

---

## APPLICATION OF MONTE CARLO SIMULATIONS FOR ECONOMIC EFFICIENCY EVALUATION OF CARBON DIOXIDE ENHANCED OIL RECOVERY PROJECTS

**MSc. Eng. Szymon Kuczyński**

**MSc. Eng. Jacek Hendel**

AGH - University of Science and Technology, Kraków, **Poland**

### ABSTRACT

Methods for the economic evaluation of oil and gas projects, both onshore and offshore, are discussed in many papers. Every year, top energy companies and research institutions publish outlooks of global energy supply and demand. Apart from fluctuations caused by economic cycles, in each of the published reports, the energy consumption growth is observed as well. Despite the percentage share decline of non-renewable energy in the energy mix, the total consumption of fossil fuels will increase. This results in growth of CO<sub>2</sub> emissions. The price of oil might also grow over the next decade. For the above-mentioned reasons, applications of carbon dioxide enhanced oil recovery methods (CO<sub>2</sub>-EOR) are being considered. The economic efficiency of CO<sub>2</sub>-EOR with carbon capture and storage (CCS) depends on many factors, i.e. capital expenditures (CAPEX), fixed and variable operational expenditures (OPEX), capture of CO<sub>2</sub> from the plant, CO<sub>2</sub> transport and sequestration costs, monitoring program, costs of CO<sub>2</sub> emission permits for the emitter and, of course, future oil prices. In this paper, an offshore CO<sub>2</sub>-EOR project, based on real data, is analyzed. The oilfield operator and the emitter (heat power plant) are in one capital group, so reduction of CO<sub>2</sub> emission provides additional income. Due to limited experience in CCS projects implementation, especially in Europe, project costs are difficult to estimate. Monte Carlo simulation method is employed to evaluate the economic efficiency of this CO<sub>2</sub>-EOR & CCS project. Based on literature and industrial experience, probability distributions for CAPEX and OPEX are defined. Additionally, various scenarios of oil and CO<sub>2</sub> permits prices are discussed and implemented to economic model. Net present values (NPV) and internal rate of return (IRR) are calculated. To show the impact of selected input data on the project efficiency, sensitivity analysis is created.

**Keywords:** carbon dioxide enhanced oil recovery (CO<sub>2</sub>-EOR), carbon capture and storage (CCS), net present value (NPV), Monte Carlo simulation, economic efficiency

## CHARACTERIZATION OF MIXED METAL OXIDE ANODES

Hussein Mesmari<sup>1</sup>

Mohammed El Marghani<sup>2</sup>

<sup>1</sup>Department of Materials and Metallurgical Engineering, University of Tripoli, **Libya**

<sup>2</sup>Linscan Oil & Gas Services, **Dubai**

### ABSTRACT

An enhanced mixed metal oxide (MMO) coating is deposited by arc-plasma spray and chemical processing, the coating consists of Iridium, Tantalum, Titanium and Oxygen resulting in a dense abrasion resistance insert catalytic surface on commercial pure Titanium. The mixed metal oxide is crystalline, electrically conductive coating that activates Titanium and enables it to function as an anode. Such anodes are receiving great attention as an alternative to the conventional anodes in the cathodic protection industry. An experimental investigation was carried out to determine the physical and electrochemical characteristics of a typical MMO anode largely used in deep ground bed installations. The results have shown that such anodes are practically insoluble in acid, have an excellent adhesion to the Titanium tubular substrate, and above all, agreement with reported value of their breakdown potential has been established. The study has also shown that such anodes are not suitable for sulfate-rich environment. The low consumption rate makes these anodes commercially attractive for long term use.

**Keywords:** MMO anode, Breakdown Potential, Potentiodynamic Polarization, X-Ray, diffraction, and physical and electrochemical characteristics.

