energies

Editorial

Improving the Efficiency of Oil Recovery in Research and Development

Marcin Kremieniewski

Oil and Gas Institute-National Research Institute, 25A Lubicz Str., 31-503 Krakow, Poland; kremieniewski@inig.pl

Citation: Kremieniewski, M. Improving the Efficiency of Oil Recovery in Research and Development. *Energies* **2022**, *15*, 4488. https://doi.org/10.3390/en15124488

Received: 9 June 2022
Accepted: 16 June 2022
Published: 20 June 2022

1. Introduction

By creating a special edition entitled Fundamentals of Enhanced Oil Recovery, the editors focus on the problem of the global increase in energy demand. In recent years, there has been a trend towards switching to alternative energy sources, but despite this, oil and natural gas will continue to be the main source of energy for the next several decades. However, it should be borne in mind that renewable energy resources have some limitations in terms of quantity. The progressive exploitation of the deposits contributes to the increasing degree of oil depletion, and this makes extraction more and more difficult, even though the deposits are not yet completely empty. Such a situation results in the necessity to search for new methods of increasing oil and gas production. Intensifying oil production is a very rational use of energy that has not yet been fully used. Production intensification methods are used to utilize these energy reserves. Such activities can be implemented and carried out at any stage of the well implementation, from the well design stage, through drilling, to oil and gas production. For this purpose, it is extremely important to conduct research and design works that include issues related to increasing the efficiency of oil extraction. It is also very important to improve the effectiveness of sealing the borehole and the correct selection of cement slurries, drilling fluids and borehole washing liquids. In addition, the issues related to the reduction in energy consumption and energy management in the oil industry are very important at the present time, both from the economic point of view and in terms of the rational use of energy. The focus should also be on innovations that include modern technologies supporting the efficiency of extraction and the latest technical, technological and operational challenges in the oil sector. All these factors are discussed in the international industrial arena, and the most important topics, after a rigorous assessment procedure by eminent specialists from around the world, find their way to prestigious magazines, such as MDPI *Energies* Special Issue.

2. A Short Review of the Contributions in This Issue

Many articles can be grouped under the title Fundamentals of Enhanced Oil Recovery. As for the improvement of oil recovery, in the first article [1], the authors discuss the problem of gas migration through fresh cement slurry and hardened cement slurry [2]. Gas transfer is an unfavorable phenomenon that can be minimized and sometimes even eliminated by using an appropriate cement slurry recipe [3]. According to the authors, the appropriate selection of the quantity and quality of components enables the design of slurries with the required static strength values [4]. Additionally, the cementitious sheath of such anti-migration slurry has a low porosity and a very low proportion of large pore spaces. Furthermore, the mechanical parameters do not deteriorate during long-term deposition in borehole conditions [5]. The authors designed a solution in the form of a cement slurry, the cement sheath of which has high corrosion resistance. The presence of appropriate additives and admixtures favors the design of the slurry, which contributes to the improvement of gas recovery by eliminating the negative phenomenon of gas migration.

The next article presents the technology of preparing drilling fluids with a high content of internal phase [6]. The correct selection of drilling fluid is very important from the point of view of improving oil recovery [7]. Various types of drilling fluids are used for drilling boreholes, but most often, due to the economic aspect, a water-based mud is used [8]. However, for drilling in difficult geological conditions, an inversion mud is used, in which the oil phase to the water phase most often occurs in the range from 70/30 to 90/10 [9]. The authors in publication [6] present a solution where the oil to water ratio is 50/50 to 20/80, and such a mud can be used to drill a borehole in HPHT conditions. According to the authors, the new drilling mud solution contributes to the improvement of the improved oil recovery. Additionally, inversion drilling muds are characterized by high electrical parameters; the ES stability is above 300 V [10]. They also have stable rheological parameters and low filtration. Due to the reduced oil content, the developed drilling fluid system is more economical and has limited toxicity.

