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

INTRODUCTION
Stefan Miska ........................................................................................................8:15 a.m. – 8:35 a.m.

PROGRESS REPORTS

Feifei Zhang ........................................................................................................8:35 a.m. – 9:05 a.m.
*Investigation of Cuttings Transport in 30~60 Degree Inclined Wells*

Babak Akbari ........................................................................................................9:05 a.m. – 9:30 a.m.
*PDC Drillbit Modeling and Experiments*

Mojtaba Pordel Shahri ..........................................................................................9:30 a.m. – 10:05 a.m.
*Stress Path Analysis in Depleted Sands*

Bahri Kutlu ..........................................................................................................10:05 a.m. – 10:30 a.m.
*Rheology of Lightweight Drilling Fluids with Microsphere Additives*

Coffee Break ........................................................................................................10:30 a.m. – 10:45 a.m.

Mehran Mehrabi ....................................................................................................10:45 a.m. – 11:10 a.m.
*Comparison of Steel, Aluminum, Titanium, and Composite Drill Pipe*

Sukru Durmaz ......................................................................................................11:10 a.m. – 11:35 p.m.
*Displacement and Mixing of Fluids in Pipe Flow*

Hao Zeng .............................................................................................................11:35 p.m. – 12:00 p.m.
*Study of Effectiveness of LCM Materials*

LUNCH ..................................................................................................................12:00 p.m. – 1:15 p.m.
Parkview Ballroom
INDUSTRY PRESENTATION

Shilin Chen- Halliburton DBS .......................................................... 1:15 p.m. – 1:35 p.m.
The Importance of Cutter Layout in the Design of PDC Bit

Arild Saasen- DetNorske .................................................................. 1:35 p.m. – 1:55 p.m.
Plug and Abandonment of Offshore Exploration Wells

PROGRESS REPORTS

Reza Ettehadi Osgouei ............................................................... 1:55 p.m.- 2:20 p.m.
Review of Cuttings Transport

Reza Ettehadi Osgouei ............................................................... 2:20 p.m.- 2:45 p.m.
Annular Pressure Build Up (APB) Analysis-Optimization of Fluid Rheology

Silvio Baldino ........................................................................... 2:45 p.m.-3:05 p.m.
Settling and Slip Velocity in Synthetic Drilling Fluids Using Field Cuttings

Coffee Break ........................................................................... 3:05 p.m.- 3:25 p.m.

RESEARCH PROPOSALS

Lewis Buitrago ........................................................................... 3:25 p.m - 3:40 p.m.
Effects of Layout of PDC Cutters on Core Bit Drilling Efficiency

Evren Bektas .............................................................................. 3:40 p.m - 3:55 p.m.
Application of Kalman Filter to Predictions of Pore Pressure

Zahra Zamanipour ..................................................................... 3:55 p.m - 4:10 p.m.
Automation of Tripping Operations in Directional Wellbore

Ibrahim Tizlak ........................................................................... 4:10 p.m - 4:25 p.m.
Investigation of HGS-Fluid Flow Through Bit Nozzles

RESEARCH UPDATE- Mengjiao Yu ........................................... 4:25 p.m. – 4:50 p.m.

Shale Stability at Simulated Wellbore Conditions- Vahid Dokhani

Downhole Microchip Instrumentation System- Yuanhang Chen

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
AGENDA

Tuesday, November 5\textsuperscript{th}, 2013  NORTH CAMPUS

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

Nicholas Takach/ Reza Ettehadi Osgouei………………………………………………9:05 a.m. - 9:20 a.m.
  \textit{Tour Schedule & Facility Improvements}

FACILITY TOUR of NORTH CAMPUS……………………………………………………………………9:20 a.m. – 11:00 a.m.

ROUND TABLE DISCUSSION…………………………………………………11:00 a.m. – 11:30 a.m.

