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Fingerprint Losses into Natural or Induced Fractures
FINAL REPORT

Reza Majidi
Mud Losses into Fractures

INVESTIGATOR: Reza Majidi

SPONSOR: TUDRP

OBJECTIVE:
- To develop a mathematical model for fluid losses in natural and drilling induced fractures.
- To distinguish between natural and induced fractures from the mud loss behavior into fractures.
- Quantitative analysis of drilling fluid losses in order to characterize the fractures.

PAST WORK:
- Development of mathematical modeling for Yield-Power-Law fluid losses in natural fractures. The effect of drilling fluid rheology and fluid leak-off on mud losses was studied.
- Analysis of field case studies of two mud lost events in Gulf of Mexico.
- Experimental study of radial flow of YPL fluids between parallel plates to simulate the losses in a single fracture.
- Development of a mathematical model for mud losses into drilling induced fractures.
- Propose a novel method to distinguish between induced and natural fractures.
- Pressure sensitivity analysis of mud losses in natural vs. induced fractures

CURRENT WORK:
- Development of a mathematical model for mud losses into multi-fracture systems.

DELIVERABLES
- Computer program/ spread sheet which allows for analysis of mud losses in fractures.
- Final Report to Advisory Board Meeting (ABM).

PROJECT STATUS:

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Modeling and Simulation of Simultaneous Drilling and Under-reaming

Georges Ishak
Modeling and Simulation of Simultaneous Drilling and Underreaming

INVESTIGATOR: Georges Ishak

SPONSOR: TUDRP

ADVISORS: Dr. Miska and Dr. Daily

OBJECTIVES:
The overall goal of this research is to present a model that should address the impact of different variables on the overall bottom hole assembly system dynamics:

- Effect of pilot hole stabilization
- Effect of underreamed hole stabilization
- Formation strength for each cutting structure
- Effect of drilling parameters (WOB, RPM)
- Pilot hole size vs. underreamed hole size
- Length of pilot BHA

Finally, the main objective is to deliver an executable software that provides a practical implementation of the model.

CURRENT WORK:
- Preliminary optimization of the position of the reamer and stabilizers for a more stable bottom hole assembly.
- Obtain the static solution for different bottom hole assembly configuration
- Obtain the dynamic solution for different bottom hole assembly configuration

DELIVERABLES:
- Semi-annual reports.
- A model that has the ability to simulate the dynamic and static interactions of the drillstring with the formations showing the effect of the position of the stabilizers and reamer on the side forces on the bottom hole assembly.
- Extracting results using the finite element analysis software ABAQUS.

PROJECT STATUS:

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<td>Build a 2-D Model in ABAQUS</td>
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<tr>
<td>Generate Results in 2-D</td>
<td>Show results of weight on bit, reamer stiffness, and reamer location on natural frequencies</td>
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<td>3-D Model Implementation</td>
<td>Perform static analysis. Determine static contact constraint forces, determine natural frequencies and deformation shapes.</td>
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<td>Develop Drill-Ahead Model</td>
<td>Program a user subroutine to calculate bit and reamer rates of penetration based on state variables (WOB, RPM, Torque, etc)</td>
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<td>Generate Performance Maps</td>
<td>Investigate the inclination angle, WOB, penetration parameter, and BHA configuration affect BHA dynamics.</td>
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<td>BHA Optimization</td>
<td>Determine the optimal configuration to minimize the dynamic side forces on the reamer and increase them on the stabilizers.</td>
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Experimental Study and Modeling of Barite Sag in Annular Flow

Yahya Hashemian
Experimental Study and Modeling of Barite Sag in Annular Flow

INVESTIGATOR: Yahya Hashemian, TUDRP

OBJECTIVE:
- Mathematical modeling and experimental study of barite sag in annular flow to investigate effects of annular velocity, eccentricity, pipe rotation and inclination angle on barite sag.

SCOPE OF WORK:
- Modeling: Velocity profile of a single phase fluid for a laminar flow in annulus with stationary inner pipe was obtained numerically. The calculated velocity was assigned to solid particles in axial direction. A correlation by Shah et al. was used to calculate falling velocity of single particle in PL fluid. Having two components of velocity, the time needed for particles to reach bottom of the casing was obtained and a corresponding new density was calculated after that time period.
- Experimental study: A large indoor flow loop was modified to conduct flow tests on an oil base mud. Flow rate, inner pipe rotation and inclination angle can be controlled to investigate their effects on change of the flowing fluid density by time.

RECENT PROGRESS:
- Mathematical modeling development considering particle sizes and falling velocity of particles in PL fluid shows a good match with experimental results. However, more work needs to be done for the case of high annular velocity.
- Second data set of experimental work regarding effects of pipe rotation.
- Flow loop modification on temperature control.

