EXECUTIVE SUMMARIES
AGENDA
THE UNIVERSITY OF TULSA
Drilling Research Projects
Advisory Board Meeting

The DoubleTree Hotel at Warren Place
6110 S. Yale Avenue
Tulsa, OK 74136

AGENDA

Monday, May 12th, 2014

CLASSIC CONTINENTAL BREAKFAST .............................................................. 7:45 a.m.
The DoubleTree Hotel at Warren Place
Tulsa Learning Theater

INTRODUCTION
Stefan Miska ........................................................................................................8:00 a.m. – 8:20 a.m.

PROGRESS REPORTS

Feifei Zhang ..........................................................................................................8:20 a.m. – 8:45 a.m.
Investigation of Cuttings Transport in 30~60 Degree Inclined Wells

Babak Akbari ........................................................................................................8:45 a.m.- 9:10 a.m.
PDC Drillbit Modeling and Experiments

Mojtaba Pordel Shahri ..........................................................................................9:10 a.m.- 9:35 a.m.
Stress Path Analysis in Depleted Sands- Final Presentation

Mehran Mehrabi .................................................................................................9:35 a.m.- 10:10 a.m.
Comparison of Steel, Aluminum, Titanium, and Composite Drill Pipe- Final Presentation

Coffee Break .........................................................................................................10:10 a.m.- 10:30 a.m.

Sukru Durmaz .....................................................................................................10:30 a.m.- 10:55 a.m.
Displacement and Mixing of Fluids in Pipe Flow

Lewis Buitrago ....................................................................................................10:55 a.m.- 11:20 p.m.
Effects of Layout of PDC Cutters on PDC Core Bit Drilling Efficiency

Zahra Zamanipour .............................................................................................11:20 p.m.- 11:45 p.m.
Automation of Tripping Operations in Directional Wellbores

RESEARCH PROPOSAL
Chao Gao .............................................................................................................11:45 p.m.- 12:00 p.m.
Shale-Fluids Interaction and Sealing of Pores and Micro-Fractures
LUNCH ........................................................................................................12:00 p.m - 1:15 p.m.
Salon A&B

INDUSTRY PRESENTATION
Uday Tare - Shell International E&P Inc...................................................1:15 p.m. – 1:35 p.m.
“Understanding Asset Integrity Challenges Through Early Integration of Geomechanics”

Arild Saasen- DetNorske .........................................................................1:35 p.m. – 1:55 p.m.
“Solids Control and Waste Handling”

PROGRESS REPORTS
Reza Ettehadi Osgouei ................................................................. 1:55 p.m.- 2:20 p.m.
Review of Cuttings Transport + New Proposals

Reza Ettehadi Osgouei ................................................................. 2:20 p.m.- 2:40 p.m.
Annular Pressure Build Up (APB) Analysis-Optimization of Fluid Rheology

Silvio Baldino ................................................................................. 2:40 p.m.- 3:05 p.m.
Settling and Slip Velocity Determination in Synthetic Drilling Fluids Using Field Cuttings

Coffee Break .................................................................................. 3:05 p.m.- 3:20 p.m.

Evren Bektas .................................................................................. 3:20 p.m - 3:40 p.m.
Application of Kalman Filter to Predictions of Pore Pressure

Okan Kirgil .................................................................................... 3:40 p.m - 4:00 p.m.
Lightweight Hollow Glass Microsphere Drilling Fluid Flow Through Nozzles

Yuanhang Chen .............................................................................. 4:00 p.m - 4:25 p.m
Modeling Transient Circulating Mud Temperature in the Event of Lost Circulation and Its Application in Locating Loss Zones

Vahid Dokhani ................................................................................ 4:25 p.m - 4:50 p.m
Shale Stability at Simulated Wellbore Conditions

Budget and Closing Comments ................................................................4:50 p.m. – 5:00 p.m.