Issues related to the geological sequestration of acid gases, including CO_2, are now an increasingly common solution to prevent the progressive changes in the Earth's climate. In the publication [11], the authors focus on the analysis of the research carried out in the Borzęcin sequestration area [12]. The area is located in western Poland. The tests are aimed at examining the migration paths of the injected acid gases (mainly mixtures of CO_2 and H_2S) to the aquifers under the natural gas deposit [13]. As part of their research, the authors conduct two well sampling actions, during which they take samples of the waters lying under the Borzęcin reservoir and then examine their physicochemical parameters. Such tests have not been conducted so far. Tests of reservoir waters from selected wells were also carried out, including isotope analyzes [14]. The work carried out was aimed at broadening the state of knowledge, which is valuable for the risk assessment of the acid gas sequestration process taking place on a specific example, and to improve the efficiency of gas injection.

During the improvement of oil recovery, one of the basic problems accompanying the use of water in EOR processes is the precipitation of inorganic sediments [15]. As the authors write in the publication [16], these are the most common deposits of calcium carbonate and deposits of calcium, barium and strontium sulphates, with calcium carbonate being the most common one [17,18]. In order to eliminate this unfavorable phenomenon, appropriate types of inhibitors are used, which was presented in the publication [16]. However, in order to carry out such tests, it is necessary to develop the research technology and build a test stand. Such a solution was presented by the authors of the publication [16] and they discussed the most important research results.

Fundamentals of Enhanced Oil Recovery is strongly associated with the improved adhesion of cement to pipes and rock formation [19]. On the other hand, the adhesion is strongly influenced by proper preparation of the borehole and cleaning of the annular space after drilling and before cementing [1,20]. It is connected with the fact that low values of adhesion of the cement sheath to the rock formation and to the surface of the casing cause the formation of uncontrolled gas flows [4]. Additionally, the lack of adhesion also reduces the stabilization of the pipe in the borehole [21]. In [22], the authors focus on determining the impact of cleaning the annular space on the adhesion of the cement sheath to the rock formation. The issues related to the preparation of the borehole for cementation by appropriate cleaning of the rock formation from mud cake residues contribute to the improvement of oil recovery, which contributes to the improvement of drilling works [23].

The increase in oil production translates into shell gas exploration [24,25]. Therefore, in the publication [26], the authors discuss the developed method of finding similarities between particular geological structures in terms of their hydrocarbon-generating properties and hydrocarbon resources. The measurements and geochemical studies of holes located in the Ordovician, Silurian and Cambrian formations of the Polish part of the East European Platform are used here [27,28]. The classification of objects is based on a cluster analysis, where the focus is on the issue of generating clusters that are grouped into samples in gas, condensate and oil windows [29]. The characteristic geochemical properties of the samples classified into selected clusters are also determined [30]. Researchers successfully classified the samples into individual windows and determined their percentages in Silurian, Ordovician and Cambrian units. Doing so is some sort of empirical challenge towards improving oil and gas recovery.

In work [31], the authors rightly state that flooding technology is an important measure for increasing the recovery of crude oil in oil fields. In this paper, the authors used the direct numerical simulation (DNS) method, which is based on the Navier–Stokes equation and the fluid volume (VOF) method, to investigate the dynamic behavior of oil-water flow in a low-permeability pore structure [32,33]. On the basis of the results obtained from the research, the authors concluded that the variability in the non-uniformity of the viscosity action results from the difference in the viscosity of oil and water. On the other hand, the complex dynamic behavior of the two-phase oil-water flow on the pore scale, demonstrated by capillarity, play a decisive role in determining the area of spatial sweep and the final index of oil recovery [34,35]. From the work, they conclude that the absolute viscosity of oil and water has a significant influence on the degree of oil recovery by adjusting the relative importance between the action of viscosity and capillarity.