FUTURE WORK:
- Continue mathematical modeling development considering:
  - Hindering effects on particle falling velocity due to high solid concentration
  - Lift force and Magnus force on particles
- Continuation of experimental work on large indoor flow loop.

DELIVERABLES
- Semi-annual advisory board meeting Progress Reports
- Experimental data set
- Modeling
- Final Report

TIME TABLE:
The Effects of Back Rake and Side Rake Angles on Mechanical Specific Energy of PDC Cutters

Vusal Rajabov
The Effects of Back Rake and Side Rake Angles on Mechanical Specific Energy (MSE) of PDC Cutters.

INVESTIGATOR: Vusal Rajabov

PROBLEM STATEMENT:
Apart from formation properties and drilling environment, PDC bit geometry is one of the major contributors to bit performance and its life. The focus of this study is to investigate the effects of PDC bit geometry parameters on drilling efficiency under different pressure conditions.

OBJECTIVE:
- To develop a mechanistic model of cutter-rock interaction process that considers cutter back rake and side rake angles on PDC single cutter forces.
- To study experimentally the effects of back rake and side rake angles on MSE of PDC cutters under atmospheric and elevated pressure conditions.

PAST WORK:
- Development of a mechanistic model of cutter-rock interaction process.
- Experimentally studying the effects of back rake angle on MSE of PDC cutters under atmospheric conditions.

CURRENT WORK:
- Experimentally studying the effects of back rake angles on MSE of PDC cutters under 250 psi and 500 psi conditions.

FUTURE WORK:
- Experimentally studying the effects of side rake angles on MSE under atmospheric, 250 psi and 500 psi conditions.
- Validation of the developed model by experimental data.

THE MATRIX OF TEST VARIABLES:

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DELIVERABLES
- Mechanistic Model of cutter-rock interaction process.
- An experimental database of rock cutting process with different back rake and side rake angles under atmospheric and elevated pressures.
- Semiannual progress reports and a final research report.
Smear Effect in Casing Drilling - The Effect of Casing Dynamics

Duc Nguyen
EXECUTIVE SUMMARY

Smear Effect in Casing Drilling – The Effect of Casing Dynamics

Investigator: Duc Nguyen, TUDRP

Introduction:

Casing Drilling is an emerging technology that helps with reducing drilling cost as well as issues associated with conventional drilling such as lost circulation, well control and borehole stability problems. Among various advantages, lost circulation reduction is one of the most beneficial phenomena of casing drilling. However, this effect has not been fully explained nor thoroughly studied. The purpose of this project is to investigate the effect of casing dynamics on the plastering mechanism of drilled solids into the borehole wall, and the relationship of this phenomenon with the reduction of lost circulation problems.

Objectives:

- Provide more thorough understanding of the smear effect and its connection to lost circulation mitigation.
- Create a dynamic model for casing drilling / narrow annulus drilling application.
- Develop a model for particle mechanics of drilled solids in the wellbore, taking into account the effect of casing dynamics.
- Verify models with field data.

Project Status:

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Recent Progress:

- Literature review on the effect of particle size distribution on lost circulation and wellbore strengthening.
- Numerical model using FEM for casing dynamics that can be applied to directional wells and multiple section casing string.

Future Work:

- Numerical dynamic solution for casing dynamics.
- Particle mechanics study and modeling.
- Effect of casing dynamics on particle size distribution.
Study of YPL Fluids
Transition Flow Regime in Pipes

Goktug Kalayci
Study of Yield Power Law Fluids Transitional Flow Regime in Pipes

Investigator: Göktuğ Kalaycı TUDRP

Objectives:

- Better understanding of behavior of YPL fluids at transitional flow regime between laminar to turbulent flows in pipes considering rotation and temperature effects.
- Determine the friction factors in the transitional flow regime and validate with experimental results.
- Develop a mathematical model for pressure drop prediction under transition flow conditions used in drilling applications.

Scope of Work:

The project includes both theoretical and experimental work to understand the transitional flow between laminar and turbulent flow regimes for Yield Power Law fluids. This work can be done in two stages: the first will include flow in pipes and the second will consider pipe rotation. In both stages temperature effects will be considered.