RECEPTION ..................................................................................7:00 p.m – 9:00 p.m.
The DoubleTree Hotel at Warren Place – Parkview Ballroom
6110 S. Yale Avenue
Tulsa, OK 74136
THE UNIVERSITY OF TULSA
Advisory Board Meeting

University of Tulsa
2450 E Marshall
Tulsa, OK 74110

AGENDA

Tuesday, May 13th, 2014  NORTH CAMPUS

All Visitors Assemble in Drill Building Conference Room.................................9:00 a.m.

Nicholas Takach/ Evren Ozbayoglu.................................................................9:05 a.m. - 9:20 a.m.
Tour Schedule & Facility Improvements

FACILITY TOUR of NORTH CAMPUS..............................................................9:20 a.m. – 11:20 a.m.

ROUND TABLE DISCUSSION.................................................................11:20 a.m. – 11:45 a.m.

LUNCH........................................................................................................11:45 a.m.-1:00 p.m.
Maxwell’s Restaurant at the Campbell Hotel
2636 E 11th Street, Tulsa, OK 74104 (located just south of TU's Main Campus)

INDIVIDUAL MEETINGS (upon request).......................................................1:15 p.m. – 5:00 p.m.

*******Next Advisory Board Meeting- November 17th and 18th, 2014**********
Doubletree Warren Place Hotel- Tulsa
MEMBER COMPANIES
BP Exploration 1977
Petrobras/Cenpes 1984
Statoil 1985
Halliburton Energy Services 1996
Baker-Hughes 1997
Schlumberger 1997
Weatherford 2000
ExxonMobil 2002
ConocoPhillips 2003
Shell E&P 2007
National Oilwell Varco 2007
Bureau of Safety and Environmental Enforcement (Formerly MMS) 2008
ENI 2008
Det norske oljeselskap ASA 2009
Hess 2011
SINOPEC 2011
3-M 2012
CNPC Chinese National Petroleum 2014
IMP -In Progress
TUDRP PERSONNEL
TUDRP PERSONNEL

EXECUTIVE DIRECTOR/PRINCIPAL INVESTIGATOR:
Stefan Miska

SENIOR ASSOCIATE DIRECTOR:
Nicholas Takach

ASSOCIATE DIRECTORS:
Mengjiao Yu
Evren Ozbayoglu

RESEARCH ASSOCIATE:
Reza Ettehadi Osgouei

PROJECT ASSISTANT:
Paula Udwin

PROJECT TECHNICIAN:
Randy Darden
Tim Smith

RESEARCH CONSULTANTS:
Charles Alworth
JJ Azar
Jeremy Daily
Robert Mitchell
Siamack Shirazi
Jim Sorem
Steven Tipton

RESEARCH ASSISTANTS:
Babak Akbari, Ph.D. Candidate
Evren Bektas, M.S. Candidate
Yuanhang Chen, Ph.D. Candidate
Sukru Durmaz, M.S. Candidate
Okan Kirgil, M.S. Candidate
Mojtaba Pordel Shahri, Ph.D. Candidate
Zahra Zamanipour- Special Student
Feifei Zhang, Ph.D. Candidate
Silvio Baldino, Visiting Scholar -M.S.
Lewis Buitraigo, M.S. Candidate
Vahid Dokhani, Ph.D. Candidate
Chao Gao , M.S. Candidate
Mehran Mehrabi, M.S. Candidate
Zhaorui Shi, M.S. Candidate
Hao Zeng, M.S. Candidate
Jesse Phillips- Ph.D. Student- Chemistry

Shipping Address:
University of Tulsa
Drilling Research Projects
2450 East Marshall Street
Tulsa, Oklahoma 74110
Telephone: (918) 631-5171

Mailing Address:
University of Tulsa
Drilling Research Projects
800 South Tucker Drive
Tulsa, Oklahoma 74104
FAX: (918) 631-5009
Executive Summaries

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*Stress Path Analysis in Depleted Sands*

Mehran Mehrabi- Final Presentation
*Comparison of Steel, Aluminum, Titanium and Composite Drillpipes*

Sukru Durmaz
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Lewis Buitrago
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Zahra Zamanipour
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Okan Kirgil
*Lightweight Hollow Glass Microsphere Drilling Fluid Flow Through Nozzles*

