Gulf Coast/Southwestern North America Regional Student Paper Contest

2024

April 27, 2024 • Houston TX

5000 Gulf Frwy BLDG 9- Tech Bridge
Houston, Tx 77204

2024 GCNA/SWNA Regional Student Paper Contest

UH Energy Research Park 9, Houston
ConocoPhillips Petroleum Engineering Building 9
Saturday April 27, 2024

Undergrad Schedule – Room 104 Building 9

Time	Name	University	Title of Paper
9:30 – 9:50	**Judges Debrief/Sign in and upload presentations**		
10:00 – 10:20	Kendall Holman	Texas A&M	Improved Methane Slip Quantification Informs Compressor Selection
10:30 – 10:50	Hoa Huy	New Mexico Tech	Cementing Techniques for Plugging And Abandonment Wells In High-Pressure Gas Reservoirs
11:00 – 11:20	Edward Ko	Texas A&M	Machine-Learning and Multivariate Regression Models Predict Delaware Basin Well Performance
11:30 - 11:50	Zaina Alfakher	University of Texas at Austin	The Development and Application of Machine Learning Models for Rig State Classification
12:00 – 12:20	God'Sway Akpabli (virtual if possible)	New Mexico Tech	Integrating Long Short-Term Memory and Artificial Neural Network Algorithms in History Matching and Forecasting Oil Production in High Heterogeneous Sandstone Reservoirs: - A Case Study
12:30	**Undergrad Division Ends and Judges Deliberation**		
12:30 – 1:30	**Lunch**		

Master's Schedule, Room 124, Building 9

Time	Name	University	Title of Paper
9:30 – 9:50	**Judges Debrief/Sign in and upload presentations**		
10:00 – 10:20	Fatima Al Marzoog	Texas A&M	Integrating Production, Pressure, and Strain Data More Effectively Models Hydraulic Fracture Geometry
10:30 – 10:50	Bruno Reinoso	University of Texas at Austin	Synergistic Impact of Low Salinity and Surfactant on Wettability Alteration in Carbonates
11:00 – 11:20	Afia Aizal Utama	University of Houston	Case study: Assessment of predictive capability of reservoir simulators for waterfloods in carbonates: how realistic is my simulation model?
11:30 – 11:50	Agustin Garbino	University of Texas at Austin	A New Algorithm for Automated ISIP Interpretation
12:00 – 12:20	Chin-Hsiang Chan	Texas A&M	Multi-Resolution Machine Learning Model Accelerates CO2 Storage Optimization
12:30	**Master Division Ends and Judges Deliberation**		
12:30 – 1:30	**Lunch**		

PhD Schedule – Saturday April 27, 2024, Auditorium, Room 135 Building 9

Time	Name	University	Title of Paper
9:00 – 9:30	**PhD Judges Debrief/Upload Presentation**		
9:30 – 9:50	Jose Benavides Arancibia	University of Houston	Selected Recommended Practices for Increasing the Efficiency and Accuracy of CO2 Sequestration Models
10:00 – 10:20	Tarek Mohamed	University of Texas Austin	Simulation of Reservoir Charge to Predict Fluid Compositional Distribution and Detect Sub-Seismic Connectivity Realizations
10:30 – 10:50	Van Tang Nguyen	New Mexico Tech	Lessons Learned and Proposed Solutions for Drilling Wells in the San Juan Basin for A CO2-Storage Project
11:00 – 11:20	Jingjing Zhang	Texas A&M	Multi-scale Simulation Optimizes Surfactant Huff-n-Puff Process
11:30 – 11:50	Olofinnika Oluwakemi	Texas A&M	Validated-Machine-Learning Models Predict Minimum Miscibility Pressure and Optimize Injection Gas Composition
12:00 – 12:20	Fatemeh Tale	University of Houston	Macro-Scale Modeling Study of Kinetics of Permeability Changes in CO2 Saturated Brine Injection for Enhanced Carbon Capture & Sequestration
12:30 – 1:30	Lunch		
1:30 – 1:50	Keju Yan (virtual if possible)	Texas Tech	Energy efficiency evaluation for in-situ hydrogen production from natural gas using electromagnetic-assisted method
2:00 – 2:20	Athar Hussain (virtual if possible)	Texas Tech	Investigating Cement Integrity for Underground Hydrogen Storage in Depleted Hydrocarbon Reservoirs: A Multifaceted Analysis
2:30	PhD Division Ends and Judges Deliberation		
3:00-4:00	**We will be announcing the winners right after the competition**		

Undergrad Abstracts

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Improved Methane Slip Quantification Informs Compressor Selection

I developed a methodology to precisely measure methane emissions, specifically from incomplete combustion, known as methane slip, in natural gas-fired engines used for gathering and boosting, as well as various production operations. This research aims to optimize facilities economically by exploring the potential transition to electric compressors. The established workflow offers a more accurate depiction of methane slip impacts, investigating the idea that current calculations significantly underestimate these emissions. This new strategy not only provides a more representative emission figure, thereby improving public image, but also highlights the potential for economic benefits through optimal compressor selection.
The initial step involved understanding the current reporting of methane emissions from incomplete combustion, using EPA formulas and emission factors. Subsequently, aerial survey data, using light spectroscopy technology for geo-registered gas-plume imagery, was examined. Since this data covers all emission leaks, reconciliation with stack test data exclusively capturing methane slip was necessary. Understanding typical fugitive emission percentages per engine enabled the interpretation of variances between these datasets. The calculation of methane slip values, based on a proposed EPA revision, was then compared to the values obtained from the advanced detection technologies. Results indicated alignment between methane detection technologies and proposed EPA values.

For four-stroke lean burn engines on residue gas, methane slip emissions were found to be 522 times greater, and on field gas, about 7.6 times higher than current reporting. Four-stroke rich burn engines on residue gas showed emissions 45 times higher, while the same engine on field gas displayed a notable decrease of 60% compared to current reporting. These findings significantly diverge from current reporting and are expected to substantially increase methane emission totals for many companies. These values underscore the economic benefits of optimal compressor selection. After a holistic review, I find it advisable to transition lean burn engines to electric drives while continuing the use of rich burn engines.

In summary, the recommended workflow enables companies to select the optimal compressor. In most scenarios, it is economically viable to replace lean burn engines with electric drive while maintaining rich burn engines. This holistic approach not only provides companies with a more representative emission figure, improving their public image, but it also holds the potential for economic benefits. This strategic resource allocation allows companies to prioritize mitigating emissions from their top sources, ultimately fostering both environmental responsibility and economic efficiency.

Cementing Techniques for Plugging And Abandonment Wells In High-Pressure Gas Reservoirs

Cementing to plug wells in high-pressure gas reservoirs is difficult because gas can pass through the cement slurry, forming channels within it, leading to a gas leak to the surface after plugging. This study developed cementing techniques that consider both additives and mixing times to prevent gas channeling problems for plugging and abandonment operations. The developed cementing techniques have been applied to the field tests to validate them. An apparatus was built to replicate gas channeling, using a clear tube with a ball valve to introduce air bubbles into a one-foot cement slurry column. Air bubbles are induced every 5 minutes until they cannot travel to the surface, and the total time for this period is obtained. This is the required time for cement slurry to become dense enough to stop gas from traveling. By increasing mixing time and adding different additives that help improve cement bonding as well as accelerate the hydrating process, the gas channeling problem can be stopped. Differential contributions, types of additives, and mixing times have been experimented with in the laboratory. This study found two additives (a nanoparticle and a slurry) that are promising for preventing gas channeling problems. It also shows that cement slurries are necessary to be mixed for a period instead of pumping immediately after mixing. The optimal concentrations of the nanoparticle or the slurry are 0.1% or 0.15% weight of cement, respectively. By adding the amount of these additives and keeping the mixing time for 35 minutes, the gas channeling can be prevented completely. Experimental results showed that the developed cement slurries could still be pumped for about 60 minutes after 35 minutes of mixing; the compressive strength of the developed cement is still the same as that of neat cement; and the viscosity increased to 100 centipoises. Therefore, it is applicable for surface plugging, which has short-time pumping and low friction. Field tests were conducted for four wells located in Texas and New Mexico. These wells were plugged before, but they still had gas leakages and needed to be re-plugged. The re-plugged operations were conducted with the developed techniques. Among them, three wells were successfully plugged; there was no gas leak after the plugging.

The developed techniques are meaningful and practical for plugging and abandonment operations. By adding a small number of additives and increasing mixing time, the developed techniques can improve the chance of success of plugging and abandonment operations, save time and money for plugging, prevent leakage, and meet the requirements of plugging and abandonment regulations.