Enhanced Oil Recovery is also about the correct selection of drilling fluids. Therefore, an appropriate design of the cement slurry to seal the borehole is important [36]. For this purpose, the additives and admixtures for the cement slurry should be properly selected in order to obtain the required parameters of the hardened cement slurry [37]. Such requirements depend on the geological conditions of the drill hole. There are very high regimes in deep boreholes, which must be met by cement slurries; therefore, the necessity to use advanced, innovative measures is implied [38]. An example of the above is the possibility of using the addition of nanosilica, as discussed in [39], in order to improve the technological parameters of both the liquid cement slurry and the resulting cement sheath. The authors of the work presented the results of research on the mechanical parameters for cement stone with the addition of silica nanoparticles. The samples are deposited in an environment of elevated temperature of 90 °C. The cement sheath made of cement slurry, which contains an admixture of nanosilica, shows an improvement in mechanical properties. This is manifested by an increase in compressive strength. It is very important from the point of view of undertaking further works in the borehole and improving the efficiency of production.

The issue of the tightness of the borehole is of key importance for its long-term durability; thus, it is part of the broad thematic spectrum of Enhanced Oil Recovery. To ensure durability for many years, the column of pipes is sealed with cement slurry [40]. However, slurry that is pumped down the mud, if it comes into contact with the mud cake, may not seal well the annular space of the borehole [41]. Therefore, it is important to properly clean the hole, which is a big problem, because there are many variables affecting its stability [42]. The contact time of the well with the scrubber is important. On the one hand, insufficient contact time does not guarantee the correct removal of the mud cake. On the other hand, long contact times can damage the borehole wall. Therefore, in [43], the researchers conducted a study to evaluate the impact of the contact time of the washer on cleaning the annular space. The study of the degree of mud cake removal depending on the contact time is based on the determination of the adhesion of the cement sheath to the rock formation [44]. By comparing the obtained adhesion with a reference sample, the researchers determine the effectiveness of the deposit removal. On the basis of these studies, they determined the optimal contact time with the cleaner.

In [45], the author deals with the issue of the influence of temperature on the gradation of oil pipes. Corrosion in the oil industry is an important aspect when extracting natural gas from a deposit with high temperatures [46]. According to the author [47], the water in the tank is often in the form of steam with a pressure of up to several dozen MPa. As a result of its extraction, it cools, which causes [48] condensation. Condensed water in contact with the acidic components of the gas causes corrosion, especially in the presence of aggressive gases. Therefore, a very important issue is to determine the effect of water condensation as a result of the changes in the temperature of gases containing CO_2 and H_2S [49,50] on the corrosion of steel, which is in contact with extraction pipes and casing pipes. On the basis of the obtained results, the author answers the question of what effect temperature, gas components and pressure have on the corrosion of the borehole construction material, and indicates the selection of the borehole material to prevent corrosion in aggressive environments.

Fundamentals of Enhanced Oil Recovery is also an operational challenge. These include the new analytical procedure for the preselection of gas wells for water shut-off procedures, as discussed in the next paper [51], based on the available results of the integrated geological and deposit data analysis. The basis for assessing the possibility of cross-flow formation is the assessment of the presence or absence of impermeable barriers at intervals, supplemented by perforation [52,53]. The authors used data from wells obtained in different years from measurements with different types of probes. Based on the modified quantitative and qualitative interpretation techniques, permeable and impermeable layers are distinguished in the analyzed drilling sections. The process of verifications carried out for eight boreholes initially selected by the operator located in the Carpathian Foredeep in Poland is discussed [54,55].

A properly designed cement slurry is one of the most important elements in the Fundamentals of Enhanced Oil Recovery through improved borehole sealing [56]. Therefore, the publication [57] discusses the influence of the Hblock fine-grained material on selected parameters of the cement slurry. The fine-grained additive used shortens the setting time and the transition time from the value of the initial setting time to the final setting time [58]. It shortens the time needed to bind the cement slurry and proceed to further work [59]. Moreover, such action helps to eliminate the possibility of the gaseous medium penetrating into the structure of the liquid cement slurry [60]. The publication discusses the effect of the additive on the technological parameters of the cement slurry and the possibility of using fine-grained material as an innovative technology in fluids for oil wells.