Proposal

Chao Gao
*Shale-Fluids interaction and Sealing of Pores and Micro-Fractures*
Investigation of Cuttings Transport in 30-60 Degree Inclined Wells

Feifei Zhang
Problem Statement:

- The cuttings concentration in wellbores needs to be estimated and controlled accurately during drilling process to keep high ROP and avoid drilling problems like stuck drill pipe and lost circulation.
- Cuttings in the wellbore have important effects on the bottom hole pressure. To better control bottom hole pressure, cuttings behavior in wellbore must be studied clearly.
- Before tripping out, the wellbore must be cleaned efficiently. To estimate the minimum circulation time to clean the wellbore, cuttings behavior in unsteady state needs to be investigated.

Objectives:

- Conduct a series of cuttings transport experiments with different drilling fluids to study cuttings behavior at different operational parameters.
- Develop models to predict solid flow configurations, cuttings concentration and pressure drop with changes in given drilling parameters.
- Study transient cuttings behavior, develop models for real-time cuttings and pressure monitoring in the whole well, and integrate the experimental and modeling results for practical applications.

Progress:

- Based on experimental observation, four solid-liquid flow configurations are proposed: constant bed flow, waved bed flow, packed dune flow and dispersed dune flow.
- From experimental data, a solid-liquid flow configuration map is developed. A physical approach is proposed to predict the map boundaries.
- Different mechanistic models are developed for each flow configuration to predict cuttings behavior and pressure gradient in the wellbore.
- CFD for multi-phase systems is being used to investigate the transient behavior of cuttings in fluid flow.
- Field data are used to verify the simulation results. A good match is obtained between the simulation results and the field data.
- A series of graphs are developed to quickly estimate the cuttings concentration for practical well design or drilling operations purposes.

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PDC Drillbit Modeling and Experiments

Babak Akbari
PDC Drill Bit Modeling and Experiments

Investigator: Babak Akbari

Sponsor: TUDRP

Objectives

- To conduct single PDC cutting tests while controlling the pore pressure
- To conduct single PDC cutting tests with different size of cutters and cutter chamfers
- To develop a semi-empirical model for a single PDC cutter based on theory and experimental results
- To develop a numerical FEM code for rock cutting based on poro-elasticity

Work Since Last ABM

- Designed and performed experiments on Alabama Marble samples using fractional factorial design of experiments method to investigate five factors: depth of cut, rotary speed, confining pressure, back and side rake angles
- Analyzed the experimental results for two responses: MSE and friction angle
- Mechanistic models explaining the experimental observations on the effects of: pore pressure, depth of cut, cuttings grain size distribution
- Finite element computer code developed based on linear poro-elasticity formulation and is verified with the analytical solution available for Mandel’s problem

Future Work and Deliverables

- FEM simulations based on poro-elasticity to compare with the results of the experimental pore pressure study
- A conclusive mechanistic model using the current results

Project Status

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Stress Path Analysis in Depleted Sands

SEE FINAL DISSERTATION ON CD

Mojtaba Pordel Shahri
EXECUTIVE SUMMARY
Stress Path Analysis in Depleted Sands

Investigator: Mojtaba Pordel Shahri, TUDRP

Problem Statement:
There has been an increasing consciousness regarding to the stress changes associated with reservoir depletion as the industry moves toward more challenging jobs in deep-water or depleted reservoirs. These stress changes have a significant impact on the design of wells in these situations. Therefore, accurate prediction of reservoir stress path, i.e., change in horizontal stresses with pore pressure, is of vital importance.