Machine Learning and Multivariate Regression Models Predict Delaware Basin Well Performance

I have developed a quick and effective approach to regression models that accurately predicts well performance, improving the speed and confidence of identifying targets to populate future drilling programs. Employing this data-driven approach, engineers can maintain accuracy in well performance forecasts without compromising the speed other traditional methods lack. Machine-learning and multivariate regression models trained on historical reservoir, spatial, and completion data drive this new approach. Results not only highlight the effectiveness of predicting well productivity but also showcase a workflow to relate well performance to economic forecasts. The adaptability and simplicity in training these regression models render this data-driven approach an inexpensive, rapid, and effective alternative for any E&P operator, capital lender, or investment fund to forecast well production and economics.

This study used Random Forest and Multivariate regression models as data-driven vehicles to forecast well performance. I trained the models on historical reservoir, spatial, and completion data to predict water-oil ratio, gas-oil ratio, and most importantly, 12-month cumulative oil production. I used a sufficient train/test data split to validate the effectiveness and accuracy of the trained regression models to specifically predict the performance of Lea County EOG-operated wells targeting the Wolfcamp A and 2nd Bone Spring Sands formations. I then forecasted production from the trained datasets that comprised hundreds of wells. Averaged on a normalized monthly basis, I related the production-decline profile for each targeted formation to the predicted initial 12-month cumulative oil production through a "production multiplication factor." This methodology forecasts the production of any potential well within the reasonable spatial confines of the target area. Finally, I assumed key economic variables, including discount rate, commodity strip prices per barrel, drilling/completion costs per foot, and total operating costs per barrel, to relate the production forecast to net economic benefit.

This research highlights the speed and effectiveness of ML-based, data-driven regression approaches in forecasting well performances. Bypassing the time-consuming nature of traditional methods while maintaining accuracy in forecasts, this workflow outlined predicts well production and proves compelling to aid in key engineering decisions. The application of this data-driven methodology will lead to more adaptable, rapid, and efficient decision-making processes for traditional E&P operators, capital lenders, and investment funds across any hydrocarbon-producing region.

The Development and Application of Machine Learning Models for Rig State Classification

This paper presents a comprehensive research project focusing on the development of accurate machine-learning models for rig state classification, a fundamental component of real-time rig analytics systems, that are widely employed in the drilling industry.

The research begins by defining the problem of rig state classification, framed as determining the activities of a drilling rig at each second using time-series data with multiple measured features. Rig states considered in the study include rotary vs. slide drilling, tripping in vs. tripping out, and reaming vs. back reaming. These states are predicted using features like hole and bit depth, block height, standpipe pressure, etc.

Three distinct machine learning models are developed and evaluated: Convolutional Neural Network (CNN), Random Forest (RF), and Extreme Gradient Boosting (XGB). The approach involves training and testing these models on a dataset obtained from Utah Forge Well 56-32. The data preparation phase includes imputing missing features, standardizing formatting, and converting units to ensure consistency with the datasets used in a publicly available cloud-based rig classification engine, which is used for labeling. Feature selection strategies are employed, incorporating correlation matrices, RF importance charts, and XGB importance plots. The CNN model, inspired by the visual cortex, is outlined with a comparative analysis of its performance against RF and XGB.

Results indicate that the CNN model is expected to have the lowest accuracy, while RF and XGB models are expected to be more accurate. Recommendations for industry adoption include establishing a uniform set of features and investing in real-time analytics systems to minimize on-site personnel requirements. In the application phase, the developed models are employed to predict rig states for a new well, and the results are compared with data obtained from the cloud-based engine. Comparisons show that RF predictions are the closest to the cloud-based engine, while CNN gave the least similar results.

The paper concludes with insights into the expected accuracy metrics and outlines plans to deliver the best-performing model for further testing, underscoring the broader implications and significance of this research endeavor in advancing drilling operations.

Integrating Long Short-Term Memory and Artificial Neural Network Algorithms in History Matching And Forecasting in High Heterogeneous Sandstone Reservoirs: - A Case Study

Achieving reliable production history matching and forecasting in the oil and gas industry remains a persistent challenge, leading to continuous research. The traditional approach using numerical simulation grapples with high uncertainties and intricate input data, leading to convergence issues and elevated costs. This paper aims to leverage machine learning and predictive artificial intelligence, such as multivariate time-series machine-learning models and Artificial Neural Network (ANN) proxy models, which have proven effective in training pattern recognition for creating robust and cost-efficient solutions for history matching and forecasting hydrocarbon recovery.

This research employs multivariate time-series analysis coupled with ANN proxy models to forecast oil recovery, with a specific focus on the use of both, directly and indirectly, dependent dynamic data to create a reliable pattern. Dynamic data, including bottom hole pressures, cumulative oil and water productions, and static data, encompassing porosity and permeability, undergo preprocessing and chronological division to facilitate the training and testing of coupled long short-term memory (LSTM) and ANN models. The input data were reshaped following LSTM architecture, and then the reconstructed data was trained, tested, and validated using Python.

The investigated field with 15 active wells has been produced from two distinct sandstone formations separated by an impermeable shale and partially surrounded by a finite aquifer. With the production and pressure database of the 15 wells, a machine learning model was created by applying the LSTM and ANN algorithms, with 70 percent of the input data used for training, 10 percent allocated for testing, and the remaining 20 percent for validation. The field history calibration analysis resulted in an average mean-squared error of 0.7, showing potential outcomes. Model validation using blind testing data exhibited an approximate R-squared value of 0.87, accurately matching historical production within a 10% deviation. Additionally, a reservoir numerical simulation was employed and showed similar outcomes to the machine learning model. By applying machine learning for history matching, it is feasible to significantly reduce the computational cost of running numerical simulations, and then the validated model could be deployed conveniently for forecasting.

This study introduces an economical approach to history matching and predicting hydrocarbon recovery that avoids using complex physical models, providing a versatile framework applicable across disciplines, particularly in scenarios influenced by past decisions. The proposed workflow could be applied readily for any other heterogeneous sandstone reservoirs. Future works can be done using the most current field development data and additional time-dependent features to improve the model's accuracy and reliability.

Master’s Abstracts

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Integrating Production, Pressure, and Strain Data More Effectively Models Hydraulic Fracture Geometry

I developed and applied a workflow that effectively determines the propped hydraulic-fracture geometry in a horizontal multi-stage fractured well by incorporating production, pressure, and strain data. This procedure uses pressure and strain changes measured in an offset monitor well equipped with external pressure gauges and a permanent fiber-optic cable. The offset well monitored various operations, including preload, refracturing, infill-well stimulation, and production. The essential feature of the workflow is the application of a coupled multi-phase fluid-flow and geomechanics model I developed.

I validated my model with data from the DOE Hydraulic Fracture Test Site in the Eagle Ford Shale. I integrated parent and offset well data, which is essential to calibrate the model. I then used the model to interpret and correlate measured pressure and strain changes in the offset monitor well. From the parent well, I included a single stage with six perforation clusters and 50-ft cluster spacing. I history-matched the 10-year production history and a one-day preload event in the parent well. For the one-day preload, I focused on interpreting the pressure and strain changes in the offset well. Field observations during the parent-well preload indicated that a water injection rate above the estimated fracture gradient resulted in a pressure-peak response, suggesting fracture dilation. Strain changes in the offset well, a cross-validating diagnostic with higher spatial resolution, showed a positive extensional strain response at the same measured gauge depth.

Integrating multivariate data into the coupled fluid-flow and geomechanics model enables us to determine propped hydraulic fracture properties and provides a computationally efficient and inexpensive tool for predicting stress changes required to optimize well-completion design and stimulation of infill and child wells. This leads to improved recovery from hydraulically fractured, ultra-low permeability reservoirs. A strong correlation between pressure and strain changes demonstrates that fiber-optic measurements with a spatial resolution of 0.2 m improve fracture diagnostics.

Synergistic Impact of Low Salinity and Surfactant on Wettability Alteration in Carbonates

The waterflood recovery is often low in tight carbonate reservoirs, which tend to be heterogeneous and oil-wet/mixed-wet. Wettability alteration is a promising strategy for improving oil recovery in such reservoirs. This study aims to improve oil recovery in such a reservoir in West Texas. The mineralogy is determined by XRD analysis. The zeta potential is measured for the drill cuttings. Contact angles are measured on core trims, and imbibition experiments are conducted to evaluate wettability alteration. The optimum salinity was determined to be produced water diluted 40 times from zeta potential measurements. The synergy between low-salinity water and surfactants yielded more than 40% oil recovery in spontaneous imbibition experiments. The addition of sulfate ions and weak acids

improved spontaneous imbibition. The results of core flood tests underscored the efficacy of surfactants in improving oil recovery through wettability alteration after waterflooding. This study highlights the potential of low-salinity and surfactant-assisted flooding to improve oil recovery in limestone reservoirs.