LUNCH……………………………………………………………………………………………………11:45 p.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- May 12\textsuperscript{th} and 13\textsuperscript{th}, 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
IMP - In Progress
CNPC Chinese National Petroleum - 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  
Siamack Shirazi  
Jim Sorem  
Steven Tipton  
Michael Keller

**RESEARCH ASSISTANTS:**
Babak Akbari, Ph.D. Candidate  
Ziad Alabdullatif, Ph.D. Student  
Silvio Baldino, Visiting Scholar -M.S.  
Evren Bektas, M.S. Candidate  
Lewis Buitraigo, M.S. Candidate  
Yuanhang Chen, Ph.D. Candidate  
Vahid Dokhani, Ph.D. Candidate  
Sukru Durmaz, M.S. Candidate  
Bahri Kutlu , M.S. Candidate  
Mehran Mehrabi, M.S. Candidate  
Mojtaba Pordel Shahri, Ph.D. Candidate  
Zhaorui Shi, M.S. Candidate  
Ibrahim Tizlak , M.S. Candidate  
Zahra Zamanipour- Special Student  
Hao Zeng, M.S. Candidate  
Feifei Zhang, Ph.D. Candidate

**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

Feifei Zhang
Investigation of Cuttings Transport in 30°-60 Degree Inclined Wells

Babak Akbari
PDC Drillbit Modeling and Experiments

Mojtaba Pordel Shahri
Stress Path Analysis in Depleted Sands

Bahri Kutlu
Rheology of Lightweight Drilling Fluids with Microsphere Additives

Mehran Mehrabi
Comparison of Steel, Aluminum, Titanium and Composite Drillpipe

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Ibrahim Tizlak
Investigation HGS-Fluid Flow Through Bit Nozzles

Ziad Alabdullatif
The Effects of Nano-Particles on Foam Stability and Rheological Properties
Investigation of Cuttings Transport in 30-60 Degree Inclined Wells

Feifei Zhang
Investigation of Cuttings Transport in 30~60 Degree Inclined Wells

Investigator: Feifei Zhang, TUDRP

Problem Statement:

- The solids concentration in a wellbore need to be estimated and controlled accurately during drilling to keep high ROP and avoid drilling problems like stuck drill pipe, lost circulation, and others.
- Cuttings in the wellbore may have important effects on the bottom hole pressure. To better control bottom hole pressure, cuttings behavior in wellbore must be understood as well as possible.
- Before tripping out, the wellbore must be cleaned efficiently. To estimate the minimum circulation time to clean the wellbore, cuttings behavior in unsteady state need to be investigated.

Objectives:

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

Steady Cuttings Behavior:

Based on experimental observation, four solid-liquid flow patterns are proposed: constant bed flow, waved bed flow, packed dune flow and dispersed dune flow. From experimental data, a solid-liquid, two-phase flow pattern map is developed. Different mechanistic models are developed for each flow pattern to predict cuttings behavior and pressure gradient in the wellbore.

Applications:

- Circulation before tripping may include three situations: 1. the flushing flow rate is larger than the drilling flow rate; 2. the flushing flow rate equals the drilling flow rate; 3. the flushing flow rate is smaller than the drilling flow rate.
- The transitions between different flow patterns are caused by cuttings sliding backward and turbulent entrainment of the packed bed or dunes.
- Temperature has a significant effect on cuttings behavior. A large part of this is caused by the effect of temperature on fluid rheology.

Project Status:

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PDC Drillbit Modeling and Experiments

Babak Akbari
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

- Experimental results and analysis for two cutter sizes of 13 and 16 mm on Carthage Marble rock samples at 450 psi confining pressure
- Experimental results and analysis for 0.010” and 0.016” cutter chamfer sizes on Carthage Marble rock samples at 450 psi confining pressure
- Experimental results and analysis of the effect of the pore pressure on Torrey Buff rock samples ranging from atmospheric to 500 psi
- Experimental cuttings particle size distribution and its correlation with the MSE

Future Work and Deliverables

- FEM simulations based on poro-elasticity to compare with the results of the experimental pore pressure study
- Experimental tests to develop a comprehensive semi-empirical single PDC cutter model