Objectives:
- To develop an understanding of the theory of poroelasticity and reservoir stress path in partially depleted sands
- To develop a model for predicting reservoir stress path during production/injection in partially depleted reservoirs
- To develop a computer simulator for predicting the reservoir stress path
- To verify the model using field data

Current Work:
- Effect of pore pressure depletion on the horizontal stress is investigated using Tri-axial Rock Mechanics Testing Facility. Currently used stress path formulation is examined against experimental data. Also, effect of fluid re-injection, i.e., pore pressure build up, on the horizontal stress is simulated for different pressure depletion ranges. According to the results, irrecoverable fracture pressure after pressure build-up follows a power law relationship with the pore pressure depletion range for the Berea sandstone samples. Utilizing the aforementioned experimental protocol, the specific power law coefficients can be determined for each reservoir using core samples

Deliverables:
- Mathematical model for predicting reservoir stress path
- Computer simulator for predicting reservoir stress path
- Verifying the proposed model with field data
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report
- PhD dissertation

Current Project Status:

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Comparison of Steel, Aluminum, Titanium and Composite Drill Pipe

Mehran Mehrabi
EXECUTIVE SUMMARY

Comparison of Steel, Titanium, Aluminum and Composite Drillpipe

Investigator: Mehran Mehrabi, TUDRP

Problem Statement:
The emergence of drill pipes made of materials other than steel needs a thorough study of advantages and disadvantages compared with conventional steel drill pipes. To the best of the author’s knowledge there is no published literature on comparison of four different categories of drillpipes (DP) that considers mechanical aspects in a single study. However, there are some scattered papers on comparison of a specific mechanical aspect in a special drilling scenario for two or three categories of DPs.

Objectives:
The following aspects of drillpipe mechanics are being studied.
I. Fatigue performance
II. Torque and drag loads
III. Dynamic Loading
IV. Buckling
V. Margin of overpull (MOP)

Scope of Work:
In this project the mechanical behavior of four different groups of drillpipes steel drillpipe (SDP), aluminum drillpipe (ADP), titanium drillpipe (TDP) and composite drillpipe (CDP) are being studied and compared. Specifically, the comparisons include:
I. Fatigue performance in build-up and drop-off sections both under tension and compression in a constant curvature dogleg
II. Torque and drag loads based on Soft String Model
III. Dynamic loading comparison in a vertical well trajectory
IV. Buckling behavior in vertical and horizontal section of a two-dimensional well
V. Margin of overpull (MOP)

Recent Progress:
In this progress report we mainly have focused on the comparison of axial force transfer of SDP, ADP, TDP and CDP in horizontal section of a two-dimensional well. The margin of overpull (MOP) for different drillstrings along an S-shape well trajectory is compared.

Deliverables:
I. A computer program for investigating and comparing:
   a. Fatigue performance
   b. Torque and Drag, and dynamic load
   c. Buckling and axial force transfer
II. Drillstring design guidelines (including MOP)
III. Semi-annual Advisory Board Meeting (ABM) and the Final Report
IV. Master Thesis

Proposed Time Table:

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Displacement and Mixing of Fluids in Pipe Flow

Sukru Durmaz
EXECUTIVE SUMMARY
Displacement and Mixing of Fluids in Pipe Flow

Investigator: Sukru Durmaz

Introduction:
There are various applications related to displacement of fluids in the petroleum industry, for example, displacement of spots, sweeps, spacers, and cement slurries. Contamination can cause significant changes in both displacing and displaced fluid properties during displacement processes and these changes can lead to serious problems in many applications. The primary objective of this project is to analyze the influence of various parameters (i.e., density and viscosity of fluids, pipe inclination, and flow rate) on the mixing of fluids during displacement processes in pipe flow.

Objectives:
- To develop better understanding of mixing of fluids flowing inside circular pipes.
- To develop a model for describing fluid displacement in circular pipes.
- To obtain high quality experimental data using different fluids at different inclination angles during the displacement process.
- To analyze the data and determine the proper fluid properties and flow parameters for efficient displacement.

Recent Progress:
- Viscosity tests have been conducted at different flow rates with fluids that have similar densities but different rheological properties. Pressure drop data and images captured during the tests have been used to analyze the displacement processes. Displacement efficiency (volume displaced at time $t$ over volume of the flow field) is calculated at different times with the imaging software, “imageJ.”
- A computer program was developed based on a model proposed by Beirute, and was run for different cases to see the effect of density and viscosity of the fluids, and flow rate on displacement processes.
- Results gathered from the image analysis were compared with the results from the computer program. It is concluded that predictions of the computer program are in agreement with the results from the image analysis for PL fluids. In particular, for displacing more viscous fluid with a less viscous fluid. However, if water is used, the predictions of the program becomes unreliable. This might be a result of the turbulent flow observed when using water.