Case study: Assessment of predictive capability of reservoir simulators for waterfloods in carbonates: how realistic is my simulation model?

Conventional approaches to reservoir modeling have proved not to be sufficient in capturing the true complexity of reservoir architecture and multiscale heterogeneity, posing significant challenges to production performances. As a result, this study aims to assess different methods for building more realistic reservoir models, to improve the accuracy of waterflood recovery forecasts in carbonate reservoirs.

A systematic simulation study was conducted to investigate the subject problem and propose a solution. The petrophysical properties incorporated into the model were derived from a geological description of the Permian Basin. In order to simulate fluid flow in the reservoir during the production history, emphasis was placed on representing the dynamic performance of the geological model rather than solely relying on the static model. Consequently, capturing geological heterogeneity in discretized flow models becomes crucially important. Various geological constraints were applied to the model, such as no flow thin layers at different intervals, depositional sequence, and permeability cutoffs. The impact of well spacing on the recovery factor was also investigated at equivalent pore volumes of injection, and the findings were compared to existing literature data and leading correlations.

The results from the case study indicate a significant increase in sweep efficiency in reservoir models, due to the inability to accurately capture reservoir heterogeneities. However, this study also shows that even when heterogeneity is added, the waterflood recovery factor forecast is not significantly affected. The results were validated by comparing them with field data and infill drilling correlations, suggesting that reservoir models tend to yield more optimistic forecasts. In addition, conventional methods to perform the history match, such as permeability cutoffs and relative permeability endpoints, that can influence the mean free path between the wells, do not have the desired effects and results in unrealistic predictions.

At present, conventional practices in reservoir modeling are not completely honoring the field data considering the complexities and the sub-grid physics, leading to the overestimation of waterflood recovery factors. This case study suggests a methodological approach and provides more insights in terms of the effect of heterogeneities, thus estimating more realistic water flood recovery factors from a simulation study. Also, emphasizes the importance of closely representing the reservoir architecture for realistic reservoir modeling. Multiple techniques are proposed here to identify the problem and mitigate the challenges. We also propose a measure of the mismatch between the predictions and the observations for various approaches. Overall, the key takeaway from this study emphasizes the need for greater caution when placing trust in simulation studies predicting waterflood recovery factors for subsequent field development management and planning.

A New Algorithm for Automated ISIP Interpretation

Objectives

Instantaneous shut-in pressure (ISIP) is useful for the analysis of hydraulic fracturing and for understanding the interaction between the reservoir and the stimulation treatment. However, this value is normally eclipsed by pressure oscillations that occur immediately after well shut-in, known as water hammer, which complicate its interpretation. Therefore, special techniques are required to estimate the effective ISIP.

The objectives of this paper are: (1) to present an automated workflow for effective ISIP interpretation based on guidelines proposed by Roussel et al. (2021 – URTeC 5681) with a new optimized algorithm; (2) to compare ISIP estimation models; and (3) to validate ISIP interpretations at different step-down rate management during shut-in with water hammer simulations carried out in a commercial fracture simulator.

Methods

We developed an automated workflow to estimate ISIP values from fracture stages that allows for the utilization of various shut-in physical models. The workflow is based on guidelines proposed by Roussel et al. (2021) and incorporates the Trust Region Reflective algorithm to optimize all parameters in the model, which allows for model convergence in a wider range of cases and is validated using field data. ISIP is estimated utilizing different models for pressure decline and testing different times for time-extrapolation considering varying step-down rates. ISIP estimation models were then compared for validation with the results from a commercial hydraulic fracture simulator capable of reproducing water hammer.

Results

The automated workflow successfully matches the pressure response after shut-in with different models and allows estimating of ISIP in almost the entirety of cases. Furthermore, comparison of fitting model parameters between stages allows for quick identification of outliers and poorly matched model predictions. Key parameters include the water hammer decay rate, which serves as a qualitative proxy for system friction and near-wellbore fracture complexity and the water hammer dominant frequency, which depends on the compressibility of the system. A systematic analysis of ISIP responses in multiple wells allows better understanding of stress shadow escalation. Simulations showed that ISIP interpretation is consistent at varying step-down rates.

Multi-Resolution Machine-Learning Model Accelerates CO_2 Storage Optimization

This study has developed an efficient deep-learning-based workflow to optimize CO_2 injection schedules during carbon-sequestration operations. Currently, existing multi-objective CO_2 storage-optimization processes require hundreds of forward simulations that are computationally prohibitive for large-scale field cases. Therefore, this study built a data-driven proxy model to accelerate the optimization workflow that is scalable to large-scale field applications.

The developed deep-learning workflow uses a Fourier Neural Operator (FNO) as a data-driven proxy model. Data-driven models require large training datasets involving thousands of numerical simulations. By leveraging the super-resolution feature of the FNO, the proposed model can be trained using low-resolution images, but then it can predict high-resolution images. Therefore, this study uses coarse-scale reservoir models for generating training data, resulting in an order-of-magnitude reduction in the time and computational resources required for data generation. For CO_2 injection schedule optimization, a multi-objective genetic algorithm uses the FNO-based proxy model as a forward model. The optimization can include several different objectives, such as minimizing pressure increase, maximizing CO_2 injection volume, and maximizing storage efficiency.

This study used a synthetic case of gas injection into an aquifer to demonstrate the advantages of the deep-learning-based workflow. Next, this study applied the proposed workflow to the Illinois Basin Decatur Project (IBDP), a large-scale CO_2 sequestration project in a deep-saline aquifer in the Illinois Basin. For training-data generation, using a coarse-scale model achieved a 90% computational time reduction compared to using a fine-scale simulation. Comparing the trained proxy model to a commercial reservoir simulator verified its prediction accuracy. Finally, I conducted the multi-objective optimization using the FNO-based proxy model. Compared to traditional workflows employing numerical simulations as the forward model, the proposed new optimization framework achieves two orders of magnitude acceleration while considering multiple objectives.

This work introduces a multi-resolution FNO-based fast proxy model for reservoir simulation and its application to CO_2 injection-schedule optimization. Using the super-resolution feature in FNO in conjunction with coarse-scale models reduces substantially the training-data generation cost. The proxy model accelerates forward simulation by orders of magnitude and enables engineers to evaluate multiple optimization scenarios for large-scale field cases.

PhD Abstracts

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Selected Recommended Practices for Increasing the Efficiency and Accuracy of CO_2 Sequestration Models

Computer simulation has become widely used to predict the life of CO_2 plumes resulting from planned subsurface sequestration schemes. The process is very similar to what has been done in the oil and gas industry for decades, however, while reservoir simulations can be "history matched" to real-world performance, analog data is mostly missing in order to calibrate proposed CO_2 project models. Therefore, it is critical to attempt to understand the impact of the various "default" input parameters that are often used in CO_2 sequestration models. This paper attempts to highlight potential enhancements in the modeling process that can lead to improved accuracy of predictions.

Many CO_2 screening investigations use simple homogeneous block models in place of utilizing more complex realistic geologic models. Comparisons between homogeneous models of porosity and permeability with simple stochastically generated porosity and permeability (having the equivalent average values), could make significant differences. The use of Black Oil models instead of Compositional models will be investigated as a method to improve time efficiency allowing the investigation of more "what-if" scenarios. Guidelines for simple calibration of a black oil model to a compositional model are also presented.

The importance of residual phase trapping as a potential primary trapping mechanism in addition to structural and stratigraphic trapping will be investigated. While including parameters for residual trapping, too often default values in simulation tools are used without recognizing the high variability of these parameters, especially considering the laboratory-based observations for some of them. Several scenarios are presented highlighting the importance of these uncertainties.

End-point values of relative permeability curves can have significant effects on plume geometry and are modeled in various scenarios. Critical Gas Saturation is often overlooked in the modeling process. This value is often defaulted to an unrealistically low value that can lead to "runaway" low saturation plumes when models are run for extended periods (as required by government regulations). Critical gas trapping at the edge of plumes can be an often-overlooked additional trapping mechanism.