Innovative technologies in oil wells are part of the Special Issue Fundamentals of Enhanced Oil Recovery. One of these technologies is the use of jet pumps for the utilization of the associated petroleum gas, as discussed in [61]. This is a very important issue because the combustion of this gas causes environmental degradation and poses a potential threat to the human body [62]. The possibility of simultaneous use of a suction-piston pump driven by a shuttle and jet machine in the oil well was proposed after prior estimation of the pressure distribution along the borehole. The authors used the well-known methods of Poettman-Carpenter and Baksendel. In order to carry out the work, the researchers developed a methodology for the practical use of these equations in order to calculate the parameters of the jet pump based on the independent parameters of the oil well [63,64]. The final result of the work [61] is a list of recommendations for the selection of the location of an oil-gas ejector inside a selected oil well and a generalization of the principles of selecting the ideal location of such ejectors for other shafts. The second result is a reasonable method to rationally determine the location of the ejector in the oil well and calculate its geometry, which ensures complete selection of the petroleum gas released into the oil well ring. Such activities will contribute to the intensification of oil extraction from boreholes and the improvement of the environment in the oil field.

The correct selection of drilling fluids is also an issue that contributes to Enhanced Oil Recovery. Therefore, in the article [65], the authors presented the influence of enzymatic and oxidizing factors on polymers used in drilling mud technology. The concentration of calcium hypochlorite, urea peroxide, sodium persulfate, amylase and cellulase was determined to reduce the rheological parameters of drilling fluids. Additionally, researchers developed a method of treating drilling fluid prior to cementation, and developed a drilling fluid containing enzymatic or oxidizing agents to prepare the borehole for cementation [66,67]. On the basis of the work carried out, the authors obtained positive results regarding the possibility of diluting the drilling fluid immediately before cementing, and it is possible to use oxidants and enzymes in the composition of the drilling fluids [68,69].