Future Work:
- Acquisition of experimental data using different fluids in different inclination angles and flow rates during the displacement process.
- Development of a model describing YPL fluid displacement in circular pipes.
- Comparison of experimental data with results obtained from the model.

Deliverables:
- Experimental data, including pressure drop and contaminated volumes.
- Digital images during displacement tests using various fluids at different inclination angles and flow rates
- A model describing the displacement process
- Case scenarios using the model developed for displacement and mixing of fluid in pipe flow
- Semi-annual ABM Progress Reports and a Final Report

Timeline:

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Effects of Layout of PDC Cutters on PDC Core Bit Drilling Efficiency

Lewis Buitrago
**EXECUTIVE SUMMARY**

**Effects of Layout of PDC Cutters on Core Bit Drilling Efficiency**

**Investigator:** Lewis Buitrago, TUDRP.

**Objectives:**
- Find cutter layouts that lead to high drilling efficiency and high bit stability for a given formation under a given set of operational parameters.
- Verify the concept of depth of cut control (DOCC) used widely in the industry for different layouts of DOCC elements.
- Propose improvements to available mechanistic models to better describe the physical phenomenon observed in experiment results.

**Work since last ABM:**
- Completed the inspection, diagnostics, replacement, refurbishment and maintenance of equipment that comprise the operating systems: pull down, rotary and circulating systems. Included are mechanical, hydraulic and electrical operational testing;
- Upgraded the data acquisition (DAQ) system to a PC-based data logger and integrated several measuring devices around the facility to the DAQ;
- Reactivated the TUDRP full-scale test rig facility and completed a successful drill test;
- Performed analysis of a full PDC core bit model and prediction of drilling response based on single PDC cutter assumptions.

**Future work and Deliverables:**
- Facility commissioning;
- Data collection from experiments on different layouts of PDC cutters and DOCC elements with the goal of achieving high drilling efficiency and bit stability;
- Mechanistic model improvements, taking into account interactions between process variables and model parameters.

**Preliminary Timeline:**

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Automation of Tripping Operations in Directional Wellbores

Zahra Zamanipour
Investigator: Zahra Zamanipour

Problem Statement:
- Considering the automation of tripping operations, the first step is to optimize the operations. In order to optimize the system for tripping operations, there are constraints that must be satisfied.
- The total force should not exceed the yield strength of the drillstring to avoid damage to the drillpipe.
- The bottom-hole pressure should be within the range of allowed pressure. It should not exceed the fracture pressure and should be less than the formation pressure.
- Dynamic axial load and transient pressures should be determined to optimize the tripping operations.

Objectives:
- Modeling drillstring dynamics in a directional wellbore during tripping operations
- Modeling surge and swab pressures using a tripping velocity
- Optimization of the tripping velocity to obtain minimum tripping time
- Automation of drawworks using optimized tripping velocity

Progress:
- The dynamic load of the drillpipe in tripping-out and tripping-in operations in different wellbore trajectories has been modeled.
- An elastic model has been applied for the surface load calculations for tripping-in in a vertical wellbore. An improved dynamic soft string model is developed to calculate the dynamic forces in tripping operations in different 2D wellbores.
- Improved dynamic model shows ~10-43% increase (depending on the wellbore trajectory) in maximum surface load compare with conventional soft string model.
- In a vertical wellbore, according to the elastic string model, the maximum surface load at some points is larger than the yield strength of the drillstring with grade E. The maximum surface load in all cases in 2D wellbores is considerably less than yield strength of the drillpipe with grade S-135.
- Load calculations have been performed for a whole tripping-out operation.