Recent Progress:

- Modification of Pipe Viscometer (replacing the old pipe, insulation, adding new supporters, voltage regulator)
- Developing data acquisition system
- Pressure Transmitters and Wireless Transmitters are Calibrated
- Conducting sample experiment test with water
- Developing mathematical model (Modification of Ryan & Johnson Criteria for YPL fluids)

Future Work:

- Adding two additional pipe to the rotating pipe viscometer
- Start running experiments
- Continue developing mathematical model

Deliverables:

- Rheological parameters for Yield Power Law fluids used in this study.
- Experimental results of pressure distributions and friction pressure losses measured for different Yield Power Law fluids at different flow velocities and temperatures.
- A mathematical model to predict friction pressure losses during to transition from laminar to turbulent flow.
- Friction factor correlations as a function of Reynolds Number for transitional flow.
- Onset point of transitional and turbulent flow of Yield Power Law fluids.
- Semi-annual Advisory Board Meeting (ABM) Progress Reports and the Final Report.

Project status (completed)

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Pressure Signature of Gas Influx

Ali Karimivajargah
Pressure Signature of Gas Influx

Investigator: Ali Karimi

Sponsor: TUDRP

Objectives:
Developing a gas kick simulator for:
- Early detection of gas influx and its location in the wellbore by using Wired Drill String Technology during MPD and conventional operations by using Wired Drill-string Technology
- Predicting annular pressure profile when gas influx enters the wellbore
- Predicting gas and liquid fractions along the wellbore and pit gain vs. time
- Obtaining gas and liquid velocity distribution in the annular space
- Predict bottom-hole pressure or surface pressure (depending on the boundary condition) during gas influx

Current Work
- Applying Drift-Flux model in two-phase region instead of Homogenous No Slip model
- Introducing a solution procedure for the Drift-Flux model
- Updating models for single-phase region and reservoir/wellbore interaction
- Predicting annular pressure profile, pressure profile and its derivatives at desired locations, pit gain, velocity distributions and flow patterns from the developed program and compare them with No Slip Model
- Introducing a method for early gas detection based on pressure profile and its derivative

Future Work
- Predicting after shut in pressure profile, casing pressure and drill pipe pressure after shut in.
- More sophisticated transient reservoir model is to be coupled with wellbore flow model
- Considering the effect of diameter on the obtained results
- Extending the model to deviated wells

Deliverables
- Advanced gas influx simulator to observe pressure profiles, detect gas influx, and determine its location, volume, and movement in the wellbore while using Wired Drill String Technology
- Matching the model with field data obtained from Wired Drill String Technology
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report

Project Status

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Buckling and Axial Force Transfer of Buoyancy Assisted Casing

Mehmet Arslan
INVESTIGATOR: Mehmet Arslan, TUDRP

OBJECTIVES

- Better understanding of the buckling behavior and axial force transfer of nearly weightless tubulars inside horizontal wellbores
- To experimentally investigate the effect of buoyancy on the behavior and axial force transfer of tubulars in horizontal wellbores through the transition from both straight to sinusoidal and sinusoidal to helical configurations
- To experimentally observe the effect of rotation on buckling behavior and axial force transfer of buoyancy assisted tubulars in horizontal wellbores

PROJECT STATUS

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RECENT PROGRESS

In order to carry out the experimental research, a horizontal buckling facility was constructed. The length of the tested section is 91 ft, so it is long enough to simulate the buckling behavior of an infinite pipe. It also allows rotation. Experiments with two different materials have been conducted. Experiments have been conducted both with air and water in the annular section at different loading speeds and including rotation.

FUTURE WORK

- Three more different types of pipes will be tested. At the moment, experiments are being conducted with two of them, both with water and air in annulus. In order to obtain the perfect floating conditions, all the pipes will also be tested with a type of transparent drilling mud. In the first stage, experiments with all the pipes under consideration will be conducted.
- An analytical study will be conducted based on the results from experiments.

DELIVERABLES

- Experimental observation and analytical analysis of buckling behavior and axial load transfer of tubulars inside a constraining cylinder with emphasis on buoyancy.
- Semi-annual Advisory Board Meeting Reports.
- A Final Report.
Investigation of Cuttings Transport in 30-60 Degree Inclined Wells

Feifei Zhang
EXECUTIVE SUMMARY

Investigation of Cuttings Transport in 30~60 Degree Inclined Wells

Investigator: Feifei Zhang, TUDRP

Introduction:

Hole cleaning during directional well drilling is a major concern in the oil patch and must be monitored and properly controlled during the entire drilling operation. Hole cleaning for intermediate inclined wells is the most difficult part for the dramatic change of cuttings behavior and moving cuttings bed. This work focuses on cuttings transport in intermediate inclined wells. Cuttings begin to show the tendency to fall down to the lower side of the annulus and cuttings bed begins to appear when the well inclination angle is over 30 degrees. The cuttings bed also shows the tendency to slide down in the range of 30~60 degree inclined wells. A critical model was used to simulate the cuttings behavior and most of the simulation results make sense.