3. Conclusions

The present publication focuses on issues related to improved oil recovery technology. The articles presented in this Special Issue show various related challenges, including the following: increasing the efficiency of oil recovery, improved borehole sealing, correct selection of drilling fluids, reducing energy consumption, appropriate energy management in the oil industry, new technologies supporting the efficiency of recovery, technical and technological challenges, operational challenges and innovative technologies in oil drilling. The works included in this Special Issue cover important elements not only of the exploitation of oil and gas fields, but most of all the most important aspects, which include the elements of borehole implementation. The published submissions cover a broad spectrum of technologies that address the fundamentals of improved oil recovery. The task of editing and selecting articles for this collection was both stimulating and rewarding. We would like to thank the staff and reviewers very much for their efforts and contributions. Thanks to their hard work, a very interesting Special Issue has been created, which will contribute to increasing knowledge and to the further development of technology to improve oil recovery.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Kremieniewski, M.; Wiśniowski, R.; Stryczek, S.; Orłowicz, G. Possibilities of Limiting Migration of Natural Gas in Boreholes in the Context of Laboratory Studies. *Energies* **2021**, *14*, 4251. [CrossRef]
2. Kremieniewski, M. O konieczności prowadzenia serwisowych badań parametrów technologicznych zaczynów uszczelniających. *Nafta-Gaz* **2019**, *1*, 48–55. [CrossRef]
3. Rogers, M.J.; Dillenbeck, R.L.; Eid, R.N. Transition time of cement slurries, definitions and misconceptions, related to annular fluid migration. In Proceedings of the SPE Annual Technical Conference and Exhibition, Houston, TX, USA, 26–29 September 2004; Society of Petroleum Engineers: Richardson, TX, USA, 2004.
4. Kremieniewski, M. Recipe of Lightweight Slurry with High Early Strength of the Resultant Cement Sheath. *Energies* **2020**, *13*, 1583. [CrossRef]
5. Kremieniewski, M.; Stryczek, S.; Wiśniowski, R.; Rzepka, M.; Gonet, A. Influence of bentonite addition on parameters of fresh and hardened cement slurry. *AGH Drill. Oil Gas* **2017**, *34*, 335–348. [CrossRef]
6. Błaż, S.; Zima, G.; Jasiński, B.; Kremieniewski, M. Invert Drilling Fluids with High Internal Phase Content. *Energies* **2021**, *14*, 4532. [CrossRef]
7. Błaż, S. Badania laboratoryjne nad opracowaniem składu płuczki inwersyjnej. *Nafta-Gaz* **2015**, *3*, 54–63.
8. Błaż, S. Analiza właściwości technologicznych płuczki inwersyjnej w warunkach HPHT. *Nafta-Gaz* **2016**, *6*, 403–412. [CrossRef]
9. Elkatatny, S. Mitigation of barite sagging during the drilling of high-pressure high-temperature wells using an invert emulsion drilling fluid. *Powder Technol.* **2019**, *352*, 325–330. [CrossRef]
10. Askø, A.; Alsvik, E.T.; Danielsen, T.H.; Haga, M.A. Low-Density Invert Emulsion Drilling Fluid Enables Recovery of Oil Reserves in Extremely Depleted Reservoirs: A Case History from Valhall, Norway. In Proceedings of the IADC/SPE International Drilling Conference and Exhibition, Galveston, TX, USA, 3–5 March 2020.
11. Warnecki, M.; Wojnicki, M.; Kuśnierczyk, J.; Szuflita, S. Study of the Long Term Acid Gas Sequestration Process in the Borzęcin Structure: Measurements Insight. *Energies* **2021**, *14*, 5301. [CrossRef]
12. Lubaś, J.; Szott, W. 15-year experience of acid gas storage in the natural gas structure of Borzęcin—Poland. *Nafta-Gaz* **2010**, *66*, 333–338.
13. Lubaś, J.; Szott, W.; Jakubowicz, P. Effects of Acid Gas Reinjection on CO2 Concentration in Natural Gas Produced from Borzęcin Reservoir. *Nafta-Gaz* **2012**, *68*, 405–410.
14. Chadwick, R.A.; Marchant, B.; Williams, G.A. CO_2 storage monitoring: Leakage detection and measurement in subsurface volumes from 3D seismic data at Sleipner. *Energy Procedia* **2014**, *63*, 4224–4239. [CrossRef]
15. McGlade, C.; Sondak, G.; Han, M. Whatever Happened to Enhanced Oil Recovery? International Energy Agency. 2018. Available online: https://www.iea.org/commentaries/whatever-happened-to-enhanced-oil-recovery (accessed on 10 January 2022).
16. Wojnicki, M.; Lubaś, J.; Gawroński, M.; Szuflita, S.; Kuśnierczyk, J.; Warnecki, M. An Experimental Investigation of WAG Injection in a Carbonate Reservoir and Prediction of the Recovery Factor Using Genetic Programming. *Energies* **2022**, *15*, 2127. [CrossRef]
17. Mogensen, K.; Masalmeh, S. A review of EOR techniques for carbonate reservoirs in challenging geological settings. *J. Pet. Sci. Eng.* **2020**, *195*, 107889. [CrossRef]