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Shale – Fluids Interaction and Sealing of Pores and Micro-Fractures
RESEARCH PROPOSAL

Chao Gao
EXECUTIVE SUMMARY
Shale Fluid Interaction and Sealing of Pores and Micro-fractures

Investigator: Chao Gao

Introduction:
Shales make up over 75% of drilled formations. However, they cause over 90% of wellbore instability problems. Wellbore instability in shale occurs due to the following reasons: (1) interaction of clay minerals with an aqueous fluid; (2) micro-fractures that accelerate the failure mechanism. One way to solve wellbore instability problems is through the addition of chemical agents to the drilling fluids. The agents should be capable of sealing pores and micro-fractures in the shale.

Objectives:
- Design experiments to study the shale-fluid interaction after application of different sealing agents.
- Build a model to characterize the strength of shales before and after application of the sealing agents.
- Conduct Tri-axial experiments to study the failure of some of the shales and use these experiments to examine the validity of the model.

Approach:
Drilling fluid, with added sealing agents, will be in contact with shale samples. Some of the shale samples will have micro-fractures. After the shale-fluid interaction, some samples will subject to tri-axial tests to determine their strengths. A mathematical model will also be developed to characterize the strength of shales, both before and after application of the sealing agents. A tentative test matrix can be found in the proposal.

Deliverables:
An experimental method to evaluate the effect of different sealing agents.
A mathematical model to characterize the mechanical failure of shales after applying sealing agents.
A computer program to solve the mathematical model.
Semi-annual ABM Progress Reports and a Final Report.

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Review of Cuttings Transport

Reza Ettehadi Osgouei
EXECUTIVE SUMMARY

Cuttings Transport Review

Investigators: Reza Ettehadi Osgouei, The University of Tulsa, Drilling Research Projects

Introduction:
Numerous experimental and theoretical studies dating back more than seven decades have been conducted by researchers to better understand the factors influencing cuttings removal from the wellbore. Consequently, empirical and semi-empirical correlations, and analytical models, have been developed based on experimental observations to characterize the carrying capacity of drilling fluids. In addition, many guidelines have been developed to improve hydraulic programs and to tackle challenges encountered during drilling operations. Although a growing number of research studies on cuttings transport have led to publication of some review articles during the past decades, a comprehensive and systematic review has not been reported. The Final Report, which is in development, is an evaluative review of 52 completed research projects at TUDRP and studies found in the literature related to the carrying capacity of drilling fluids in the wellbore. The present report is a summary of the Final Report.

Objectives:
The basic purposes of this study are to:
- Highlight flaws in previous research
- Outline gaps and weaknesses in previous research
- Address conflicts in the research
- Prevent duplication of effort
- Point the way forward for further research

Scope of Work:
The overall scope of this study is to evaluate completed research projects in TUDRP and technical papers related to the carrying capacity of drilling fluids. The focus of the present report will be on what is so far understood about the mechanisms controlling cuttings transport in wellbore, and how this knowledge can be applied to solving the prevailing drilling problems in the field.

Summary and Conclusions:
- Extensive literature review has been done.
- A summary of experimental parameters has been prepared. It consists of experimental data extracted from 52 completed research projects at TUDRP.
- A technical report has been prepared. The present report describes, summarizes, evaluates and clarifies completed research projects at TUDRP and studies found in the literature related to the carrying capacity of drilling fluids in the wellbore.

Deliverables:
- Summary of extracted experimental data
- Final ABM Progress Report and a Final Report

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Annular Pressure Build Up (APB) Analysis-Optimization of Fluid Rheology

Reza Ettehadi Osgouei
EXECUTIVE SUMMARY

Annular Pressure Build Up (APB) Analysis- Optimization of Fluid Rheology

Investigators: Reza Ettehadi Osgouei, The University of Tulsa, Drilling Research Projects

Introduction:
To reach insulation performance, either annular fluid natural convection or annular fluid static thermal conductivity should be reduced. In order to reduce the free convection, it is necessary to prevent the initiation of convective flow initiation using a high yield-stress fluid or using a fluid with very high viscosities at low shear rates. Since drilling fluids are unstable suspensions, the solid particles will, with time, settle to the bottom of the annular space between the casing strings. Consequently, the rheological and thermal properties of trapped drilling fluids between the casing strings change gradually with time and depth due to the sedimentation process. In this study, the combination of sedimentation theory and a free convective flow model are used to analyze the reliability of insulating performance by considering the effect of time on rheological and thermal properties of trapped drilling fluid.