## **COMPARISON BETWEEN FUZZY LOGIC CONTROL AND PID CONTROL FOR THE CATALYTIC CRACKING PROCESS**

**Assist . Prof. Dr. Popa Cristina**

**Assoc. Prof. Dr. Cangea Otilia**

**Assist. Prof. Dr. Bucur Gabriela**

Petroleum Gas University of Ploiești, **Romania**

### **ABSTRACT**

The goal of this work is to make an analysis of the performances of a fuzzy controller and a comparative study of fuzzy control algorithms versus a conventional control approach (Proportional Integration Derivative) in a case of the catalytic cracking process. The study is structured in four parts. The first part presents the process description and the classic control structure of the catalytic cracking process. The next two parts contain a detailed presentation of the fuzzy logic control structure for the proposed process and the development steps of the controller. In the last part of the paper, a performance analysis of the conventional PID controller and fuzzy logic controller has been done by the use of Matlab and Simulink and in the end a comparison of various time domain parameters has been performed in order to prove that the fuzzy logic controller has small overshoot and fast response as compared to the PID controller.

**Keywords:** PID control, fuzzy control, catalytic cracking

**CONSIDERATIONS REGARDING THE IMPROVEMENT OF  
MAINTENANCE OF EXPLOSION PROOF ELECTRIC MOTORS IN ORDER  
TO ENHANCE THE RELIABILITY IN EXPLOITATION**

**PhD. Eng. Mihai Magyari**

**PhD. Eng. Burian Sorin**

**PhD. Eng. Friedmann Martin**

**PhD. Eng. Lucian Moldovan**

**PhD. Eng. Stud. Dragos Fotau**

**PhD. Eng. Cosmin Colda**

National Institute for Research and Development in Mine Safety and Protection to Explosion,  
Petrosani, **Romania**

**ABSTRACT**

The purpose of the paper is to perform a thorough analysis of the types of breakdowns, both electrical and mechanical, which are likely to occur in the case of electrical drives made up of explosion proof electric motors used in hazardous locations.

Based on this analysis, several solutions are identified, in order to enhance the reliability in exploitation and the maintenance of electrical drives consisting of Ex proof electric motors commonly used in the oil and gas industry.

These solutions can be used both by explosion proof motor manufacturers and the end users of this equipment in oil and gas applications, in order to enhance the safety against explosion hazard.

**Keywords:** electric motor, explosion proof, maintenance, reliability.

**EASE THE TRANSPORT OF VISCOUS CRUDE OIL BY PIPELINE  
THROUGH PERFORMING RIGHT BLENDING RECIPES**

**Lect. Dr. Timur Chis**

**Lect. Dr. Ancaelena Eliza Sterpu**

**Prof. Dr. Claudia Irina Koncsag**

**Anca Iuliana Dumitru**

Ovidius University of Constanta, **Romania**

**ABSTRACT**

In Romanian Oil Field, heavy oil viscosity and pour point affect transportation by pipeline. In many cases, the oil is transported by car and railway with some drawbacks (high costs, special condition at discharging, etc.). This is why, for the purpose of lowering costs, it is necessary to blend viscous crudes in recipes leading to physical properties prone to transportation by pipeline,

The aim of this paper is to study the evolution of additive properties (density, sulfur content) and non-additive properties (viscosity, pour point, distillation curve) of oil mixtures with their mixing ratio.

Mixtures of two crude oils or three crude oils were considered. A new algorithm based on discrete-time neural network was worked out for finding the oil blends properties evolution.

The theoretical analysis of stability and convergence of the neural networks is also presented.

An application example is provided to illustrate the neural network-modeling approach.

We believe that modelling of crude oil blending via neural networks is a very effective method.