Project Status

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Stress Path Analysis in Depleted Sands

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 Works:
- 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, the permanent horizontal stress reduction after a complete depletion/injection cycle changes linearly with the pressure depletion range.
- A fast running, semi-analytical workflow is proposed to accurately predict fracture width distribution and fracture re-initiation pressure (FRIP). The algorithm and workflow can account for near wellbore stress perturbations, far field stress anisotropy, and wellbore inclination/deviation providing a pseudo 3D solution. The semi-analytical algorithm is based on singular integral formulation of stress field and solved using Gauss-Chebyshev polynomials. Proposed model is verified using the numerical methods’ results. The proposed semi-analytical model is accurate and computationally efficient. The model also provides a comprehensive perspective on the formation strengthening scenarios; a tool for improved LCM design and how they are applicable during drilling operation (in particular through depleted zones).

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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Rheology of Lightweight Drilling Fluids with Microsphere Additives

Bahri Kutlu
Introduction

During conventional drilling of a vertical well, the major parameters controlling the circulating bottomhole pressure are density and flowrate. Since flowrate is mostly selected based on hole cleaning needs, fluid density management is the most practical method to avoid problems while drilling subnormal-pressured and depleted zones. To be able to drill these mentioned formations, use of a lightweight drilling fluid is necessary. The primary objective of using lightweight drilling fluids is to reduce wellbore pressure in order to prevent potential downhole losses, formation damage or fracture of the formation. This project aims to reduce circulating bottomhole pressure through the addition of lightweight solid additives (hollow glass microspheres \{HGS\}) to conventional drilling fluids and to study the HPHT rheological properties and flow characteristics of this alternative type of incompressible, lightweight drilling fluid.

Objectives

The goal of this project is to conduct a study to examine incompressible drilling fluids with specific gravities less than that water without using air or any other gas phase. The aim is to offer an alternative to existing lightweight drilling fluids to decrease circulating BHP and HGS were added to conventional fluids for this purpose. The rheological properties and flow characteristics of the HGSF (Hollow glass sphere-containing fluids) were evaluated at HPHT and dynamic conditions.

Scope of Work

Rheological experiments were conducted under HPHT conditions using a Fann75 viscometer. Fluids containing HGS were exposed to as high as 18000 psi and 200 F to characterize their rheological properties and to determine the microsphere survival ratio. In addition, flow experiments containing HGSF were conducted under a wide range of shear rates that covered both laminar and turbulent regimes. Rheological characterization and hydraulic drag reduction analysis were conducted using data collected from three different base fluids for comparison to HGSF.

Summary

- A base drilling fluid was weighted to 9.6 ppg with NaCl and viscosified with PAC and XCD. HGS with 0.46 SG were added to reduce the density of the fluid to 7.84 ppg at 30% volumetric concentration (Chapter 6.1.1).
- High pressure experiments were conducted at 17,000 psi using a Fann75 HPHT viscometer. On average, 90.8% of the HGS survived the experiments. (Chapter 6.1.1).
- Flowloop experiments with HGSF showed similar changes in rheological behavior compared to the base fluids tested in this project. The rheology of the drilling fluid after introducing microspheres can be estimated using the modified Einstein Viscosity Model. Chapter (6.2.2.1 and 6.2.2.2).
- Drag reduction analysis based on data collected from the flowloop shows that drag reduction is possible at up to 9% HGS volumetric concentration, with a peak around 6% (Chapter 6.2.2.3).
- Centrifugal pump experiments were conducted to determine if microspheres break due to high impact with pump impellers and high shear rate. Microspheres survived at a high level under the tested conditions (Chapter 6.4).
- Low and high pH experiments were conducted to observe whether the microspheres stay intact at different levels of pH. No change in density of the HGSF is observed, which indicates that microspheres stay intact at the tested pH levels. (Chapter 6.5).
- Hydraulic calculations that combined the findings from the experiments indicate a decrease in circulating bottomhole pressure and ECD as the concentration of microspheres in the fluids increases. Calculations also account for changes in temperature profile and pressure along the wellbore and their effect on the rheology of the HGSF (Chapter 6.3).