Objectives:
- To model the convective heat transfer of Yield Power Law fluids and to predict long-term behavior of annular fluids
- To design an experimental set up and obtain experimental data using different fluids
- To design guidelines for selection of proper annular fluids for deep-water oil and gas wells to minimize the rate of heat transfer from the flowing production fluid

Scope of Work:
The proposed project consists of both modeling and experimental work to understand convective heat transfer along the annular space. This work is being done in two stages:
- To develop a mathematical model for estimating the optimum properties of Yield Power Law fluids across vertical parallel plates by solving governing equations and considering boundary conditions.
- To conduct an experimental study in a small-scale flow loop for simulating real wellbore conditions using non-Newtonian, water-based and oil-based fluids

Summary and Conclusions
- An extensive literature review has been done.
- Experiments were performed in a climate-controlled room with a synthetic based drilling fluid (SBM) donated by Baker Hughes.
- Guidelines to analyze the effect of time on insulating performance of annular fluids is proposed based on the theory of sedimentation and free convective flow in Newtonian and YPL fluids
- A computer code to define and enact the guidelines has been developed.
- The proposed guidelines can analyze the insulating performance of annular fluid quantitatively by considering the effect of time.

Deliverables:
- Experimental data, including temperature distribution, during APB (annular pressure buildup) tests with various fluids
- Mathematical model describing the convective heat transfer of Yield Power Law fluids
- Semi-Annual ABM Progress Reports and a Final Report
- A computer program for the guidelines, as described above

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Settling and Slip Velocity Determination in Synthetic Drilling Fluids Using Field Cuttings

Silvio Baldino
EXECUTIVE SUMMARY

Settling and Slip Velocity Determination in Synthetic Drilling Fluid, using Field Cuttings

Investigator: Silvio Baldino, TUDRP

Introduction:

The trend toward deeper and more complicated drilling, such as deviated wells, together with the increase in power requirements for circulating drilling fluids, has emphasized the need for a more detailed, precise and critical examination of the settling velocity process. Two of the main reasons for obtaining improved estimation of cuttings settling velocity are 1. development of cuttings concentration profiles along the wellbore, 2. improved characterization of the formation lithology.

Objectives:

- Conduct an experimental study on cuttings settling and slip velocities in synthetic drilling fluid, using actual field cuttings
- Compare the experimental results with available published correlations.
- Develop new correlations for cuttings settling and slip velocity predictions in a synthetic drilling fluid, using actual field cuttings under different conditions.
- Verify the accuracy of the developed correlations using experimental data.

Scope of Work:

The proposed project includes experimental work to understand the settling process of field cuttings in synthetic drilling fluid and to develop correlations for cuttings settling and slip velocity prediction. The experiments will be run both in static and dynamic conditions, at ambient temperature and elevated temperature, for vertical and inclined sections of wellbore. This work will be done in four stages: 1. Conduct a series of experiments, 2. Propose a modified version of the best available semi-empirical correlation that relates the drag coefficient to the Particle Reynolds number, based on the collection of experimental data; 3. Verify/modify the developed correlation by using the results of the experiments; 4. Develop a complete model to predict cuttings settling and slip velocities.

Deliverables:

- Experimental data for cuttings’ settling and slip velocities in both static and dynamic conditions.
- Correlations for both cuttings’ settling and slip velocity prediction.
- Semi-annual Advisory Board Meeting Progress Reports.
- Final Report.