**Keywords:** oil heavy, blend, neural network

**EFFECT OF POLYMER CONCENTRATION ON THE  
RHEOLOGICAL PROPERTIES OF POLYELECTROLYTE  
SOLUTIONS**

**Assoc. Prof. Dr. Khaled Benyounes<sup>1,2</sup>**

**Prof. Dr. Abderrahmane Mellak<sup>1</sup>**

**Prof. Dr. Abdelbaki Benmounah<sup>2</sup>**

**Dr. Chahrazed Oubraham<sup>2</sup>**

<sup>1</sup>Laboratoire Génie Physique des Hydrocarbures, Faculté des Hydrocarbures et de la Chimie(FHC), Université M'Hamed Bougara de Boumerdès, **Algérie**

<sup>2</sup>Unité de recherche Matériaux, Procédés et Environnement (UR-MPE), Faculté des Sciences de l'Ingénieur(FSI), Université M'Hamed Bougara de Boumerdès, **Algérie**

**ABSTRACT**

The rheology of aqueous solutions of polyelectrolyte( polyanionic cellulose, PAC) at high molecular weight was investigated using a controlled stress rheometer. Several rheological measurements: viscosity measurements, creep tests at a constant low shear stress and oscillation experiments have been performed. The concentrations ranged by weight from 0.15 to 1.2% of PAC. It was found that the aqueous solutions of PAC do not exhibit a yield stress, the flow curves of PAC over a wide range of shear rate (0 to 1000 s<sup>-1</sup>) could be described by the power law and the Wiliamson models. The dynamic moduli, i.e., storage modulus ( $G'$ ) and loss modulus ( $G''$ ) of the polymer have been determined at frequency sweep from 0.01 to 10 Hz. At polymer concentration above 1%, the modulus  $G'$  is superior to  $G''$  for high frequencies. The creep-recovery experiments demonstrated that polymer solutions show important viscoelastic properties of system water-PAC when the concentration of the polymer increases.

**Keywords:** Polyanionic cellulose, viscosity, creep, oscillation

## EVALUATION OF HEAT FLOW ANOMALIES AND HYDROCARBON ACCUMULATION IN IB FIELD, MALAYSIA

**Muhammad Aslam Md Yusof**<sup>1</sup>

**Assoc. Prof. Wan Ismail Wan Yusoff**<sup>1</sup>

**Syazana Izzati Zakaria**<sup>2</sup>

<sup>1</sup> Geoscience and Petroleum Engineering Faculty, Universiti Teknologi Petronas, **Malaysia**

<sup>2</sup> Petronas Carigali Sdn. Bhd., **Malaysia**

### **ABSTRACT**

Studies of heat flow anomalies have been conducted in the hydrocarbon field to determine types of heat flow mechanisms namely conduction, radiation and convection. A heat flow anomaly can be detected if the calculated value varies in huge difference compared to the normal heat flow in that particular area. In a sedimentary basin, two major heat transmission mechanisms are conduction and convection. Conductive heat flow usually related to heat energy transferred from deeper crust and the presence of stagnant fluid while the convective heat flow often allied with the existence of subsurface fluid flow in a field. The research has been carried out to determine the relationship of heat flow anomalies with hydrocarbon accumulation. To obtain the vertical profiles of thermal conductivity, formation temperature and heat flow of that area, data from four wells in a hydrocarbon field in South China Sea, Malaysia have been used. The conductive heat is identified when the thermal conductivity line is inversely proportional to the temperature gradient while convective heat occurred when both lines are proportional to each other. The vertical profiles were compared with the structural cross section to correlate with the existence of fluid in the field. Apparently, the result showed the presence of thick oil zone in the reservoir where convective heat has been identified. The results showed that the presence of thick oil bearing zone in the reservoir where conductive heat has been identified. Besides, the conductive heat is also found in constant heat flow profiles. In conclusion, the thermal profiles obtained are really helpful in order to detect heat flow anomalies in vertical well profiles. The anomalies were also understood to be allied with the hydrocarbon accumulation in the basin.