Deliverables

M.S. thesis will be submitted in December 2013.
Comparison of Steel, Aluminum, Titanium and Composite Drill Pipe

Mehran Mehrabi
EXECUTIVE SUMMARY
Comparison of Steel, Aluminum, Titanium 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 will 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, horizontal and inclined sections of a well
V. Margin of overpull (MOP)

Recent Progress:
In this progress report we mainly have focused on the comparison of torque and drag loads resulting from SDP, ADP, TDP and CDP in horizontal and s-shape trajectories, as well as the dynamic load introduced along a drillstring in a vertical trajectory by using the aforementioned types of drillpipes.

Deliverables:
I. A computer program for investigating and comparing:
   a. Fatigue performance
   b. Torque and Drag, and dynamic load
   c. Buckling
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 various serious problems in many applications. The primary objective of this project is to analyze the mixing of fluids in displacement processes and to observe 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:
- Construction changes on the experimental setup: test section has been elevated from its original position to get higher quality shots with the camera.
- Water tests with various flow rates and inclination angles have been conducted. Pressure losses gathered from different sections of the experimental facility are compared with predicted pressure losses. Results showed that the entrance or exit lengths do not affect flow in the test section.
- Preliminary tests have been conducted at different flow rates with fluids that have similar densities but different rheological properties. Since the densities of fluids used in these tests are similar, the densitometer could not be used to locate the mixing. Thus, only pressure drop data has been used to locate the mixing volume. Analysis of images captured with a video camera has not been completed yet. However, from the images, it can be seen that when a more viscous fluid displaces a less viscous fluid, viscous fingering takes place.
- A computer program has been developed based on a model proposed by Beirute, and it has been run for different cases to see the effect of density ratio (density of displacing fluid/density of displaced fluid) and viscosity ratio (viscosity of displacing fluid/viscosity of displaced fluid).
- Development of the model for describing YPL fluid displacement in pipe flow is in progress.

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 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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Study of Effectiveness of LCM Materials

Hao Zeng
Study of Effectiveness of LCM Materials

Investigator: Hao Zeng, TUDRP

Introduction: Lost circulation is one of the most common well control problems encountered in drilling, cementing and completion operations. It will not only waste time and drilling fluid, it can also damage formations, lead to wellbore collapse, stuck drill pipes and can even cause blowouts and well abandonment. Large amounts of time and money are spent to control lost circulation. The use of lost circulation materials (LCM) is the most common method to treat lost circulation. However, the use of LCM is poorly understood and has achieved no significant breakthroughs in the past 40 years. As a result, maximizing the effectiveness of LCM is important to minimizing the costs associated with lost circulation.

Objectives:

- Provide more thorough understanding of existing LCM selection theories and rheological issues that occur in fractured wellbores.
- To observe LCM behavior in uniform-sized fractures under different pressures.
- To determine the effectiveness of different LCM materials.
- To simulate the LCM behavior and fluid loss after LCM bridge formation.
- To develop an optimized LCM selection model.

Work Done:

- Evaluated existing fracture size and pressure models, hydraulic ECD models and LCM selection models.
- Developed a model to evaluate LCM effectiveness, based on fluid loss after the LCM bridge.
- Modified the Parallel Plates Radial Flow Facility in TUDRP.
- Designed and ran a series of tests with the Parallel Plates Radial Flow Facility.
- Analyzed the experimental data; verified existing methods and theories based on the experimental data; compared test data with simulation data.
- Developed a computer simulation program to evaluate LCM effectiveness.
- Applied field data to the simulator to simulate fluid loss and pressure profiles after the LCM bridge.

Deliverables:

- Advanced LCM effectiveness testing facility.
- Experimental observation and analysis of LCM bridging behavior.
- Drilling fluid loss model under radial flow conditions after an LCM bridge.
- Computer program that can simulate fluid loss into fractures and provide a pressure profile at given points in the fracture.
- Optimized LCM selection model.
- Semi-Annual Advisory Board Meeting (ABM) reports and the Final Report.
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 in order 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 the 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. This portion of the review is concerned with the inclined and horizontal sections of a wellbore.