Simulation of Reservoir Charge to Predict Fluid Compositional Distribution and Detect Sub-Seismic Connectivity Realizations

Reservoir fluids often exhibit compositional complexity vertically and laterally in reservoirs. These complexities include variable gas-oil ratios, and can also include more subtle fluid variations such as biomarker ratios. Present-day distributions of reservoir fluid properties result from mixing of gas and oil charges, over geologic time. Fluid mixing outcomes are highly variable, covering the whole range of reservoir realizations from simple equilibrated to complex disequilibrium distributions. Recent advances have led to resolving many mixing dynamics of reservoir charge fluids over geologic time. The objective here is to use simple modeling of reservoir charge over geologic time to constrain key attributes of the reservoir which comprise the geologic model, and to improve the prediction of fluid properties. Reservoir simulation can be used to predict resulting compositional distributions; these predictions depend on (1) reservoir attributes, both known and uncertain, (2) the range and properties of charge fluids such as density and viscosity, and (3) the time since charge. The comparison of predicted and measured fluid distributions allows history matching of reservoir charge and enables accurate predictions.

Forward modeling with reservoir simulation shows that even simple 2D simulations can illuminate key reservoir properties that impact fluid compositional distributions. Several reservoir case studies are described to validate the charge and mixing dynamics that are employed in modeling. Reservoir simulation shows that a substantial range of the extent of mixing is found dependent on reservoir and fluid properties, thereby providing a very sensitive test of these reservoir parameters. In addition, the location of charge and the range of fluids also impact the predicted compositional distributions across the reservoir. More comprehensive and complicated simulation models can be developed if preliminary, simple models show significant promise in testing important reservoir uncertainties. The impact of many parameters is quantified, including reservoir architecture, dip angle, aspect ratio, various baffling structures, and the sequence of the fluid charges. Generalized systematics are developed which are very useful to characterize the dynamics of reservoir charge over geologic time. Furthermore, by understanding hydraulic connectivity implications on oil chemistry, I provide an effective method for the assessment of reservoir connectivity.

Simulation of reservoir charge for history matching is a new concept, yet, it relies on standard reservoir simulation (over geologic time) for comparison between predicted and measured fluid compositional distributions of the present day to test the reservoir and geologic models. This approach has shown that several presumptions about mixing of charge fluids were not general and inhibited the new workflow. Removing such conceptual limitations has been crucial to developing novel workflows to test the reservoir.

Lessons Learned and Proposed Solutions for Drilling Wells in the San Juan Basin for A CO2-Storage Project

The primary objectives of this paper are: (1) to provide a comprehensive review of drilling operations of a stratigraphic well for a CO2-storage project in the San Juan Basin, New Mexico, US; (2) to analyze and discuss associated challenges while drilling the well; (3) to draw lessons from each incident encountered during the drilling operations; and (4) to present proposed solutions for drilling CO2-storage wells in the area in the future.

A detailed literature review of common problems when drilling wells in the area was carried out. Before drilling the stratigraphic well, a geomechanical model and data from offset wells were used to perform the following designs for the well: casing design, cementing design, hydraulics, and surface equipment selection. A commercial software was used to carry out these designs. The paper compared the designs with the actual executions and operations to draw lessons. From the lessons learned, solutions are proposed for drilling CO2-storage wells in the area in the future. A user-friendly simulation model is also built to validate the solutions.

We found that the most frequent issues encountered during drilling of wells in the San Juan Basin are fluid loss, stuck pipes, and poor control of drilling parameters. This is due to the complexities of the formation lithology and reservoir pressure depletion. The reservoir depletion causes the formation fracture pressure to be much lower than that of the anticipated values. The key recommendations were introduced as follows: (1) Updating the geomechanical model to have the latest pore, fracture, collapse, and breakout pressures; (2) Applying an underbalanced drilling technique using aerated mud by injecting gas into the annulus using a parasite when drilling the intermediate and production holes; (3) Keeping the weight on bit under 10,000-lbs, the speed of top drive rotation under 45-rpm and the pump fluid rate under 350-gal/min are recommended to have good fluid return during drilling through low fracture pressure formations. The simulation model results show that the proposed solutions are applicable.

This paper will provide insights into the root causes of common incidents when drilling wells in the San Juan Basin. The recommendations could also be used to improve the success rate of drilling CO2-storage wells in the area. The user-friendly simulation model can be used to design underbalanced drilling for wells in the area.

Multi-scale Simulation Optimizes Surfactant Huff-n-Puff Process

I have developed a comprehensive workflow to optimize surfactant huff-n-puff treatments of depleted horizontal wells in unconventional reservoirs. The workflow maximizes tertiary oil recovery using minimal surfactant. The process comprises five sequential history-matching steps to integrate laboratory measurements and field data into a multi-scale numerical simulation. The historically matched reservoir model serves as a base case for further optimization of well operation schedules via a multi-objective genetic algorithm.

In my study, I simulated an Eagle Ford shale well stimulated by a surfactant huff-n-puff treatment. The injected surfactant formula was rigorously determined through experimental screening on reservoir rock and fluid samples in the laboratory. Following a 17-hour injection and a one-month shut-in period, the production rate in this well increased five times over the baseline rate and produced incremental oil for at least two years.

The proposed workflow characterizes the mechanism of surfactant-enhanced oil recovery (EOR) and is primarily driven by rock wettability and fluid interfacial tension (IFT) alteration, both in laboratory settings and in the field. Compared to existing operational practices, the simulation indicates that optimal schemes of a huff-n-puff cycle often involve higher injection rates, reduced injection durations, and extended well shut-in periods. The proposed workflow not only proved effective for the Eagle Ford shale case study but also offers general applicability to other unconventional wells. It provides valuable insights into surfactant huff-n-puff treatment, facilitating the optimization of well operations and maximizing tertiary oil recovery.

Validated-Machine-Learning Models Predict Minimum Miscibility Pressure and Optimize Injection Gas Composition

This study validated a neural-network machine-learning (ML) minimum miscibility pressure (MMP) prediction model with minimal error. The study recommends optimal injection gas compositions with low MMP for the "G field" in the Permian Basin. The major alternative, slimtube experiments (considered most reliable for MMP predictions) is time-consuming and expensive.

I tested nine ML models with 142 available public slimtube MMP data points. I split the data into 75% for training and 25% for testing with cross-validation implemented to ensure good generalization. Eleven features governed the ML models. These included reservoir temperature, compositions of light and heavy hydrocarbons in the oil and gas phases and impurities in the gas phase such as H_2S, CO_2, and N_2. I performed two slimtube MMP experiments using CO_2 and produced gas from "G Field." I then validated the ML models using experimental results to identify the optimal ML MMP model. Although the reservoir temperature, oil composition, and gas composition determine the MMP, only the gas composition is controllable. Thus, I varied the injection-gas composition to enable MMP predictions for the specified temperature and reservoir oil composition of the "G field" using the optimal model.

The validated model showed good prediction performance in record time and low cost compared to experiments performed. The workflow reduces the time required to predict MMP by >99% with prediction time in a minute scale compared to months of experiments. The neural-network model performed best with mean absolute error (MAE)<7 after testing and validation. I identified tree-based methods as poor predictors of MMP with MAE >7 after testing and validation. The neural network model predicted optimal compositions containing produced gas and CO_2 of injection gas with low MMP for the "G field."

This study validated the neural-network model to predict MMP quickly and with minimal error. The workflow presented reduces the cost and time associated with MMP prediction, thereby expediting investment decisions. I developed a library typical for a Permian Basin field for instant predictions of optimal injected gas compositions with low MMP. Adopting the library for varied injected gas compositions can reduce greenhouse gas emissions associated with flaring produced gas and the cost of pure CO_2 injection.

Macro-Scale Modeling Study of Kinetics of Permeability Changes in CO2 Saturated Brine Injection for Enhanced Carbon Capture & Sequestration

Objective/Scope: Storing CO2 in deep saline aquifers is one of the key solutions for greenhouse gas reduction strategies globally. High reactivity of the minerals in saline aquifers to CO2 triggers mineralogical changes following CO2/brine/rock interactions, impacting storage capacity and integrity, as well as potentially causing formation damage or permeability enhancement.

This study aims to develop an integrated model evaluating mineral behaviors during CO2-saturated brine flow, considering equilibrium and kinetic reactions in convective, dispersive reactive flow regimes.

Methods, Procedures, and Process: This study employs a 1-D model including fundamental physics: integrating geochemical reactions (dissolution/precipitation, multi-ion exchange) with continuity equations to quantify the kinetics of brine and rock species at the core scale. This coupling enhances accuracy in modeling formation damage/stimulation and permeability changes. The reactive model assesses reaction rates via saturation index evaluation for precipitation/dissolution potential. Permeability alterations are evaluated using the Kozeny-Carman equation through implicit finite difference methods.