**Keywords:** thermal conductivity, heat flow anomaly, conductive heat flow, convective heat flow, hydrocarbon accumulation

**INFLUENCE OF ENVIRONMENTAL CONDITIONS ON TEST MIXTURES  
USED FOR TESTING OF EQUIPMENT WITH TYPE OF PROTECTION  
INTRINSIC SAFETY**

**PhD. Eng. Sorin Burian**

**PhD. Eng. Jeana Ionescu**

**PhD. Eng. Emilian Ghicioi**

**PhD. Eng. Marius Darie**

**PhD. Eng. Lucian Moldovan**

**PhD. Eng. Tiberiu Csaszar**

National Institute for Research and Development in Mine Safety and Protection to Explosion,  
Petrosani, **Romania**

**ABSTRACT**

Following the dispersion ascertainment for the results obtained on proficiency testing program of an assembly of identical low current equipments, the International Electrotechnical Committee (IECEX) decided to identify the dispersion sources of the tests results.

In this paper is analyzed, using theoretical and numerical models, the variable humidity impact amplexness of the testing mixture over the resulted sensitivity of the spark test apparatus.

Thus, the paper will indirectly appreciate the impact of humidity over the spark test apparatus sensitivity by determination of humidity influence over concentration and also over the caloric properties of the testing mixture affected by humidity.

**Keywords:** humidity, spark test apparatus sensitivity

## **METHODS FOR THE SEPARATION OF CO<sub>2</sub> FROM SYNGAS IN THE UCG PROCESS**

**M.Eng. Ján Kačur, PhD.**

**M.Eng. Milan Durdán, PhD.**

Institute of Control and Informatization of Production Processes, Faculty BERG, Technical  
University of Košice, **Slovak Republic**

### **ABSTRACT**

This paper deals about overview the methods of the CO<sub>2</sub> separation and sequestration. There are described various possible methods that can be used in underground coal gasification process for best performance of underground gasifier. Separated CO<sub>2</sub> from the syngas can be returned to the process along with injected air. Added CO<sub>2</sub> supports chemical reaction where calorific CO in syngas is produced during gasification. Paper describe classical methods of CO<sub>2</sub> sequestration e.g. membrane, chemical based separation, zeolites utilization and new progressive technologies (e.g. metal organic frameworks, CO<sub>2</sub> hollow fiber membrane and polymer membranes). Paper provides description of these methods and shows to possible application in gas production industry. Authors perform some experimental gasification and provided results show the relevancy of utilization of CO<sub>2</sub> considering its percentage volume in produced syngas.

**Keywords:** UCG, experimental gasification, CO<sub>2</sub>, separation, sequestration

**MODELING OF THE TRIASSIC AND JURASSIC RIFTING IN THE  
SOUTHERN PART OF CENTRAL NORTH BULGARIA – IMPLICATIONS  
FOR THE SOURCE ROCK MATURITY**

**Assoc. Prof. Dr. Nikola Botoucharov**

Sofia University “St. Kliment Ohridski”, Department of Geology, Paleontology and Fossil Fuels, Sofia, **Bulgaria**

**ABSTRACT**

The geodynamic evolution of the study area, restored from numerous well section data, demonstrates increased tectonic and basin subsidence during Late Permian-Early Triassic, Late Triassic and Early Jurassic rifting phases as well as after Mid-Cimmerian compression. There is a distinct trend for higher burial rates and depths of sediments from central southern part of the Moesian Platform to the south towards the Balkan orogenic system. Although, the extensional processes are very important for the tectonic subsidence the Late Jurassic-Early Cretaceous deposition of very thick sedimentary complex affected the overall basin subsidence to a greater extent.

The main objective of modeling is to quantify the extension of the lithosphere for rift phases and their importance for the burial and thermal maturity of the source rocks. Modeling allowed the possibility of multiphase rifting and different extension of the crust (factor  $\delta$ ) and sub crust lithosphere (factor  $\beta$ ). Comparing the computed lithospheric deformation with the actual tectonic history of the basin allows a relatively accurate assessment of the validity and limitations of the underlying models.

The extensional phases during Late Permian-Early Triassic, Late Triassic and Early Jurassic are adopted, reflecting the complex history of the deposited sediments in the Mesozoic. Three models (A, B and C), which are close to the highest degree to the actual development of the study area, was drafted after a thorough analysis of the computer-generated curves and comparing them with the observed tectonic subsidence. Model B is the most plausible for the time of lithospheric extension during the Triassic and Jurassic. Quantitative indicators of lithospheric extension and the lack of widespread volcanism manifested probably a passive model with multiple rifts phases. The observed phases were not significant on its intensity and duration.