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 cuttings transport. 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.
- Summary of experimental parameters was prepared. It consists of experimental data extracted from 34 completed research projects at TUDRP.
- A technical report has been prepared. The present report is an evaluative review of completed research projects at TUDRP and studies found in the literature related to cuttings transport in the inclined and horizontal sections of a wellbore. It describes, summarizes, evaluates and clarifies the literature.

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

Tentative Time Table:
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 improve insulation in the annular space of a wellbore, either the 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 initiation of convective flow by using a high yield-stress fluid or a fluid with very high viscosities at low shear rates. There are some experimental studies regarding the performance of non-convective packers in large-scale heating cells. The objective of such studies is mainly to determine whether or not the fluid provides the expectation of a non-convective. To the best of our knowledge, there is little work related to the modeling and characterization of convective heat transfer in non-Newtonian annular fluids.

Objectives:

- To develop a better insight of convective heat transfer in the annulus of casing
- To model the convective heat transfer of Yield Power Law fluids across vertical parallel plates and to predict the long-term behavior of annular fluids
- To design an experimental set up that allows us to obtain high quality experimental data using different fluids
- To design a guideline 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 includes both modeling and experimental work to understand convective heat transfer along the annular space. This work can be done in two stages:

- By developing 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.
- Conducting 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.
- Preliminary experiments were performed in a climate-controlled room with tap water and two non-Newtonian fluids.
- An analytical model was formulated for steady state free convection between two parallel plates.
- A guideline to design YPL annular fluids was proposed, based on the analytical model.
- A computer code to formulate the guideline was developed.
- The proposed guideline can quantitatively analyze the insulating performance of annular fluids.

Deliverables:

- Experimental data, including pressure drop and 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
- Computer program

Tentative Time Table:
Settling and Slip Velocity 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 well, together with the increase in power requirements for circulating the 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 to cuttings settling and slip velocities in synthetic drilling fluid, using actual field cuttings
- Compare the experimental results with Zeilder and Chein correlations and modify these correlations if needed.
- Develop correlations for cuttings settling and slip velocities prediction in synthetic drilling fluid, using actual field cuttings.
- 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 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 semi-empirical correlation that relates the drag coefficient to the Particle Reynolds number, based on the collection of experimental data; 3. Develop a correlation to predict cuttings settling and slip velocities; 4. Verify/Modify the developed correlation and Zeilder and Chein correlations by using the results of the experiments.

Deliverables:

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

Tentative Time Table:

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Effects of Layout of PDC Cutters on Core Bit Drilling Efficiency

Research Proposal

Lewis Buitrago
EXECUTIVE SUMMARY

Effects of Layout of PDC Cutters on Core Bit Drilling Efficiency

Investigator: Lewis Buitrago, TUDRP.

Problem Statement:
Drill bits have a significant impact over the entire project economics. This critical role has demanded a very detailed evaluation on the elements and parameters involving the interaction between the drill bit and the rock. Currently, Polycrystalline Diamond Compact (PDC) bits are the type of fixed-cutter bits where most efforts are being conducted, and core PDC bits basically represent particular designs in terms of the reduced cutting area. In the past two decades, various single cutter force models have been developed which consider formation properties and bit characteristics, but the use of these models to predict bit drilling efficiency is usually inadequate. The depth-of-cut control (DOCC) technology was introduced in 2002. Although the effects of DOCC elements on bit performance are marketed extensively, no detail experimental studies are available to the industry. All these arguments clearly demand more effort to understand the influence of PDC cutters and DOCC elements arrangements on bit performance, therefore on drilling efficiency and stability.

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 DOCC used widely in the industry for different layouts of DOCC elements.
- Propose improvements on available mechanistic models to better describe the physical phenomenon observed on experiment results.