18. Afzali, S.; Rezaei, N.; Zendehboudi, S. A comprehensive review on Enhanced Oil Recovery by Water Alternating Gas (WAG) injection. *Fuel* **2018**, *227*, 218–246. [CrossRef]
19. Kremieniewski, M. Cleaning of the casing string before cementation, based on research using a rotational viscometer. *Nafta-Gaz* **2018**, *74*, 676–683. [CrossRef]
20. Lavrov, A.; Torsæter, M. *Physics and Mechanics of Primary Well Cementing*; Springer International Publishing: Houston, TX, USA, 2016. Available online: https://www.springer.com/gp/book/9783319431642 (accessed on 9 August 2021); ISBN 978-3-319-43165-9.
21. Stryczek, S.; Wiśniowski, R.; Gonet, A.; Rzyczniak, M.; Sapińska-Śliwa, A. Wpływ wybranych superplastyfikatorów na właściwości reologiczne zaczynów cementowych stosowanych podczas cementowania kolumn rur okładzinowych w otworach wiertniczych. *Przemysł Chem.* **2018**, *97*, 903–905. [CrossRef]
22. Kremieniewski, M.; Błaż, S.; Stryczek, S.; Wiśniowski, R.; Gonet, A. Effect of Cleaning the Annular Space on the Adhesion of the Cement Sheath to the Rock. *Energies* **2021**, *14*, 5187. [CrossRef]
23. Jasiński, B. Ocena wpływu cieczy przemywającej na jakość zacementowania rur w otworze wiertniczym po użyciu płuczki glikolowo-potasowej. *Nafta-Gaz* **2016**, *6*, 413–421. [CrossRef]
24. Mandal, P.P.; Rezaee, R.; Emelyanova, I. Ensemble Learning for Predicting TOC from Well-Logs of the Unconventional Goldwyer Shale. *Energies* **2021**, *15*, 216. [CrossRef]
25. Ma, L.; Slater, T.; Dowey, P.J.; Yue, S.; Rutter, E.; Taylor, K.G.; Lee, P.D. Hierarchical integration of porosity in shales. *Sci. Rep.* **2018**, *8*, 11683. [CrossRef] [PubMed]
26. Kwilosz, T.; Filar, B.; Miziołek, M. Use of Cluster Analysis to Group Organic Shale Gas Rocks by Hydrocarbon Generation Zones. *Energies* **2022**, *15*, 1464. [CrossRef]
27. Piesik-Buś, B.; Filar, B. Analysis of the current state of natural gas resources in domestic deposits and a forecast of domestic gas production until 2030. *Nafta-Gaz* **2016**, *6*, 376–382.
28. Puskarczyk, E. Application of Multivariate Statistical Methods and Artificial Neural Network for Facies Analysis from Well Logs Data: An Example of Miocene Deposits. *Energies* **2020**, *13*, 1548. [CrossRef]
29. Mroczkowska-Szerszeń, M.; Ziemianin, K.; Brzuszek, P.; Matyasik, I.; Jankowski, L. The organic matter type in the shale rock samples assessed by FTIR-ART analyses. *Nafta-Gaz* **2015**, *6*, 361–369.
30. Łętkowski, P.; Gołąbek, A.; Budak, P.; Szpunar, T.; Nowak, R.; Arabas, J. Determination of the statistical similarity of the physicochemical measurement data of shale formations based on the methods of cluster analysis. *Nafta-Gaz* **2016**, *72*, 910–918. [CrossRef]