Experimental procedures validate the model output, including sample preparation, high-salinity brine injection, and CO2-saturated brine injection. Post-test analyses, like micro-CT scanning and geomechanical testing, further illuminate permeability changes.

Results, Observations, Conclusions: The analysis of the results indicate that brine injection minimally impacts permeability, even at higher pore volume injections. Conversely, injecting CO2-saturated brine into the rock composed of Limestone and Quartz leads to a notable permeability increase, doubling the original value of the permeability due to the system-scale mineral dissolution, while the amounts vary from upstream to downstream direction. However, in contrast, injecting CO2-saturated brine into dolomite formations results in a 35% decrease in permeability, caused by magnesium carbonate precipitation. These contrasting effects underscore the complex interplay between injection fluids and rock composition, highlighting the importance of considering geological formations in CO2 storage assessments. Moreover, the system's pH drops by as much as 4 units after CO2- saturated brine injection, due to the formation of carbonic acid resulting from CO2/ brine reactions.

Novel/Additive Information: The study emphasizes and quantitatively reveals the implications of CO2 reactivity by using the learnings from experimental and numerical results underscoring its relevance to the field of carbon capture and storage (CCS) in deep saline aquifers. Furthermore, by manipulating brine composition and further saturating it with CO2, the optimum brine composition is attainable. Sensitivity analysis on rock composition helps in targeting suitable rocks for CCS under operational conditions, reducing formation damage risk and injectivity losses.

Energy efficiency evaluation for in-situ hydrogen production from natural gas using electromagnetic-assisted method

An emerging technology, in-situ hydrogen production from oil and gas reservoirs using electromagnetic (EM)-assisted catalytic heating, has recently been proposed and validated through lab-scale experiments. The results demonstrate that not only can the reservoir rocks be heated to over 700 °C under EM irradiation, but also high purity hydrogen can be generated from hydrocarbon cracking within formation rocks. The highest hydrogen concentration, reaching 91% and 77%, is obtained from methane and shale oil, respectively, with only negligible carbon dioxide produced. However, the energy efficiency of this approach remains unknown. Therefore, in this study, we aim to analyze the energy input and output during the experimental process for in-situ hydrogen, thereby providing an in-depth understanding into energy analysis of this technology.

Energy efficiency, defined as the ratio of useful output to consumed input, both expressed in terms of energy, serves as a pivotal metric in evaluating the effectiveness of the proposed technology. To assess the system efficiency, lab-scale experiments involve passing methane through sandstone rock samples. These samples are loaded into a purpose-designed reactor and subjected to microwave irradiation, heating them to 700 °C. Different methane flowrates (100, 150, and 200 mL/min) are utilized to investigate the sensitivity of energy efficiency in both catalytic (utilizing synthesized iron catalyst) and non-catalytic (using pure sandstone) conditions. The real-time gas composition of the produced gas streams is analyzed by a mass spectrometer (Extrel, Max300-IG), enabling the determination of flowrate and cumulative hydrogen production.

Results indicate that sandstone samples can be heated to 700 °C utilizing a microwave input power of 0.20 kW. The highest hydrogen concentration achieves 94.0% through methane cracking in sandstone rocks with the assistance of the synthesized iron catalyst. Moreover, the generation of carbon oxides (i.e., CO and CO_2) is negligible. The overall methane conversion during the experiments is 70.5% and 48.2% for samples with and without catalysts, respectively. The gross energy consumption of produced hydrogen ranges from 365 to 586 kJ/g H_2, corresponding to an energy efficiency range of 24.6% to 41.1% for in-situ hydrogen production via electromagnetic-assisted catalytic heating. When considering carbon-zero emissions during the process, the systematic efficiency could be higher.

By conducting an energy analysis through electromagnetic-assisted catalytic experiments, this study firstly delves into the energy efficiency of in-situ hydrogen production from gas reservoirs using our innovative technology. The findings contribute to a comprehensive understanding of the technical aspects regarding energy efficiency. The insights are instrumental in both the technical assessment and commercialization endeavors of the in-situ carbon-zero hydrogen technology.

Investigating Cement Integrity for Underground Hydrogen Storage in Depleted Hydrocarbon Reservoirs: A Multifaceted Analysis

Abstract:

Promoting the adoption of renewable energy is crucial to meeting our energy needs, but large-scale storage is necessary for its applicability. Underground hydrogen storage (UHS) is a promising solution that could offer a reliable source of clean energy worldwide. Due to their existing infrastructure, depleted hydrocarbon reservoirs can serve as suitable UHS storage sites. However, maintaining the integrity of the well poses a significant challenge when storing hydrogen in such reservoirs.

In this investigation, three different batches of cement samples measuring 3.81 × 7.62 cm were cured for 12 and18 months and subjected to cyclic exposure to hydrogen for three 28-day and 84-day cycles at a maximum pressure of 10.34 MPa and 60°C, with pressure increments occurring at a rate of 2.06 MPa/hour. The cement's porosity, permeability, and ultrasonic velocity were examined before and after each cycle. Subsequently, dynamic elastic properties were derived from ultrasonic velocity measurements. Scanning Electron Microscopy (SEM) was employed to analyze changes in the structure and elemental composition of the cement surface before and after exposure. A core holder mimicking wellbore conditions was employed to investigate underground hydrogen storage's viability further. A 30.48 cm long, 10.16 cm diameter Berea Sandstone core sample with a concentric 5 cm drilled hole was utilized. A 2.54 cm perforated stainless-steel pipe served as a casing inside the 5 cm hole, with cement filling the space between the pipe and core. After 72 hours of cement curing, hydrogen was injected into the sandstone through the casing via the cement. CT scanning detected any leakage channels or cracks compromising system integrity. Transducers connected to a Data Acquisition system monitored leakage.

Results indicate increased porosity and permeability following exposure, although ultrasonic velocity changes were negligible. SEM images revealed no discernible alterations in the microstructure, yet Energy-Dispersive X-ray Spectroscopy (EDS) Mapping revealed mineral dissolution. For the wellbore model, the cement deformations were negligible. However, the pressure transducer readings demonstrated leakage from the cement annulus, confirmed by CT Scanning of micro annuli formation.

This innovative method offers a promising approach to detecting and ensuring well integrity. It underscores the impact of cyclic hydrogen exposure on the integrity and sealing efficiency of aged cement, highlighting the importance of such considerations when repurposing existing oil and gas wells for hydrogen storage in depleted hydrocarbon reservoirs.

STUDENT PAPER CONTEST RULES AND REGULATIONS

2024 Edition

www.spe.org/en/students/contest

Contents

Overview

The Student Paper Contest (SPC) is SPE's primary student competition to highlight an individual student's technical merit. Through the review of an abstract, presentation, and question and answer session, a panel of judges review sole-authored technical presentations to find the most innovative, relevant, and well researched papers across SPE.

The top ranked presentations from the regional competitions will be invited to submit their full paper and join the international round to determine our International Student Paper Contest winners across Undergraduate, Master's, and PhD divisions.

The rules and information in this document are to guide participants and volunteers, as well as aid the organization of Regional and International Student Paper Contests as part of the SPE International program. Only participants from official SPE Regional Contests will be permitted to take part in the International Round at ATCE.

Similar competitions can be run by SPE Sections and Chapters, however, these do not influence the application or qualification process for participants of SPC Program. Non-official contests are not required to follow the rules and regulations laid out in this document. The official SPE Student Paper Contests can be found listed on the SPC Schedule Webpage. Only participants in these events will be considered for qualification to the international round.

The SPE International Standing Committee, the Student Development Committee (SDC) and the SPE Young Member Programs Team are the ruling bodies on changes to the Student Paper Contest program. The SDC report directly to the Board of Directors who authorise any significant changes.

Program Updates

Since the period of the COVID-19, pandemic several changes have been made to the Student Paper Contest Program. Any new changes made since 2023 will be highlighted using this symbol.

NEW FOR 2024

The Student Development Committee and SPE Young Member Programs Team will regularly review the rules and processes, and the SPE Board of Directors will have the final approval on any significant changes to the Student Paper Contest.

The most recent significant change is that **Full Technical Papers are no longer required to participate in the Regional Student Paper Contest**. Regional participants will only be judged on the abstract and presentation given.