Approach:
- Phase I: Experimental study with the TUDRP full-scale test rig facility to evaluate different layouts of PDC cutters and DOCC elements for a given rock sample under a given set of operational parameters.
- Phase II: Mechanistic model improvements to match to experimental results, taking into account interactions between process variables and model parameters.

Deliverables:
- Data from experiments;
- Layouts of PDC cutters and DOCC elements leading to high drilling efficiency and bit stability;
- Mechanistic model improvements;

Preliminary Timeline:

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Application of Kalman Filter to Predictions of Pore Pressure

Research Proposal

Evren Bektas
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.
- 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.
- The approach for this research will be as follows: i) theoretical work, ii) model verification.
- A literature review will be conducted on existing formation pore pressure prediction methods.
- Existing methods of pore pressure prediction will be compared using field data
- In the model verification, the Kalman filter will be utilized to attain more accurate results than the results estimated from well logs.

DELIVERABLES:
- A reliable mathematical model for predicting formation pore pressure
- Semi-annual Advisory Board Meeting Reports
- Final Report
Automation of Tripping Operations in Directional Wellbore
Research Proposal

Zahra Zamanipour
EXECUTIVE SUMMARY
Automation of Tripping Operations in Directional Wellbores

Investigator: Zahra Zamanipour

Introduction:
One of the most important processes in drilling is tripping operations, when the drillstring goes into or comes out of the wellbore. If the tripping speed is too high, it may cause pipe failure, formation fluid kick off, lost circulation, wellbore instability, and formation fracturing. On the other hand, running the string at low speeds is time consuming and extends this non-productive time. Therefore, optimization of tripping procedure and minimizing tripping time is essential to maintain a safe and cost-effective operation.

Objectives:
- Modeling drillstring dynamics in a directional wellbore during a tripping operation
- Modeling pressure variation for predicting surge and swab pressures based on the velocity profile of the drillstring
- Optimizing the velocity profile of the drillstring using practical velocity profiles to obtain minimum tripping time
- Verifying the model with real-case tripping operations and making corrections if needed
- Automation of draw-works based on optimized velocity of drillstring

Scope of Work
The main goal of the project is modeling of tripping operation in a directional well to optimize it for minimum operating time and maximum safety. Both drillstring dynamics as well as surge and swab pressure dynamics will be calculated and modeled. The model will be optimized for various typical velocity profiles of hookload based on governing physical conditions of the drilling system. The results will be applied to model the automation of the drawworks for the safest and most cost-effective performance. All modeling results will be evaluated with field data.

Deliverables
- Mathematical model for dynamics of drillstring and fluid pressure in tripping operations
- Optimized model of tripping velocity
- Automated tripping operation algorithm for optimum drawworks performance
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report
- PhD dissertation

Proposed Time Table

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Investigation of HGS-Fluid Flow Through Bit Nozzles
Research Proposal

Ibrahim Tizlak
EXECUTIVE SUMMARY

Investigation of HGS-Fluid Flow through Bit Nozzles

Investigator: Ibrahim Tizlak, TUDRP

Introduction:

HGSs (soda lime borosilicate glass bubbles) are low-density particles which are mostly being used different areas of oil and gas industry. The previous study on HGS at TUDRP clearly identified rheological properties and pipe flow characteristics of different samples of HGS-containing drilling fluids (HGSF). Although HGS have been used in various operations in oil and gas industry, there is a lack of understanding the flow behavior through nozzles. Besides, jet impact force is a major factor having a significant effect on the drilling. Furthermore, utilizing underbalanced drilling using HGSF is one of the most promising methods. Therefore, a proper understanding of the behavior of HGSF flow through bit nozzles should be investigated.

Objectives:

- To develop a better understanding for different samples of HGSF flow through nozzles under various parameters (i.e., nozzle sizes, standoff distances, impact angle and jet impact force).
- To obtain high quality experimental data under different conditions.
- To determine the flow behavior and survival ratio of HGS while flowing through jet nozzles for different parameters from the hydraulics standpoint, considering impact force.