31. Ning, T.; Xi, M.; Hu, B.; Wang, L.; Huang, C.; Su, J. Effect of Viscosity Action and Capillarity on Pore-Scale Oil–Water Flowing Behaviors in a Low-Permeability Sandstone Waterflood. *Energies* **2021**, *14*, 8200. [CrossRef]
32. Su, J.; Wang, L.; Gu, Z.; Zhang, Y.; Chen, C. Advances in Pore-Scale Simulation of Oil Reservoirs. *Energies* **2018**, *11*, 1132. [CrossRef]
33. Kamal, M.S.; Hussein, I.A.; Sultan, A.S. Review on Surfactant Flooding: Phase Behavior, Retention, IFT, and Field Applications. *Energy Fuels* **2017**, *31*, 7701–7720. [CrossRef]
34. Tsuji, T.; Jiang, F.; Christensen, K. Characterization of immiscible fluid displacement processes with various capillary numbers and viscosity ratios in 3D natural sandstone. *Adv. Water Resour.* **2016**, *95*, 3–15. [CrossRef]
35. Guo, Y.; Zhang, L.; Zhu, G.; Yao, J.; Sun, H.; Song, W.; Yang, Y.; Zhao, J. A Pore-Scale Investigation of Residual Oil Distributions and Enhanced Oil Recovery Methods. *Energies* **2019**, *12*, 3732. [CrossRef]
36. El-Gamal, S.M.; Hashem, F.S.; Amin, M.S. Influence of carbon nanotubes, nanosilica and nanometakaolin on some morphologicalmechanical properties of oil well cement pastes subjected to elevated water curing temperature and regular room air curing temperature. *Constr. Build. Mater.* **2017**, *146*, 531–546. [CrossRef]
37. Khalil, M.; Jan, B.M.; Tong, C.W.; Berawi, M.A. Advanced nanomaterials in oil and gas industry: Design, application and challenges. *Appl. Energy* **2017**, *191*, 287–310. [CrossRef]
38. Lau, H.C.; Yu, M.; Nguyen, Q.P. Nanotechnology for oilfield applications: Challenges and impact. *J. Pet. Sci. Eng.* **2017**, *157*, 1160–1169. [CrossRef]
39. Pikłowska, A.; Ziaja, J.; Kremieniewski, M. Influence of the Addition of Silica Nanoparticles on the Compressive Strength of Cement Slurries under Elevated Temperature Condition. *Energies* **2021**, *14*, 5493. [CrossRef]
40. Kremieniewski, M. Influence of Graphene Oxide on Rheological Parameters of Cement Slurries. *Energies* **2020**, *13*, 5441. [CrossRef]
41. Błaż, S. Nowe rodzaje cieczy przemywających osady z płuczki inwersyjnej przed zabiegiem cementowania otworów wiertniczych. *Nafta-Gaz* **2017**, *5*, 302–311. [CrossRef]
42. Wiśniowski, R.; Skrzypaszek, K.; Małachowski, T. Selection of a suitable rheological model for drilling fluid using applied numerical methods. *Energies* **2020**, *13*, 3192. [CrossRef]
43. Kremieniewski, M.; Kędzierski, M.; Błaż, S. Increasing the Efficiency of Sealing the Borehole in Terms of Spacer Pumping Time. *Energies* **2021**, *14*, 6702. [CrossRef]
44. Kremieniewski, M. Hybrid Washer Fluid for Primary Cementing. *Energies* **2021**, *14*, 1295. [CrossRef]
45. Bęben, D. The Influence of Temperature on Degradation of Oil and Gas Tubing Made of L80-1 Steel. *Energies* **2021**, *14*, 6855. [CrossRef]