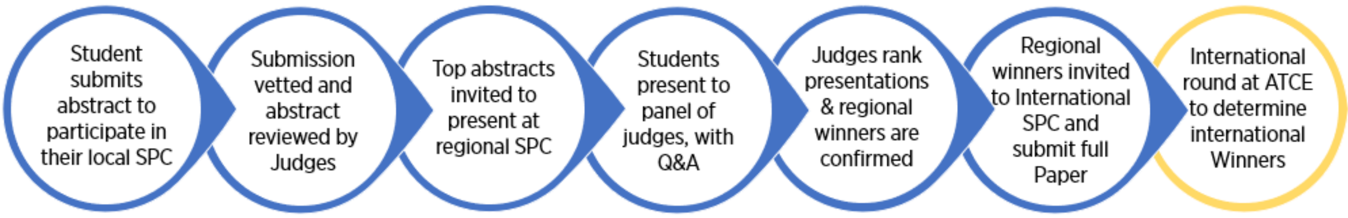
If invited to the International Student Paper Contest at ATCE, a full technical paper will be required, and this will be considered by the judging when scoring presentations.

SPE International reserves the right to update the rules and regulations at any time, but we will make all efforts to ensure participants and potential applicants are made aware of these changes.

For any questions or queries relating to this program, please contact the SPE Young Member Programs Team at spc@spe.org or speak to your regional specialist who is managing your local SPC.

Competition Process

The basic overview for participating in the SPE Student Paper Contest is shown below, however, more detailed specifics are detailed throughout the rules in this document.



Participation Steps (detailed)

1. In order to participate in the Student Paper Contest, all students must submit an application, including an abstract using the SPE Online Application Form. This is used by SPE staff to vet your eligibility to participate in the contest, and for judges to review your topic and abstract. Please remember that you should only apply for the Regional contest that corresponds to the university you are representing.
2. Your status and application contest is reviewed to ensure it meets the criteria for the Student Paper Contest. This includes reviewing your Membership Status, Graduation date, Sanction eligibility, Content Suitability, and the region you are applying for. If you meet all criteria, judges will then review your abstract.
3. The judges will score and rank all submitted abstracts. Depending on the capacity of the regional contest, the top candidates will be invited to participate in the Regional Contest. If a minimum number of abstracts is not met, some divisions may be merged or cancelled. The requirement to host in-person or virtually may vary from region to region depending on available AV.
4. Participants will present their work to a panel of judges. Presentations will be a maximum of 20 minutes, plus a question and answer period from the judges.
5. Judges will score presentations looking at relevance to industry, importance, strength of information, organization of project/work shown, novel information provided, and commerciality of information. Once all presentations have been scored, the presentations will be ranked. These rankings will combined with other judges rankings to determine the final ranking.
6. The highest ranked participants will be announced the regional SPC winners. They will be asked to provide a full technical paper and be invited to present their work as part of the ATCE International Student Paper Contest, where they will be joined by winners from other regions.
7. Regional winners will present at the Annual Technical Conference & Exhibition. The contest will follow the same procedures as the regional contest, though information in the full technical papers will also be considered during the scoring. The judge rankings will be used to determine the International Winners for that year.

Regional Event Organization

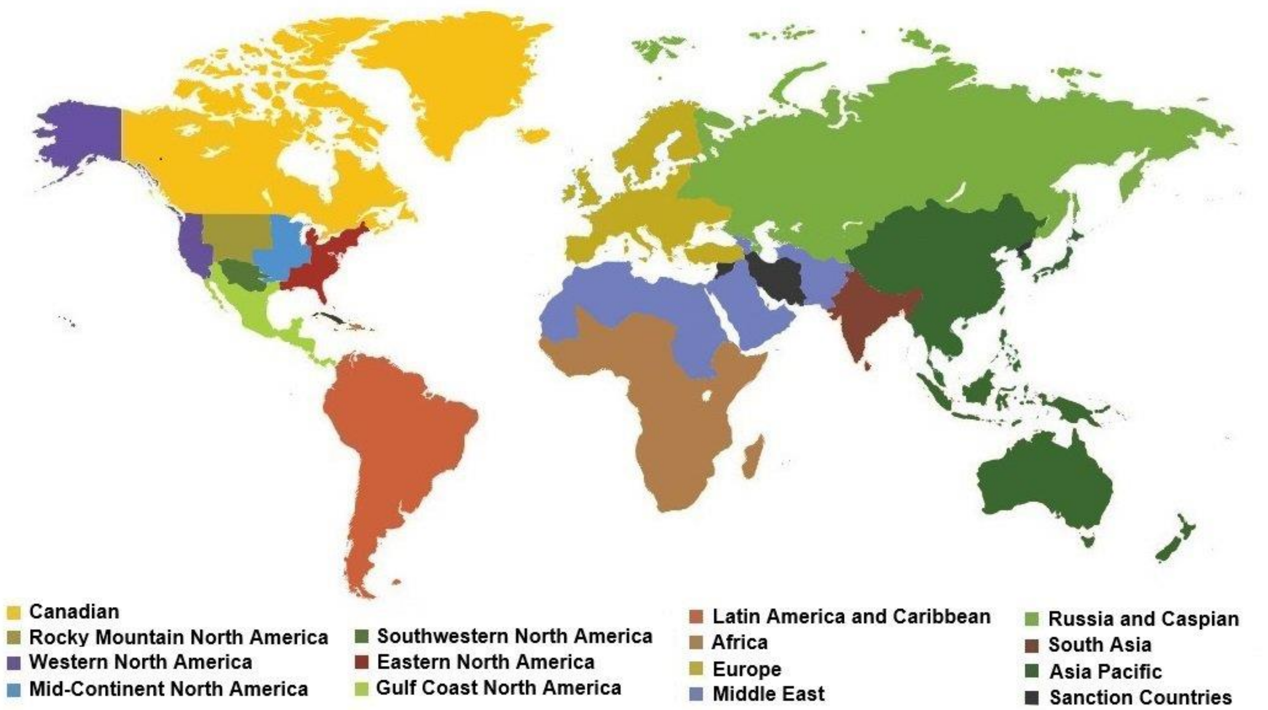
Regional event dates, platforms and locations will be determined by SPE Staff in collaboration with SPE Regional Directors who are responsible for activities in those areas. SPE Student

Chapters/Sections may be invited by SPE to host a regional contest, or they may be stand-alone events. Contests can be hosted as fully virtual events, physical events, or hybrid events (combined virtual and physical). Contests may also be hosted to accompany a major regional or SPE International conference. <u>The approach used for a specific Regional event will be made by SPE Staff in collaboration with the Regional Director(s) which represent that region.</u>

Currently, fourteen Regional Student Paper Contests are recognized by SPE, taking place as shown on the map below.

A map of SPC Regions can also be found on our website, but for any concerns about what region your university is represented by, please email *spc@spe.org*.

TIP: Please see <u>rule 2.8</u> *for rules regarding which region students should apply for.*



Dates and details for applying to individual SPC Regional Contests can be found at the SPC Webpage once they are confirmed; <u>https://www.spe.org/students/schedule.php</u>.

<u>All students should participate in the SPC Region that covers the location of the University they are representing</u>. Only participants that take part in the Regional Student Paper Contests listed can be selected for the International Round. On occasions regions may be merged, for example, if a large student event is taking place that covers students from multiple regions.

In the event that a contest or a division is not held in their assigned region, a student may request to participate in an alternate region. This request is reviewed on a case-by-case basis. Any applications to participate in alternate regional contest must be made to the Young Member Programs Team at spc@spe.org. This must be approved by the Regional Directors representing the SPC Regions involved, and they reserve the right to decline any such requests.

The following explanations **will not** be considered sufficient to move to another contest; Failure to meet submission deadlines, being unaware of contest dates, matters of convenience, conflict or clash of timings.

Contest Rules:

The following rules described in this document will apply to all official SPE Student Paper Contests. All rules will be enforced, and it is the responsibility of each participant to ensure that they are aware of these rules prior to the competition. We trust that our participants will adhere to the rules in good faith, and any deliberate breaking of the rules will result in immediate removal from the contest. For any questions relating to eligibility or contest processes, please contact spc@spe.org

1.0 Contest Structure

1.1 Each contest division must have at least three contestants in order to be organized. A regional contest is normally conducted in three separate divisions: Undergraduate, Master's, and PhD.

1.2 If there are entries from three or more eligible students for a division, that division must be held as part of a regional contest.

1.3 Combined Divisions:

If a Master's or PhD division contest does not have the minimum number of entries of at least three students each, they can be combined to create a "Postgraduate" division. If there are still not enough applicants to run a combined Postgraduate division, the Master's and PhD applicants should not be combined with Undergraduate division.