The measured and calculated maturity parameters (%Ro, Tmax and PI) for Triassic and Lower-Middle Jurassic sediments vary from Early mature to Postmature stages. Significant subsidence and accumulation style during Early-Middle Jurassic and Late Jurassic-Early Cretaceous evolution, as well as the development of intensively block-faulted structures seem to be the most important factors for the source rock maturity. The higher catagenetic transformation of these deposits in the study area, however, suggests that the significant hydrocarbon generation has already taken place.

Based on the analysis of the obtained results it can be concluded that the thermal maturity trends of the Triassic and Jurassic sediments are determined by the Mesozoic geodynamic evolution of the study area with several rifting and compressional events.

**Keywords:** Central North Bulgaria, Moesian Platform, Triassic and Jurassic rifting, tectonic subsidence modeling, source rock maturity.

## NEW OPPORTUNITIES OF HIGH-RESOLUTION GRAVIMETRY FOR THE STUDIES OF SUBSURFACE GEOLOGY AND PREDICTION OF OIL FIELDS

**Z. M. Slepak**

Kazan Federal University, Kazan, **Russia**

### ABSTRACT

Detailed analysis of rock density using laboratory and well logging data enabled the author to identify key features that characterize its variability in the areas of many local structures (uplifts) identified by exploration drilling. It was established that on the structural crests the rock is prone to unconsolidation that can be traced throughout the entire sedimentary cover while some layers of compacted rock can be also encountered. Such parts of the structures generally exhibit extensive secondary alteration of rock and contain the areas of ground water discharge above the basement faults.

Forward modeling established that the main change in gravity occurs due to unconsolidation of rock that is one order of magnitude greater than the effect of the density contrasts and oil pools. High-resolution gravimetric data acquired along the survey lines across the structures allows tracking local gravity lows to 1–2 mGal created by lateral unconsolidation of rock. These gravity lows are indicative of the presence of structures and are reliably tracked over the local uplifts of various morphologic and genetic styles.

With consideration for the established regularities that characterize variability of the rock density and using the output of forward modeling, the author of this paper has proposed the method of gravity modeling for identification of anomalous changes of the gravity field in the areas of predicted structures and for their geologic characterization. Involving the solution of reversed linear problem in gravity exploration directly by using Bouguer effects, the proposed method permits the construction of physical geological models of the predicted subsurface features that reflect the peculiarities of the geology of oil fields, and also permits evaluation of their certainty using the available information.

Studies of geological structure of oil fields include high-resolution gravity measurements along the survey lines across the strike of predicted subsurface structures. Anomalous changes of the gravity field created by the lateral variability of rock on the local structures are reliably tracked. [1,3]. Further, 3D density models reflecting the details of subsurface geology of the oil fields are built using the data of field gravity surveys. In contrast to gravity modeling, identification of the anomalies created by lateral heterogeneity of the density of rock in different parts of the structures using the gravity maps is challenging.

State-of-the-art software processing significantly improves the level of geologic information received by solving inverse problems and reliability of prediction of the oil pools. Additional details of the density variability in the areas of interest are observed in the course of 3D density modeling, which is very important for the future drilling projects and improved efficiency of petroleum exploration.

This paper discusses the case studies of successful appraisal of subsurface geology of the oil fields that were further confirmed by the drilling.