46. Zhang, Y.; Pang, X.; Qu, S.; Gao, X.; Li, K. The relationship between fracture toughness of CO_2 corrosion scale and corrosion rate of X65 pipeline steel under supercritical CO2 condition. *Int. J. Greenh. Gas Control* **2011**, *5*, 1643–1650. [CrossRef]
47. Bęben, D. Badania skuteczności działania wybranych inhibitorów korozji stosowanych okresowo w przemyśle wydobywczym. *Ochr. Przed Korozją* **2019**, *62*, 376–381.
48. Mahmoodian, M.; Qingi, C. Failure assessment and safe life prediction of corroded oil and gas pipelines. *J. Pet. Sci. Eng.* **2017**, *151*, 434–438. [CrossRef]
49. Yougui, Z. Electrochemical Mechanism and Model of H_2S Corrosion of Carbon Steel. Ph.D. Thesis, Ohio University, Athens, GA, USA, 2015.
50. Stachowicz, A. Korozja rur wydobywczych odwiertów gazowych zawierających CO_2. *Nafta-Gaz* **2011**, *11*, 395–400.
51. Falkowicz, S.; Urbaniec, A.; Stadtműller, M.; Majkrzak, M. A New Strategy for Pre-Selecting Gas Wells for the Water Shut-Off Treatment Based on Geological Integrated Data. *Energies* **2021**, *14*, 7316. [CrossRef]
52. Lakatos, I.J.; Lakatos-Szabo, J.; Szentes, G.; Jobbik, A.; Vago, A. Application of Self-Conforming well Stimulation technology in Oil and Gas Fields—Fundamentals and Case Histories. In Proceedings of the IOR 2017—19th European Symposium on Improved Oil Recovery, Stavanger, Norway, 24–27 April 2017.
53. Alfarge, D.K.; Wei, M.; Bai, B. Numerical simulation study of factors affecting relative permeability modification for water-shutoff treatments. *Fuel* **2017**, *207*, 226–239. [CrossRef]
54. Myśliwiec, M. Poszukiwania złóż gazu ziemnego w osadach miocenu zapadliska przedkarpackiego na podstawie interpretacji anomalii sejsmicznych—podstawy fizyczne i dotychczasowe wyniki. *Prz. Geol.* **2004**, *52*, 299–306.
55. Dziadzio, P. Sekwencje depozycyjne w utworach badenu i sarmatu w SE części zapadliska przedkarpackiego. *Prz. Geol.* **2000**, *48*, 1124–1138.
56. Stryczek, S.; Wiśniowski, R.; Gonet, A.; Złotkowski, A. Wpływ rodzaju cementu na właściwości reologiczne zaczynów uszczelniających stosowanych w technologiach wiertniczych. *Wiert. Naft. Gaz* **2010**, *27*, 721–739.
57. Kremieniewski, M. Influence of Hblock Fine-Grained Material on Selected Parameters of Cement Slurry. *Energies* **2022**, *15*, 2768. [CrossRef]
58. Stryczek, S.; Małolepszy, J.; Gonet, A.; Wiśniowski, R.; Kotwica, Ł. *Wpływ Dodatków Mineralnych na Kształtowanie Się Właściwości Technologicznych Zaczynów Uszczelniających Stosowanych w Wiertnictwie i Geoinżynierii Wydawnictwo*; S.C.M.R: Kraków, Poland, 2011; pp. 1–164. Available online: http://katalog.nukat.edu.pl/lib/item?id=chamo:4133282&fromLocationLink=false&theme=nukat (accessed on 21 May 2015).
59. Kremieniewski, M.; Stryczek, S. Zastosowanie cementu wysokoglinowego do sporządzania zaczynów uszczelniających w technologiach wiertniczych. *Cem. Wapno Beton* **2019**, *22*, 215–226.
60. Stryczek, S.; Brylicki, W.; Małolepszy, J.; Gonet, A.; Wi´sniowski, R.; Kotwica, Ł. Potential use of fly ash from fluidal combustion of brown coal in cementing slurries for drilling and geotechnical works. *Arch. Min. Sci.* **2009**, *54*, 775–786.
61. Bazaluk, O.; Dubei, O.; Ropyak, L.; Shovkoplias, M.; Pryhorovska, T.; Lozynskyi, V. Strategy of Compatible Use of Jet and Plunger Pump with Chrome Parts in Oil Well. *Energies* **2022**, *15*, 83. [CrossRef]
62. Le Billon, P.; Kristoffersen, B. Just cuts for fossil fuels? Supplyside carbon constraints and energy transition. *Environ. Plan. A Econ. Space* **2020**, *52*, 1072–1092. [CrossRef]
63. Pavlychenko, A.; Kovalenko, A. The investigation of rock dumps influence to the levels of heavy metals contamination of soil. In *Mining of Mineral Deposits*; CRC Press: Boca Raton, FL, USA, 2013; pp. 237–238.
64. Skitsa, L.; Yatsyshyn, T.; Liakh, M.; Sydorenko, O. Ways to improve safety of a pumping-circulatory system of a drilling rig. *Min. Miner. Depos.* **2018**, *12*, 71–79. [CrossRef]
65. Uliasz, M.; Zima, G.; Błaż, S.; Jasiński, B. Enzymatic and Oxidizing Agents for the Decomposition of Polymers Used in the Composition of Drilling Muds. *Energies* **2021**, *14*, 5032. [CrossRef]
66. Błaż, S. Dobór środków chemicznych do degradacji polimerów i koloidów ochronnych w płuczkach wiertniczych. *Nafta-Gaz* **2009**, *5*, 371–383.
67. Jasiński, B. Wpływ oksydantów na wielkość sedymentacji fazy stałej w zasolonych płuczkach wiertniczych. *Nafta-Gaz* **2012**, *9*, 602–610.
68. Uliasz, M.; Zima, G.; Błaż, S.; Jasiński, B. Ocena właściwości cieczy wiertniczych w aspekcie zapobiegania migracji gazu w otworach na przedgórzu Karpat. *Nafta-Gaz* **2015**, *1*, 11–17.
69. Nasr-El-Din, H.A.; Al-Otaibi, M.B.; Al-Qahtani, A.A.; Samuel, M.M. An Effective Fluid Formulation to Remove Drilling Fluid Mud Cake in Horizontal and Multi-LateralWells. *SPE Drill. Complet.* **2007**, *22*, 26–32. [CrossRef]