivity (drop of water table, lower yield), change of chemical composition of water, sanding up of the well as well as well failures and damage. The use of a well with underrated output does not shorten the life of the well, though is disadvantageous for the economic reasons.
The productivity of wells can be verified after a few years of controlled extraction, on the basis of which the cost of water extraction, stability of chemical composition or impact on other intakes in given work conditions. Accordingly, this is a basis for updating usable groundwater reserves of the wells. Moreover, after many years of observation of groundwater intakes, one can formulate recommendations warrantying long life of wells, rational management of pump aggregates and well renovation plans.

Keywords: *well, intake well, usable reserves, establishing reserves, life of well, water extraction, groundwater reserves, test pumping, well construction*

Apostol R., Łaciak M., Oliinyk A., Szurlej A.: **Analysis of the methods for gas demand forecasting** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Natural gas is a very important and strategic resource. In the structure of the world's primary energy, its share is currently approx. 25% and according to the forecasts it will continue to grow. In addition, the transition the large cities to gas as the main energy resource is an effective solution for reducing harmful emissions and improving air quality. The trend of increasing consumption of natural gas causes the complex technical issues, especially the need of accurate forecasting the gas demand, design the new distribution networks and modernization of the existing systems of gas supply. This article presents a review of existing methods for gas demand forecasting based on the gas engineering literature analysis and the approach for the forecasting of gas consumption based on the analysis of the gas consumption diagrams of gas station.

Keywords: *natural gas, gas consumption, gas demand forecasting*

Cieślik T., Metelska K.: **Modeling of gas consumption in the city** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Based on the data collected over a two year time period, which included temperature, wind speed and gas consumption during the day, the effects of weather factors on gas consumption in the city have been established with the use of multiple regression. The impact of a particular month, day (dummy variable) or holiday of a year on the gas consumption has also been determined. The models of linear regression and artificial neural networks have been constructed for determining the gas consumption. An attempt has been made to find the best regression models and compare them to the neural network models with the use of mean absolute percentage error (MAPE).

Keywords: *gas, gas consumption, models*

Gasiński J., Macuda J., Szewczyk S.: **Drainage wells as an integral part of a deep dewatering system in Szczerców field in the Bełchatów Lignite Mine** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The open-pit extraction of lignite in the Bełchatów Lignite Mine can be conducted after prior deep dewatering of the rock mass, realized with large-diameter dewatering wells distributed in the form of outer and inner barriers.

This type of dewatering system allows for safe extraction of lignite, however residual waters in the overburden may locally create hazard. These are rain waters infiltrating into the rock mass, and which, due to the complicated geological structure of the deposit and disturbed system of layers, were not intaken by wells belonging to the primary dewatering system. They are removed through the existing and newly drilled exploration wells, which are converted into drainage wells. Such wells are used for removing waters suspended in permeable overburden and gravitationally moved to the lower absorbing layers, from where they are directed to the primary dewatering system wells and then to the surface water courses. The applied enhancement of the dewatering system used in the lignite deposit significantly improves the safety of mining works conducted in this place.
Technical and technological aspects of drilling dewatering wells in Bełchatów Lignite Mine are discussed in this paper and followed by the evaluation of efficiency of dewatering of the overburden.

Keywords: *dewatering of rock mass, wells, large-diameter dewatering wells, drainage wells, groundwater, open-pit mining, extraction of lignite*

Kruszewski M., Thorhallsson S., Assadi M., Śliwa T.: **Slimhole well casing design for high-temperature geothermal exploration and reservoir assessment** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

It is anticipated that utilization of geothermal resources for renewable energy production will continue to grow globally. Since cost of drilling and well construction constitutes a considerable share of the total cost of the geothermal installations, development and evaluation of low-cost alternatives is crucial for expansion of this industry.
This paper describes slimhole casing design for geothermal exploration wells, as an alternative for reduced cost and improved environmental performance. The main goal of the paper is to contribute to cost effective casing design program that satisfies severe reservoir conditions of geothermal wells. A case study is presented for casing design for a 2000 m deep vertical well with water level at 200 m, where the New Zealand Code of Practice has been applied. The "worst case scenario", i.e. when temperature and pressure follow the boiling point depth curve (BPD), has been considered as base case for the casing design, when drilling in a high-temperature geothermal area. Alternative methods are also presented for determining the minimum casing setting depths and the results are compared. Pressure and temperature conditions inside the well were established using X-steam program, an Excel add-in, and the final results, establishing loading criteria that the casing has to withstand i.e.: burst, collapse and tension/compression are presented.