Objectives:

- Build a model to predict change of cuttings concentration profile and cuttings bed sliding behavior with changes in flow rate at a set of given parameters.
- Design a method to calculate the flow rate below which cuttings beds begin to slide down at every given inclination angle, ROP, Eccentricity, fluid properties, pipe rotation combination.
- Conduct a series of experiments to study cuttings movement and use these experiments to examine the reliability of the model.

Model

The model was based on the analysis of mechanism on a single particle in the annulus. Cuttings bed height and suspended cuttings concentration can be calculated in the model. The calculation results make sense.

Experiment Facility

The experiment facility was rebuilt in the past 8 months. The rebuilding work includes following:

- A new data acquisition system and loop control system was installed, most of the old sensors were replaced.
- Old pipe line system including pipes, joints, and valves was renewed.
- A new winch was installed to replace the old dangerous winch.
- A new pump with better working capability was added to the loop.
- A high-speed camera and a camera moving and control system were added to the loop.

Project Status:

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Determination of Viscoelastic Properties of Drilling Fluids

Binh Bui
DETERMINATION OF VISCOELASTIC PROPERTIES OF DRILLING FLUIDS

INVESTIGATOR: BINH BUI

INTRODUCTION:

Drilling fluids exhibit viscoelastic properties at various levels. However those properties are not fully investigated. Viscoelastic properties of drilling fluids can have significant effects on hydraulic modeling and predicting many phenomena, including pressure peak and dynamic barite sag. Viscoelastic tests are also the standard method to obtain material functions of the samples. In drilling fluid applications viscoelastic tests are indispensable to investigate low shear viscosity, gel formation and gel breakage. Therefore, this theoretical and experimental study is being carried out to determine viscoelastic properties of selected drilling fluids.

OBJECTIVES:

1. To enhance our understanding of the viscoelastic properties of drilling fluids and the applications of viscoelastic properties in hydraulic calculations.
2. To investigate and evaluate experimentally the linear viscoelastic range and viscoelastic properties of different drilling fluids using dynamic tests.

CURRENT WORK:

1. Experimentally investigate the viscoelastic properties and linear viscoelastic range of polymeric and Bentonite samples with varied concentrations and at different temperatures using amplitude sweep and frequency sweep tests.
2. Investigate the applicability of the Superposition Principle and Cox-Merz Rule for the tested samples.

FUTURE WORK:

1. Extend the current experiments to Oil-Based Fluids.
2. Investigate the effect of temperature using oscillatory temperature sweep tests.
3. Investigate the application of the superposition principle for linear viscoelastic ranges of drilling fluids, with special focus on the Time-Temperature Superposition Principle to obtain the shift factors for each fluid system.
4. Investigate the application of the Cox-Merz Rule for other drilling fluids. For fluids that do not follow this rule, modification of this empirical correlation will be carried out.

DELIVERABLES:

1. Semi-annual Advisory Board Meeting progress reports.
2. Experimental database.
3. Correlations for obtaining the viscoelastic properties of drilling fluids.

PROJECT STATUS:

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A Study on Pressure Drop of Aerated Drilling Fluids Flowing Through Drill Bit Nozzles

RESEARCH PROPOSAL

Matthew Camp
INVESTIGATOR: Matthew Camp, TUDRP

OBJECTIVES

- Acquisition of experimental data for two-phase gas-liquid flow through drill bit nozzles, with the use of several different nozzle sizes, flow rates, and gas-liquid ratios
- Creation of a model for pressure drop that fits the observed data and will be useful for the design of aerated drilling fluids

RECENT PROGRESS

A literature review is currently underway involving two-phase flow through orifices of any description. Current progress has turned up a distinct lack of information involving two-phase flow through nozzles, with most research being conducted involving chokes or orifice plates. The design of the facility to be used to conduct the experimental portion of the proposed study has been discussed and a schematic and description appears in the full proposal. A preliminary test matrix has also been devised to give an idea of the breadth of the experimental investigation.

FUTURE WORK

- The experimental facility must be constructed.
- Experimental work can be conducted once the construction of the facility is complete.
- An analytical examination of two-phase flow through bit nozzles must be conducted for the purposes of building a model of the phenomenon, and can be carried out concurrently with the previously mentioned items.
- As further data is acquired, the model will be refined to accurately determine pressure drop across the nozzle as indicated by the experimental data.
- A final report will be prepared upon completion of both the analytical and experimental portions of the study.

DELIVERABLES

- Experimental data for the pressure drop of two-phase gas-liquid flow through drill bit nozzles
- Analytical model for the pressure drop of two-phase gas-liquid flow through drill bit nozzles with practical applications
- Program using the developed model to predict pressure drop
- Advisory Board Meeting reports
- Final report