Scope of Work:

The following research activities will be involved in this study: i) literature review on drilling fluids containing HGS and their drill bit hydraulics, ii) conducting experiments using a jet operator with water flow to obtain qualitative data and HGSF flow through real nozzles to obtain quantitative data, iii) experimental investigation to develop a model estimating two major information which are the survival ratio and hydraulic behavior as a function of nozzle sizes, standoff distances, impact angles and jet impact force during HGSF flow through nozzles.

Deliverables:

- Experimental data from the Hollow Glass Sphere Breakage Flow Loop, including survival ratio and hydraulic behavior under various conditions.
- A model estimating the survival ratio of HGSs and hydraulic behavior of HGSF flow during jetting process.
- Semi-annual Advisory Board Meeting Reports.
- A Final Report.

Tentative Time Table:

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The Effects of Nano-Particles on Foam Stability and Rheological Properties
Research Report

Ziad Alabdullatif
INVESTIGATOR: Ziad Alabdullatif

INTRODUCTION:
Nano-particles, due their exceptional surface area, have proven to be very effective in stabilizing foam when mixed with appropriate surfactants/agents. In this study, different nano-particles were mixed separately with two different surfactants to generate particle-stabilized foam (PSF). These nano-particles are: silica [AEROSIL®], alumina, calcium carbonate, and calcium phosphate. Generating a very stable foam is the first step for good control of the desired ECD for deep applications and UBD. The stability of foam is determined from a half-life test, which is the time needed for foam to decay to a liquid volume comprising half the volume of the original foam base solution. Large half-life values indicate a more stable foam system. The importance of large half-lives comes from the fact that if circulation is interrupted in the hole, foam will last longer before it breaks down into liquid and gas. Downhole foam breaking is very critical and can result in wellbore instability, high-pressure fluctuation, and the possibility of undesirable well control incidents.

MATERIALS AND EXPERIMENTAL SET-UP:
- Four different nano-powders were used in the stability tests. These powders are 12-nm silica, 20-nm alumina, 15-40-nm calcium carbonate, and 20-40-nm calcium phosphate.
- Two surfactants were used in combination with the above four nano-powders. The surfactants are NatSurf™ 265 (a non-ionic fatty alcohol surfactant obtained from Croda, Inc.) and sodium dodecyl sulfate (an anionic surfactant available in powder form).
- Foam is generated using a Multi-Mixer® with 100-mL of foam base solution (using tap water as the solvent) at ambient pressure and temperature.
- Sodium chloride, NaCl, was introduced into the foam base solution to analyze the foam behavior in the presence of saline water.
- Static half-life tests were conducted to determine the stability of foam. In this test, after foam is generated, it is poured into graduated cylinder and a stopwatch is started. The time is recorded for each 5-mL of drained liquid. The half-life is the time required for the drained liquid to reach 50-mL.

RESULTS:
- **NatSurf™ 265**: The base fluid that consists of 100-mL tap water + 1-mL NatSurf™ 265 gives an unstable foam with a 2-min half-life. Nano-silica addition to the base fluid greatly improves the half-life to around 90 minutes, at a silica concentration of 600 – 700 mmol/L (3.6 – 4.2 g of silica per 100 mL of tap water). Nano-silica generates a smaller volume of foam compared to other the nano-particles with NatSurf™ 265 as the surfactant. An increase in salinity leads to an increase in half-life for silica-based foam, up to 135 min, although the foamability (foam volume) is reduced upon the addition of salt.
- **Sodium Dodecyl Sulfate (SDS)**: The base fluid containing 100-mL tap water + 10 mmol/L (0.29 g) of SDS gives an unstable foam with a 6-min half-life. The presence of alumina and calcium phosphate improve the stability of foam dramatically (100 and 60 minutes half-life, respectively). Nano-silica and calcium carbonate show moderate improvement in foam stability (11 and 20 min, respectively). An increase in salinity leads to a decrease in half-life for alumina and calcium phosphate (50 and 35 min, respectively).