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Application of Kalman Filter to Predictions of Pore Pressure

Evren Bektas
Application of Kalman Filter to Predictions of Pore Pressure

INVESTIGATOR: Evren Bektas

STATEMENT OF THE PROBLEM:
Determination of overpressure zones required for safe drilling has become a major issue. Proper formation pore pressure prediction plays a key role to avoid drilling risks and provide cost-effective drilling of wells. Accurate estimation of formation pore pressure also helps to determine casing points and to select sufficient mud weight for depth of interest. Even though there are some methods that rely on resistivity, seismic prediction, effective stress, etc, to predict pore pressure, there are still uncertainties in the estimation of formation pore pressure. In order to increase accuracy, there is room for proposing alternative methods for this purpose.

OBJECTIVES:
- To obtain Well log data
- To predict formation pore pressure ahead of a bit by using the Kalman Filter
- To apply the Kalman Filter and modify the methodology, if necessary, in order to increase accuracy
- Using field data, compare results obtained using the Kalman filter and other well-known prediction methods

SCOPE OF WORK AND APPROACH
- The main objective of this research is to develop a mathematical model and obtain more accurate results for formation pore pressure prediction.
- A literature review will be conducted on existing formation pore pressure prediction methods.
- The approach for this research will be as follows: i) literature review; ii) theoretical work; iii) model development and verification.
- Existing methods of pore pressure prediction will be compared using field data.
- In the model verification, the Kalman filter will be utilized with the goal of attaining more accurate results than the results estimated from well logs.

PRESENT WORK
- Study on Pore Pressure Prediction Methods
- Application of Kalman Filter to field data

DELIVERABLES:
- A reliable mathematical model for predicting formation pore pressure
- Semi-annual Advisory Board Meeting Reports
- Final Report
Lightweight Hollow Glass Microsphere Drilling Flow Through Nozzles

Okan Kirgil
EXECUTIVE SUMMARY
Investigation of HGM- Drilling Fluid Flow through Bit Nozzles

Investigator: Okan Kirgil

Introduction:
HGMs (Hollow Glass Microspheres) consist of soda lime borosilicate glass bubbles and are low-density particles mostly used in different areas of the oil and gas industry. The previous study on HGMs at TUDRP identified rheological properties and pipe flow characteristics of different samples of HGM-containing drilling fluids (HGMFs). Although HGMs have been used in various operations in oil and gas industry, there is a lack of understanding of their behavior during fluid flow through nozzles, particularly the jet impact force to which the fluids are exposed in nozzles. Underbalanced drilling using HGM-containing fluids (HGMF) is one of their most potential applications. Therefore, understanding of the behavior of HGMF flow through bit nozzles should be pursued.

Objectives:
- To develop a better understanding of the flow of HGMF through nozzles and specifically to analyze the influences of various parameters (e.g., collapse pressure of HGM, nozzle sizes, standoff distance and base fluid properties)
- To obtain experimental data under conditions that simulates actual field operations.

Recent Progress:
- Modifications to the Jet Operator modifications have been completed. The Jet Operator provides velocities higher than the maximum nozzle velocities observed in the field.
- Experiments using the Jet Operator were conducted to obtain qualitative data at 1-in. and 2-in. standoff distances at 40 and 60 psi compressor pressures. Volumetric concentrations of fluids containing HGS5000 and HGS8000 were prepared in the range of 3-15% in 3% increments. HGS5000 and HGS8000 are manufacturer code names for HGM with 5000 psi and 8000 psi collapse pressure ratings, respectively.

Future Work:
- Construct a new experimental setup and conduct tests that are more realistic and comparable to field conditions.
- Experiments to investigate the effects of different parameters, such as HGM volumetric concentration, standoff distances, HGM type, temperature, and nozzle velocity on the survival ratio of the HGM and hydraulic behavior of HGMF.
- Convert results obtained in lab conditions to the corresponding field conditions.
- Apply an impact law to HGM types to evaluate experimental results from the new flow setup.

Deliverables:
- Experimental data from the HGM Nozzle Tester, including survival ratio and hydraulic behavior under various conditions.
- A model estimating the survival ratio of HGM and hydraulic behavior of HGMF flow during the jetting process.
- Semi-annual Advisory Board Meeting Reports.
- A Final Report.

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