If an Undergraduate, or Postgraduate division, is not possible due to low participation (less than three participants), the students may be allowed to present at an alternative region if the Regional Directors are in agreement.

In the event of a combined Master's/PhD division, it should be made clear to the judges which contestants are of what level within a merged category. This ensures that they judge each student accordingly to their level of ability. However, **only one winner will result from a combined contest.** These winners will enter the division that meet their degree level in the international round.

TIP: Please see rule 7.2 for entry requirement changes for applicants per university during combined divisions.

2.0 Entrance Requirements

2.1 Contestants must be SPE Members in good standing at the time of application and still be in good standing at the date of the contest.

2.2 If the participant has already graduated, it must have been less than 12 months before the Regional Contest. Thus, a student graduating in March 2023 must compete by March 2024.

The student should only present work carried out at the educational level that corresponds with the division in which they are competing, regardless of whether they have gone on to a higher level of education. For example: A student who has earned a degree as an undergraduate less than twelve months ago, and has proceeded into a Master's degree, can still compete in the Undergraduate division, but must only present work carried out as an Undergraduate. If a student wins within his/her division at a Regional Contest, he/she will compete at the International Contest within that same division and present work on the same topic which was presented at the Regional Contest.

2.3 Students are not required to be a member of an SPE Student Chapter in order to participate in the contest.

2.4 Students must be eligible to compete in their regional contest in accordance with the USA and EU Sanction laws which SPE operates by: http://www.spe.org/about/laws.php. Please note that Sanction Laws may impede a student's ability to accept SPE International prizes or continue to the international round even if they are successful at a regional level. Please note that Sanction Laws also apply to virtual events, though physical travel is not required.

2.5 All applications will be vetted by SPE Staff before consideration. Final rulings on questionable eligibility will be made by SPE. Please direct enquiries to spc@spe.org for any concerns.

2.6 Only one entry per student, per year (between ATCE's) will be accepted. Multiple abstracts or entries to the SPC within the same year will not be accepted.

2.7 A student may participate in SPC more than once across several years, and in the same category, as long as they still meet all other eligibility requirements and do so with new and previously un-presented paper as per Rules of Form and Content of Presentation/Paper *(Please see* rule 4.0 to 4.9*)*.

2.8 Students must participate in their allocated region unless their region is not hosting a contest during that SPC cycle. In the event of no contest being hosted, an alternate region may be requested, which will be clarified by SPE Staff. An Individual's inability to participate in their region cannot be considered in order to avoid a university having an unfair representation across different regions across the overall contest.

TIP: Please see item 7.0 Selection of Contestants for related information.

3.0 Entrance and Participation Procedures

3.1 Each participant must adhere to the procedures and deadlines established by the contest host and that of this document.

3.2 NEW FOR 2024 A full technical paper will only be required in order to participate at the International level of the contest. **Only abstracts are necessary at the Regional level**. Failure to provide this by the required deadlines will result in expulsions from the contest. Paper guidelines will be provided by SPE Staff if you are accepted to present at the international level.

3.3 Students must provide all that is requested from them by the host Chapter/ Section or SPE Staff – this includes papers, videos, forms, applications etc. – by the deadlines provided. Failure to provide a form or paper that is asked of them by the deadline provided may result in a forfeit of their place in the contest.

3.4 If virtual and hybrid events are permitted at your contest, submitting a pre-recorded version of your presentation in advance of the contest is the preferred option. In the event of any connection issues, your presentation can still be viewed by judges without impeding the overall contest, and judges' questions can be quickly hosted on an alternative platform or phone line. Live streaming your presentation may be permitted, however, poor internet connection, failure to reconnect, or participate during your assigned timeslot in the agenda may result in disqualification from the contest. You must confirm your method of presentation with regional event organizers in advance of the contest by the deadlines given.

3.5 If a student is unable to participate in the international round, either virtually or physically, the subsequent highest-ranking contestant in the regional division may be extended an invitation to compete internationally as the region's representative. This will only occur if ample notice is provided, considering submission deadlines, and allowing sufficient time for necessary arrangements. The decision will be made at the discretion of the SPE Young Member Programs Team.

4.0 Rules on Form and Content of Presentation/Paper

4.1 Only single-author presentation/papers are eligible, **jointly written, or co-authored papers are not permitted**. The definition of sole or single-author is a student that has written the presentation/paper independently, even though other researchers or contributors may have been involved in the project or subject matter. Researchers and contributors, such as supervisors or tutors who assisted the project, must be acknowledged as "Contributors" to the paper and presentation but not as an author.

NEW FOR 2024 Using AI generated content as part of your abstract/paper is considered an additional author, and is not permitted as part of the Student Paper Contest. Sole authored content means that only content written by the person presenting at the contest should be considered. Using content created by AI or other authors will disqualify participants from the contest.

TIP: If you are unsure if your paper is sole author or not, please contact spe@spe.org to avoid disqualification at a later stage.

For more information SPE Publication policies please visit
https://www.spe.org/en/authors/policies/

4.2 A presentation/paper should present, as completely as possible, the original work of the author in planning the investigation, performing the work, interpreting the results, and preparing the presentation/paper. **Submitting or presenting others work as your own, including AI generated content, or work already presented in a Student Paper Contest, will result in removal from the contest.**

4.3 The subject of a presentation/paper must be related to petroleum engineering, which is defined as the application of basic and engineering sciences to the finding, development, and recovery of oil, gas, and other resources from wells.

4.4 A presentation/paper based on course work, including theses and dissertations, is eligible.

4.5 NEW FOR 2024 If selected to present at the international level, participants will be required to provide a full paper on the presentation topic. Information from the technical paper will be considered when judges review presentations. You will retain all rights to your paper. Technical Papers are not required for the regional level of the contest.

All winners of the regional contests will be offered the opportunity to publish their paper in OnePetro, at which point copyright forms will need to be completed in order to distribute your paper. Publishing your paper is not mandatory, however, a copy of your paper will be necessary in advance of the presentation for the judges to review. Failure to provide a full paper for judges by the deadline given, may result in expulsion from the competition.

NEW FOR 2024 *TIP: SPE is adopting ORCID (Open Researcher and Contributor ID), a widely accepted unique identifier for authors, giving them control over their content and eliminating ambiguities. All SPE contributors, including those who wish to publish their work through the Student Paper Contest, will be required to have an ORCID iD starting 1 January, 2023. For more information on getting your FREE ORCID account please visit;*
https://www.spe.org/en/authors/resources/orcid/

4.6 All papers will be checked that they meet the SPC Rules and Regulations including authorship, word count, AI generated content, and plagiarism before we can confirm your place at the competition.

4.7 At time of submission, the presentation/paper must not have been accepted for publication in any SPE peer-reviewed journal, or presented at previous official SPE Regional Student Presentation/Presentation. (Papers presented at non-SPC presentations, or contests sponsored by universities, SPE sections, or other organizations are allowed.)

4.8 The presentation/paper must be presented in the English language, the official language of SPE. All contestants that progress to the International Student Paper Contest must present in English.

4.9 Papers must be submitted in a typed form in English. The paper must consist of a minimum of 1,000 words of text, plus as many diagrams and supporting illustrations as necessary to clarify the subject matter. The paper must not exceed 7,000 words equivalent of text and diagrams, with each diagram considered to be the equivalent of 250 words.

TIP: Word count includes everything in the main body of the text (including headings, images, tables, citations, quotes, lists, etc). References, appendices and footnotes ***should not*** *the main body of their text. If information integral to then understanding of your paper is not in the main body of your text it may result in a lower score in clarity and communication in your paper.*

SPE Staff are able to provide templates and guidance on writing your technical paper, please visit the SPC Webpage or email spc@spe.org for more information. For publication manuscript guidance SPC follows the same formatting guidance as all other SPE Publications.

4.10 The presentation may not exceed 20 minutes, less presentation time may be allotted to Regional contests, to a minimum of 10 minutes for the presentation, depending on the number of contestants per category. The time allowed for questions will be at the discretion of the moderator, questions will only be invited from the judging panel, not from the audience.

TIP: It should be made clear to the students who have been selected to compete that they will have between 10-20 minutes for their presentation and that the exact time they will have will be confirmed to them nearer to the contest date once final numbers and the schedule have been determined.