**Keywords:** geology, gravimetry; modeling; oil field prediction

**OPTIONS AND PROSPECTS OF UNDERGROUND STORAGE OF CARBON  
DIOXIDE IN THE SLOVAK REPUBLIC**

**Prof. MSc. Ján Pinka CSc.**

**MSc. Oľga Végsöová, PhD.**

**MSc. Petra Pinková**

**MSc. Daniela Popčáková PhD.**

Institute of Montaneous Sciences and Environmental Protection, the Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Košice, **Slovakia**

**ABSTRACT**

This paper describes an overview of particular solutions and approaches to dealing with the issue of carbon dioxide storage options in the Slovak Republic. This paper deals with the options of capture and subsequent storage of carbon dioxide in underground geological formations. The Carbon Capture and Storage (CCS) technology, which seems to be very promising in this context, is one of such technologies. Smaller or larger CCS projects are carried out in different countries around the world. This contribution emphasizes the overview of solutions and approaches to the issue of dealing with CO<sub>2</sub> and options of its storage in Slovakia. Concept of CO<sub>2</sub> storage in deep geological formations has its supporters, but also opponents. Global climate changes will likely be a very important factor that could significantly change the life conditions on the Earth.

**Keywords:** Carbon Dioxide, Carbon Capture and Storage (CCS), depleted hydrocarbon deposits, coal seams, salt deposits

**QUANTUM MATRIX AND INFORMATION CONTENT OF HYDROCARBON  
MOLECULE ARE KEY ELEMENTS OF PETROLEUM GENESIS  
COGNITION**

**Dr. Prof Rustem Seiful-Mulyukov**

Institute of Informatics Problems, **Russia**

**ABSTRACT**

The inorganic petroleum genesis process performing on sub atomic level is considering. The genesis of hydrocarbon molecules of different structure and composition depends on the interaction of valence electron orbitals of the carbon and hydrogen atoms. Atom's elementary particles are quantum objects and at the same time they are carrier of information. On that basis the notion of quantum matrix of hydrocarbon molecules is substituted. It was shown the properties and behavior of matrix determined the genesis process as self development of complex system which petroleum is and keeping into petroleum the hydrocarbon molecules of different structure and formation stage. It was proved that individual hydrocarbon molecule formation occurs on nanosecond level and time of whole variety about 500 hydrocarbon petroleum molecules formation is comparable with the time of hydrocarbon fluid migration from mantle to oil field.

**Keywords:** quantum matrix, hydrocarbon molecule developemnt, petroleum genesis, carbon atoms in petroleum, hydrogen atoms in petroleum

**SPECIFICS OF LAND COVER OF NATURAL ANTHROPOGENIC  
LANDSCAPES IN OIL PRODUCTION REGIONS**

**E.V.Smirnova,**

**I.A.Urazmetov**

Kazan (Volga-region) Federal University, Kazan, **Russia**

**ABSTRACT**

The study explores specificity of natural and anthropogenic landscape complexes in areas of oil production and describes the main properties of the landscape, based on the current ecological status of soil-plant systems. Using internal landscape-forming factors, such as soil and vegetation, the extent of the natural functioning of geosystems altered as a result of oil production was portrayed.

**Keywords:** geo-environmental condition components of the landscape, natural and man-made landscapes, soil cover, plant associations, oil pollution, the transformation properties of the environment.

**TECHNICAL AND TECHNOLOGICAL MEANS FOR VIBRATION  
COMPLETION OF PAY ZONES WHILE CONSTRUCTING WELLS**

**Boranbay T. Ratov**

**Boris V. Fedorov**

**Temirkhan A. Zhanabayev**

The Kazakh National Technical University after name of K.I. Satpayev, Almaty, **Republic of Kazakhstan**

**ABSTRACT**

Options for rational use of hydraulic and air hammering machines, applied as a drive for working body to remove filter clay cakes from the pay zones, have been reviewed. Efficiency of the technical means reviewed for well completion, has been showed.