Keywords: *geothermal exploration wells, slimhole casing*

Śliwa T., Kucper M.: **Accessing Earth's heat using Geothermal Radial Drilling for borehole heat exchangers** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Sometimes there is not enough room for drilling vertical borehole heat exchangers. Hence, the idea of slant boreholes emerged. They can provide access to a rock mass, being an underground heat reservoir, located beneath infrastructure.
To optimize the average value of thermal conductivity and use those layers in a given geological profile that possess best properties in the view of thermal efficiency, Geothermal Radial Drilling is used, being a very efficient technology. A GeoDrill 4R drill rig, specially designed for the Geothermal Radial Drilling technology, enables drilling at an angle between 30 and 65 degrees, which in turn, together with data on the geological profile, allows for designing the layout of exchangers so as to obtain longest possible section of a given exchanger within most energetic layers. The paper includes a description of a few investments which use Geothermal Radial Drilling for heating purposes. It also presents a comparative study between Geothermal Radial Drilling and conventional vertical borehole exchangers.

Keywords: *slant BHE, GRD, geoenergetics, borehole heat exchangers, geothermal heat pumps*

Kowalski R., Łaciak M., Liszka K., Oliinyk A., Paszylk P.: **Application of ORC systems at natural gas compression station** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Natural gas is a mixture of hydrocarbons with combustible methane as the main component, the content of which usually exceeds 90%. Among the remaining components of natural gas are ethane, propane, butane, nitrogen, carbon dioxide, sulfur compounds. Helium can be also found in some natural gas fields. The composition of natural gas depends on, e.g. the field from which the gas comes, and also way in which it is transported, i.e. pipelines, LNG technology. The quality of natural gas is regulated by respective standards. Gas transmission pipelines are the most popular method, dominating on the international gas market, though LNG technology has recently started to play the more and more prominent role. The intensive development of renewable energy sources is accompanied by the development of the Power to gas technology – the electric energy excess is used for the hydrogen production, which can be directed to the existing natural gas network and such a mixture of natural gas and nitrogen is transmitted. At present transmission pipelines for nitride natural gas Ls and Lw exist in Poland. The aim of this paper is analyzing the influence of natural gas admixtures on the operation parameters of transmission pipelines.

Keywords: *natural gas, transmission pipelines, natural gas composition, contamination of natural gas*

Denysov Y.P., Klymenko V.V., Martynenko V.V., Rybicki C.: **Technology for development of methane-hydrate deposits jointly with receiving fresh water** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The technology of development of bottom gas-hydrate deposits, which allows to receive fresh water simultaneously with methane, is presented. Principal schemes are presented and methods of operation of dual-purpose plants implementing this technology and described on the basis of the methods of gas production from methane hydrates that are most prepared for practical implementation: 1) injection of warm water into the well; 2) depressive effect on the deposit; 3) replacement of methane in hydrates with carbon dioxide injected into the reservoir. The magnitude of the decrease in temperature with the depression effect on the deposit is determined. It is shown that, the amount of fresh water obtained in dual-purpose plants operating with the replacement of methane in hydrates with carbon dioxide is proportional to the coefficient of the recycling rate of CO_2.

For the considered schemes of dual-purpose plants, processes of decomposition of methane hydrates in the gas-hydrate formation are analyzed, an exergic efficiency estimation is performed. Such installations. The economic efficiency of a single-purpose and dual-purpose gas-producing units operating according to an approved method of depression is considered. It is shown that the most effective are dual-purpose facilities operating using the method of methane replacement in hydrates with carbon dioxide, and the coefficients of economic efficiency of dual-purpose installations are at least 1.2 times higher than similar coefficients of single-purpose gas production facilities.

Keywords: *gas-hydrates, gas-hydrate deposit, methane, carbon dioxide, fresh water, exergy efficiency, economic efficiency*

Macuda J., Łukańko Ł.: **Monitoring of explosive gases with a portable gas detector Dräger X-am 5600** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

During exploration and extraction of hydrocarbon deposits, the risk of elevated methane concentration above the lower explosive limit occurs. In some cases a higher concentration of hydrogen sulfide threatening the health and life of the crew also may be observed.

The use of a portable gas detector Dräger X-am 5600 for constant monitoring of methane and hydrogen sulfide concentration in dangerous situations is proposed in the paper. Thanks to the IR sensors and

modern electrochemical sensors, this detector allows for monitoring of 6 types of gases simultaneously. The applied infrared sensor IR EX allows for measuring explosive and combustible gases both within the lower explosive limit, and also measuring of methane in the range of 0 to 100 vol.%. The measured values are stored in the computer and also sent to the central through GSM.