4.11 When presenting virtually you must adhere to the guidance and format requested by SPE Staff. Virtual presentations ideally consist of a pre-recorded video, followed by a live videoconference Q&A session, following the same time criteria as the physical contest. If any technical issues prevent your video from being shown live, it will be shared with judges directly and live Q&A will be hosted on an alternative platform. Judges will only be able to watch your video once prior to scoring your presentation. If for any reason a pre-recorded video is not possible, a live videoconference will be allowed if permitted by SPE Staff in advance.

4.12 The format of virtual presentations will consist of your presentation slides as the sole visual element, and your unaltered verbal delivery (i.e., without alterations in the voice such as fast-forwarding) as the sole audio element. In order to ensure fair comparison between physical and virtual presentations, if the submitted video does not meet with guidelines by the deadlines given, this may result in expulsion from the contest.

4.13 Videos will only be shared with SPC Judges unless permission has been given by the participant to allow for wider distribution. Participants will maintain all rights to their presentation and paper, and can withdraw permission to share at any time, even if prior consent has been given. If successful at the regional level, participants will be offered the opportunity to publish their paper in OnePetro, at which point transfer of copyright to SPE is a requirement for publication.

TIP: SPE Staff are able to provide best practices on how to record your video which is also available on the SPC Webpage.

5.0 Financial Assistance for Participants

Students should be encouraged to approach their sponsoring Section and/or local companies to apply for financial assistance for the costs of travelling to the Regional Qualifier contests. SPE International cannot provide any funding for regional contest travel. Funding for International participants may vary year on year and cannot be guaranteed.

6.0 Selection of Judges and Moderators

The host group / SPE Staff are responsible for:

- Selecting a “review panel” to review abstracts where a contest is open-applications (not applicable where Chapters submit representative candidates).
- Selecting judges to review abstracts and oral presentations on the day of the contest.
- Providing a non-voting moderator for the presentations.
- Ensuring all judges and moderators are up to date with contest procedures and rule updates.

The following guidelines apply to the selection of judges for the contest:

- A minimum of three and a maximum of six judges should participate for each division of the contest. It is recommended to recruit more than the minimum number of judges to account for potential dropouts.
- Preferably an odd number of judges should participate in case of a tie break situation.
- It is recommended to have only one judge per university, where possible, to address any (perceived) conflicts of interests.
- Judges in the undergraduate division must hold at least an undergraduate degree in engineering or applied science. Judges in the master's division must hold at least a master's degree. Judges in the PhD division must hold a PhD degree.
- A balance among representatives from different technical disciplines including research, production, management, and education should be considered in selecting the judges.
- Ideally each judge should be a member of SPE.

7.0 Selection of Contestants

7.1 No more than two contestants can be from each Student Chapter or university for each division of the contest.

7.2 In the event of combined divisions, two contestants may be from the same chapter/university for each degree category. For example: In a combined Master's/PhD Division, two contestants from a student chapter/ university may present Master's papers and two from the chapter/university may present PhD papers.

7.3 In contests with open applications, students of that region shall receive notification of the call for abstracts and the deadline by which they must submit their abstracts, and any other necessary forms, and who to submit them to. The review panel must then select from the abstracts which contestants will advance to the regional contest to compete. Abstracts will be submitted to the review panel anonymously to protect members of the review panel from potential conflicts of interest. In contests of open applications, the review panel shall confer via phone or email to select the finalists to present at the contest, as well as the alternates should a finalist be unable to present.

7.4 Some SPE Chapters may decide to host their own preliminary contest in order to determine which two students may represent their university in the regional contest in order to adhere to rule 7.1. In these cases, Chapters of that region must host their contests prior to the official Regional Contest. Chapters will receive notification of the call for abstracts and the deadline by which they must submit their two candidates, their abstracts, and any other necessary forms. Chapters may then host their own paper contests to select their two candidates for the regional contest. Chapter led selection processes may vary from official SPC rules, and participation at a Chapter run contest does not guarantee acceptance to the Regional Contest if SPC eligibility criteria is not met. Chapter contest winners will still be required to apply using the normal regional application process.

8.0 Judging of Presentations and Selection of Winners

Judges must use the official SPE Student Paper Contest Judge Score Form to determine the ranking of their contestants. These forms can be accessed by emailing spc@spe.org or your Regional Activities Specialist. These forms are used for evaluating contestants' presentations and must adhere to the following procedures:

- Following each presentation, judges must score each speaker on the **Official Judges' Score Form**, retaining copies of all sheets until the session is completed. Based on the

Scores, the judge will rank each presentations in order of preference. This ranking should be recorded on the **Judges Ranking Sheet** and given to the Moderator. In the event of a tie score, the judge should determine which they prefer to rank higher.

- Based on the judges ranking, a score is allocated to each contestant per judge. For example, in a contest of 10 people the top ranked place will get 10 points, and the lowest ranked will get 1 point. Each judge will complete a ranking form which will be given to the Moderator after all presentations have been viewed.
- Each judges' ranking score is recorded on the **Official Moderator's Score Card** by the Moderator at the end of the contest to collate the ranking scores.
- The Moderator(s) will check the results with SPE Staff or the Judges (if no staff are available) to confirm the top participants. The result should be agreed by the panel of judges before being announced.
- There is no provision for tie votes; ties must be resolved by the judges. In the event of a tie, judges will collectively agree on the final ranking of contests, and the final ranking may vary from the individual scores of judges.

- Winners are to be named as follows:
  - If there are six or more contestants in the division, first, second, and third place winners shall be named.
  - If there are four or five contestants in the division, only first and second-place winners shall be named.
  - If there are only three contestants in the division, only a first-place winner shall be named.

- Judges individual scores will not be shared to participants, however, Judges feedback or ranking can be provided to students where appropriate to assist them with the continuous development of their presentation skills.

The first-place winners of each division from each SPE Regional Student Paper Contest will automatically qualify for the International Student aper Contest to be held in conjunction with the Annual Technical Conference and Exhibition. The contestants shall follow the submission format and schedule of the conference as provided to them by SPE's Young Member Programs team at spc@spe.org.

9.0 Awards and Funding

9.1 Funding for participation in regional paper contests will not be provided for by SPE International. Sections and Chapters are encouraged to source sponsorship to cover costs of running the program.

9.2 Prizes: For the first-place Regional contestants, SPE International will invite them to participate in the ATCE International Round, covering flights, accommodation, VISA fees, and ATCE registration. All Regional winners will be listed on the SPE International Website.

9.3 All regional winners will be offered the opportunity to publish their paper in OnePetro. This is considered part of the Prize but it is not a mandatory requirement to publish with SPE, and if you choose not to do so, this will not impact your scores in the contest. Your full paper will still be required for Judges to review prior to the contest, but your paper does not have to be published.

9.4 SPE will also grant runner-up prize money to second and third place contestants, with the amount to be confirmed year on year. The decision to grant additional awards, honourable mentions, and honorariums to contestants who did not reach finalist status but deserve recognition is at the discretion of the regional host.

9.5 Presentation of Awards: SPE will provide certificates to each participant in the International Student Paper Contest. SPE can provide a template for regional certificates for hosts. Awards and certificates should be presented by an SPE Officer or Director, a member of the SPE Student Development Committee, or a representative of the host group.

10.0 Responsibilities of Host Group

Where relevant, SPE will notify the SPE Section or Student Chapter of its opportunity to host the Regional Student Paper Contest. The host group assumes responsibility for the conduct of the contest and for adhering to the rules laid out in this document. The first task is to determine the date, time, and site of the oral presentations.

The contest should be conducted in connection with an SPE technical conference or regional meeting whenever possible. In such cases, SPE suggests that:

- The oral presentations be held within the same week and preferably integrated into the conference program rather than appended onto the beginning or end of the conference.
- The decision on the date, time, and site of the presentations should be discussed with the chairperson of the Conference Program Committee.
- The host group may add an amount to the conference fee to cover contest costs.
- Consideration should be given to providing all contestants and judges with complimentary tickets to award/presentation functions.
- The host group for the conference has the option to arrange for assistance with travel and accommodation expenses for contestants if appropriate.
- Contestants should be afforded the status and privileges of other authors presenting technical papers at the conference, including complementary registration at the conference/exhibition.
- The host group should maintain the professional standards of SPE International events and the SPE Code of Conduct.

For any queries or concerns with the rules and procedures featured in this document please email spc@spe.org for more information.

Staff Lead: SPE Young Member Programs Team
E-mail: spc@spe.org
Webpage: www.spe.org/en/students/contest

Student Development Committee

The Student Paper Contest is regulated by the Student Development Committee (SDC), and changes to the program are ratified by the SPE Board of Directors. Both parties reserve the right to update and review the rules and regulation at any stage.