**Keywords:** Drilling wells, well completion, hydraulic hammer, air hammer, working body, vibration.

---

**THE ECONOMIC ANALYSIS OF DEEP COAL BED METHANE  
EXPLOITATION USING PINNATE HORIZONTAL WELL IN UPPER  
SILESIAN COAL BASIN**

**MSc. Eng, Damian Janiga**

**MSc. Eng, Jacek Hendel**

AGH - University of Science and Technology, Kraków, **Poland**

**ABSTRACT**

Due to growth of natural gas price in Poland, coal bed methane (CBM) may become an important source of energy in Upper Silesian Coal Basin. However, previous attempts of CBM exploitation in that region, using vertical wells, did not give any satisfactory results. This is because the Silesian coal plays have extremely low values of permeability (~ 1 mD to 1 mD) and fracture porosity. The probability distribution of these parameters was published in many papers, reports and books. Is it possible for exploitation of CBM in Upper Silesian Coal Basin to be profitable, using pinnate horizontal wellbores without hydraulic treatments or ECBM-CO<sub>2</sub>/N<sub>2</sub> operations? The answer to this question is the objective of this paper. Solving the above-mentioned problem was achieved in two steps. Firstly, based on the literature, the values of geological and petrophysical parameters (and its distribution), characterizing researched coal seams, were determined. Next, using Monte Carlo simulation method, one hundred different numerical models were built. To calculate methane and water production for each of the scenarios, Eclipse300 simulation software was used. Second step was creating an economic model to evaluate project efficiency. The model including factors as: capital expenditures (CAPEX), fixed and variable operational expenditures (OPEX), taxes, estimated income from gas selling and, finally, water utilization cost, was developed for determining the viability of the project. Based on literature, industrial data and American experiences, probability distributions for CAPEX and OPEX were defined. Gas and water rates were imported from numerical simulations. Net present values (NPV) were calculated. Monte Carlo simulation method was used to calculate the economic indicator described above.

**Keywords:** deep coal bed methane (CBM) exploitation, pinnate horizontal well, Monte-Carlo simulation, economic efficiency

## TORQUE AND DRAG ANALYSIS FOR WELL PLANNING THROUGH THREE-DIMENSIONAL SUB-SURFACE BASIN

**Assoc. Prof. Dr. Chintana Saiwan**<sup>1</sup>

**Dr. Ruktai Prurapark**<sup>1,2</sup>

**Amornthep Klayhan**<sup>1</sup>

<sup>1</sup> The Petroleum and Petrochemical College, Chulalongkorn University, **Thailand**.

<sup>2</sup> Energy Thai Trading Hubs Company Limited, **Thailand**.

### ABSTRACT

Directional drilling reduces the number of vertical wells needed, thus reducing operation time. It is a way to economically access and produce of unconventional resources such as shale oil, shale gas, tight oil, etc. However, torque and drag (T&D) is a limiting factor in directional drilling because drilling equipment can be damaged prior to reaching a target depth due to excessive T&D. Therefore, T&D analysis is an essential in the well planning phase to insure efficient, economical, and safe planning.

An advanced technology using process and simulation of T&D during drilling has extraordinary potential to improve drilling performance and reduce unexpected risks and drilling costs. In this study, T&D analysis was performed using a soft-string model to develop program via the graphic user interface (GUI) of MATLAB. The program can run multiple scenarios of operation modes: rotating off-bottom, rotating on-bottom, pulling out of the hole, and running into the hole; and then update well planning at the site with real-time data to rapidly improve operation efficiency. Furthermore, it can be applied to almost all wellbore types, such as build, hold, drop, and horizontal. The well trajectory can be illustrated in three-dimension. Additionally, the normal contact force, axial force, buckling and torque can be presented in graphical form.

This program has the capability to evaluate an example field in Thailand with a reasonably accurate prediction of T&D values, including reduced drilling operation risks, such as bucking, stuck pipe, and wellbore instability. The program can detect torque measurement with greater accuracy which is rarely available, and also help determine a more accurate confined compressive strength (CCS) that can be used to evaluate the rock formation from the drilling parameters. This program is also user friendly. A user can predict T&D values through wellbore data and drilling parameter input. Consequently, it will help engineers identify feasible well designs and define drilling limitation for particular field developments as well as provide data for the new wells in the same field with improved efficiency and safety, while protecting health and environment.

**Keywords:** torque and drag, well planning, directional drilling, horizontal drilling, bucking