Keywords: *methane, hydrogen sulfide, measurement of methane concentration, monitoring of explosive gases, portable gas detector, exploration of hydrocarbon deposits, extraction of hydrocarbons, tubing, reservoir water*

Tătaru A., Balázs S., Foidaş I.: **Underbalanced interventions in gas wells belonging to mature fields** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The exploitation of natural gas fields from Transylvanian Basin started a century ago. The majority of these fields were discovered and developed in the last century, from the 1920s through the 1980s. So, these reservoirs have almost 100 years of production historical.
Even if at their discovery, the initial reservoir pressures were relative high (around 100–150 bar), nowadays these mature gas fields have a very low reservoir pressure. For some of these reservoirs the pressure is 10–20% of initial values.
With the rehabilitation projects ongoing, and where the challenge is to maintain or even better to increase by just a little the base production, the greatest challenge is to make certain interventions in depleted reservoirs wells. At the beginning it was not a problem to do workover for these wells because the completion fluids were lost in the reservoir and the reservoir pressures helped the wells to clean up. Now, because of the low reservoir pressures, after the interventions it would take a long time for the wells to be cleaned, or in the worst cases the wells could be abandoned.
From time to time, some net pays have to be bypassed because the fluid can be lost in the reservoir.
So the best method is to do workovers jobs in these wells underbalance or even with live well, and interventions using snnubing unit or the coiled tubing unit.
This paper presents some of the technologies used by Romgaz to accomplish this goal and also some case studies from different types of interventions in these gas wells.

Keywords: *initial reservoir pressure, base production, workover, abandoned, underbalance, live well, coiled tubing*

Vlasin I., Ştefănescu D.-P., Şuţoiu F.: **Productivity stimulation of depleted reservoirs by applying new technologies to open the productive layers** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The greatest natural gas fields belonging to Romgaz company are characterized by an advanced stage of exploitation, which actually involves a special approach, from the perspective of the works performed in the wells.
As part of the most recently Romgaz strategy, for these fields have been created new geological models based on 3D seismic acquisitions, which allowed identifying some new less drained or even undrained zones.
This aspect created the premises for developing the opportunities for capitalization of the new reserves volumes, by applying the advanced technologies of opening productive layers by perforation and reperforation operations with deep penetration guns, using also underbalance conditions.
We mention also that new cased hole geophysical methods like PNN and RCI consisted also important elements in establishing the perforation intervals and identifying the by-passed layers.
The paper contains some relevant case studies, which illustrates the efficiency of these new methods.

Keywords: *depleted reservoirs, geological model, 3D seismic, undrained zones, perforation and reperforation*

Sasu R., Tataru A.: **Brown field rehabilitation success through an effective project management system** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Laslau Mare is a mature gas field in Transylvania Basin. The field exploitation began in 1975 and has been operated since then by Romgaz.
In 2004 Romgaz entered into an Association agreement with Schlumberger to rehabilitate Laslau Mare field. Association's main goals for project rehabilitation has been maximization of field potential by increasing gas production and reservoir ultimate recovery factor. The incremental production, defined as the additional gas volume obtained above a production baseline negotiated at project inception is the key objective of Association.
According to Project Management Body of Knowledge (PMBOK®) framework from the Project Management Institute (PMI), the project management breaks in processes groups, knowledge area and professional and social responsibility all of them being integrated in a system approach.
This paper examines key aspects of the project management system processes, adapted to the oil and gas industry and implemented in our project to meet and exceed project goals.

Keywords: *Brown Field, well rehabilitation, project management system*

Macuda J., Wysocki S., Gaczoł M.: **Water well activation with application of clay minerals disintegration agent** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

While drilling a well using rotary drilling method with drilling mud application, permeability damage of aquifer layers in near-well zone takes place. It is caused mainly by inflow of both solid phase and filtrate originated from the mud into pores or fractures of drilled rock. In consequence of this phenomenon, pressure drawdown increase and well hydraulic efficiency decrease can be observed, what leads to exploitation capacity diminution.
For the reparation of formation damaged permeability in near-well zone, new agent for disintegration of clay minerals called SKINAUT was developed at the Drilling, Oil and Gas Faculty of AGH-UST Krakow. In order to confirm its effectiveness in industrial conditions, it was conducted test of well activation for water intake from loose formation. Applied agent allowed to counteract the clogging of pore spaces and to reduce the hydraulic resistance of well thereby decreasing pressure drawdown and considerably improving well efficiency.

Keywords: *formation permeability, formation clogging, disintegration of clay minerals, well, well activation, well efficiency, well exploitation, well life expectancy*

Śliwa T., Kruszewski M., Assadi M., Sapińska-Śliwa A.: **The application of Vacuum Insulated Tubing in Deep Borehole Heat Exchangers** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

The world's demand for energy is constantly increasing mainly due to population growth and improved living standards. Currently, the share of electricity generation is 37% of the global primary energy consumption. Fossil-based electricity production is accounted for 68% of the total generation with coal, the most carbon-intensive fossil fuel, being the largest contributor (41%) to the world's electricity supply in 2012. Electricity demand is projected to grow rapidly and is also expected to be 70% higher in 2035, than the current demand. The Polish energy sector is heavily dependent on coal, resulting in large CO_2 emission per capita. Poland has considerable potential for geothermal energy production, as there is a large number of deep, abandoned wells that might be utilized for geothermal energy production. Utilizing these resources would contribute to the CO_2 emission reduction without negative impact on security of energy supply.

Following paper describes method of reconstructing negative or abandoned oil and gas wells for Deep Borehole Heat Exchangers (DBHE). In many old boreholes, exploiting underground geothermal waters is impossible, thus adaptation for DBHE is sometimes the only option to utilize geothermal heat reservoirs. The insulated coaxial inner column which enables the circulation of heat carrier plays the crucial role in effective functioning of DBHE systems.
Vacuum Insulated Tubing (VIT) can improve heat production as well as increase efficient energy use. This technique found plethora of applications in offshore and onshore deep drilling and production. Throughout recent years, VIT technology is being more commonly applied in geothermal industry. Negative or abandoned wells could be reconstructed for DBHE. To maximize the heat uptake from such boreholes, it is advised to use inner column made from material with lowest possible thermal conductivity coefficient. Article deals with possible application of vacuum pipes as inner column in deep coaxial borehole heat exchangers.

Keywords: *Vacuum Insulated Tubing (VIT), Heat Exchangers*

Duse D.M., Duse C.S.: **Creativity and innovation in engineering education** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Creativity is vital in process engineering innovation. The research can reveal with certainty on tests of creativity whether in universities, in cycles (bachelor, master and doctoral school), creativity is present and what are its dimensions prevail. Our study was focused on creativity tests analysis of two European universities, the AGH University of Science and Technology, Faculty of Drilling Oil &Gas, PL and "Lucian Blaga" University from Sibiu, RO for two cycles of study, master and doctoral school. We aim to find existing links between creativity and engineering skills of master's programs offered and the level of creativity existing in doctoral schools of the two universities. Knowing and understanding the characteristics of the group of students, teachers surgery offers the opportunity to get a successful learning and professional development. Then, these findings can be used to optimize learning, performance and perfection engineering training. Not least research highlights the first noticeable effects of the Bologna cycles studies on the generation "Z" (milliennials) students, in terms of creativity existence.

Keywords: *engineering education, creativity*

Wysocki S.: **Influence of ionic hydration inhibitors on triple inhibition system mud properties – clay rock swelling** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Recently past years, while drilling clay rock, mainly mud with triple inhibition system is applied. In the light of abovementioned fact, it can be seen growing importance of studies related to improvement and development of this type of mud formulas. The paper describes undertaken studies of QSE Pellets swelling and linear swelling (LST) of the Miocene shale under influence of different concentration of chosen clay rock hydration inhibitors in mud with triple inhibition system.

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

Yao T., Wojtanowicz A.: **Criteria and risk of integrity loss for wells with sustained casing pressure** • AGH Drilling, Oil, Gas 2017 • Vol. 34 • No. 2

Sustained casing pressure (SCP) represents a major issue because of its large scale occurrence and risks to health, safety, and the environment. Present regulatory assessment of sustained casing pressure is mostly qualitative with implicit risk formulation. It currently holds that wells with casing head pressure that can be bled-down to zero and is followed by slow 24-hour pressure buildup are below acceptable level of risk.

This study introduces new quantitative metrics of well integrity loss risk – the instant cement sheath leak rate of 15 scf/min (barrier integrity), and the total annual environmental gas discharge of 6 tons of volatile organic compounds (VOC) per year. Field data from 19 wells reportedly affected by sustained casing pressure (SCP) are examined with a SCP testing software to assess whether or not wells with pressure that is able to bleed to zero would meet the proposed criteria.
Using modeling and software tools developed by Xu and Wojtanowicz (2001) and Kinik and Wojtanowicz (2011), it is determined that three of the 19 wells (15.8%) examined would fail the instant leak rate criterion. On the total discharge criterion, assuming the wells' annuli above the cement top filled out with seawater, it was also found, again, that 15.8 percent of the wells would fail the total environmental discharge criterion. Moreover, for the worst-case scenario of absolute open gas flow (empty annulus above the cement top), five of 19 wells (26.3%) would fail the criterion. It is shown that – statistically, the bleed-down of casing pressure to zero gives a 90-percent confidence of the well passing the proposed criteria. Furthermore, no clear correlation was observed between pressure build-up and the barrier integrity or the environmental gas discharge criteria, thus questioning the 24-hour pressure buildup relevance as a risk indicator.

Keywords: *well integrity, gas migration, sustained casing pressure, environmental risk*