Fingerprint Losses into Natural or Induced Fractures

INVESTIGATOR: Reza Majidi

SPONSOR: TUDRP

OBJECTIVE:

- To develop a mathematical model for fluid losses in drilling induced fractures.
- To distinguish between natural and induced fractures from the behavior of mud losses.
- 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 on minimizing the losses was studied.
- Analysis of field case studies of two mud lost events.
- Experimental study of radial flow of YPL fluids between parallel plates to simulate the losses in a single fracture.

CURRENT WORK:

- Development of mathematical model for drilling induced fractures.
- Continue of the modeling in order to distinguish between induced and natural fractures.
- Pressure sensitivity analysis of mud losses in natural vs. induced fractures

FUTURE WORK

- Examine the validity of the provided model by field data. (if available)

DELIVERABLES

- Computer program/ Spread sheet which allows for analysis of mud losses in fractures.
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report.

PROJECT STATUSE:

Tasks	2009						2010						
	2	4	6	8	10	12	2	4	6	8	10	12	
Literature Review	×	×	×	×	×	×							90%
Mathematical			×	×	×	×	×	×					80%
Computer				×	×	×	×	×					70%
Field Data Analysis													00%
Final Report										×			00%

Modeling Transient Borehole Failure Using Discrete Element Method

INVESTIGATOR: Yongfeng Kang

OBJECTIVES:

- To develop an understanding of transient borehole failure;
- To predict transient borehole failure by modeling rock behavior at the grain level using the discrete element method;
- To develop a computer program to simulate transient borehole failure at downhole conditions;
- To verify the model with field data or published data if available.

STATUS OF PROJECT:

Task	Description	Percentage completed
Literature review	Traditional models	100%
	DEM	100%
Mathematical modeling of DEM	For 2D case	100%
Computer Simulator Development	For 2D case	95%
Verification and Improvement	For 2D case	75%
Final report		--%

RECENT PROGRESS:

- Simulations of fractures have been successfully conducted.
- Large scale simulations have been conducted for unconsolidated (weakly-consolidated) sands. The results show fractures are induced, and a tensile layer and a compressive layer are also induced in the formation around the wellbore.
- Development of transient fractures failures with time can be tracked in the simulation, which includes the depth, width and distribution of the fractures.
- Simulations indicate that before major fractures are induced, some micro-fractures may be induced. Once the major fractures are induced, these micro-cracks tend to be closed again.

FUTURE WORK:

1. Use field/lab data as inputs for case studies in the 2D condition;
2. Final report;
3. Dissertation.

Cuttings Transport with Foam at Simulated Downhole Conditions –

The Effect of Hole Inclination Angle

INVESTIGATOR: Jiafu Xu

OBJECTIVES:

- Bench top experiments to study the effect of concentration of surfactant and polymer on foam stability;
- Foam characterization experiments using Foam Generator and Viscometer (FGV) apparatus;
- Cutting Transport experiments using Advanced Cuttings Transport Facility (ACTF) to investigate the influence of high inclination angle and other variable.
- To develop a correlation and a computer simulator based on previous model to describe cutting transport with foam with inclination angle;

STATUS OF PROJECT:

Mission	Sub Mission	Percentage of Completion
Literature Review		100%
Foam characterization and stability study	Bench top experiments on foam stability study.	100 %
	Foam characterization with FGV	100 %
Cuttings transport experiments with ACTF		100%
Correlation development		100%
Modeling and computer simulator	Model development considering inclination angle	100%
	Computer simulator	100%

RECENT PROGRESS:

- Experimental investigation based on the following test matrix.

Foam quality	Polymer(%)	I(deg)	Drillpipe Rotational Speed (rpm)	Flow Rate(gpm)
0.7 - 0.9	**0.25 - 0.5**	**90-70**	**0 - 80**	**100-200**

- Theoretical analysis and computer simulation.

RECOMMENDATIONS:

Based on the results of this study, following researches are recommended for the future work:

- The influence on ROP, cuttings size shall be investigated
- The study of cuttings transport with foam at medium inclination angle with elevated pressure and temperature should be conducted.

EXECUTIVE SUMMARY

Experimental Study on Gelation Phenomena of Synthetic Drilling Fluids

Investigator: Gorkem Gokdemir, The University of Tulsa Drilling Research Projects (TUDRP)

The aim of this research is to analyze and investigate the gelation phenomena and to develop a mathematical model for determining the pressure peaks in the annulus, incorporating the effects of temperature and aging time on gelled structure development of Synthetic Based Mud (SBM). Developed model contains intrinsic parameters which are needed to be determined experimentally. Pressure peaks at pump startup and transient pressure responses are calculated and validated via flow loop experiments by using the Dynamic Testing Facility (DTF).

Objectives

- To measure the gel strength of SBM with different gelling times and temperatures by using a rheometer.
- To measure the effect of breaking gel strength on pump pressure; this can be determined using the Dynamic Testing Facility (DTF) at TUDRP.
- To provide a hydraulic model, and evaluate and refine the model using experimental results.

Research Plan

The research is divided into two stages:

Stage1: Determining gel strength and time-dependent stress behavior of synthetic based mud at different temperatures and gelling time by using Anton Paar Physica MCR301 Rheometer with different measurement geometries. Dynamic testing facility (DTF) is used to investigate the pump pressure overshoot in the annulus.

Stage2: A hydraulic model for estimating the frictional pressure losses inside the annulus that considers the effect of gel strength, temperature and aging time is developed.

Recent Progress

- Stress over-shoot experiments are repeated with vane geometry, at the shear rate range of 1.7 s^{-1} to 171 s^{-1} and various temperatures.
- Experimental results are analyzed to find the developed model parameters both in non-equilibrium and equilibrium conditions.
- Dynamic Tests at different flow rates and temperatures are conducted by observing the aging history effect on the pressure responses.

Future Work

Data analyzes are continued at different temperatures to find the model parameters and to see the temperature effect on the parameters.

Deliverables

- Mathematical Model for predicting the gel-breaking pressure along the well trajectory.
- Experimental results of this study and final report.

Modeling and Simulation of Simultaneous Drilling and Underreaming

INVESTIGATOR: Georges Ishak

SPONSOR: TUDRP **ADVISORS**: Dr. Miska and Dr. Daily

OBJECTIVES:

The research objectives are to produce a flexible numerical model capable of modeling the dynamic (harmonic) response of a drillstring bottom hole assembly due to following:

- The location and quantity of pilot hole (below reamer) stabilizers
- The location and quantity of under-reamed hole (above reamer) stabilizers
- The effect of drilling parameters such as the surface weight on bit (SWOB) and speed (RPM)
- The foundational stiffness/hardness encountered by each cutting tool (different lithologies)
- Relationship between pilot hole and reamer diameters
- Length of the pilot BHA
- Inclination Angle

CURRENT WORK:

- Model a BHA with two stabilizers.
- Compare a model of a BHA with a reamer and a BHA with a stabilizer located at the same position.
- Show the difference of the natural frequencies and mode shapes between a BHA with a reamer and a BHA with a stabilizer

FUTURE WORK

- Building and verifying 3-D model of the drill string.
- Extracting the mode shapes and natural frequencies of the 3-D model.
- Predicting drill string stresses and displacements based on harmonic forcing functions.
- Presenting transient dynamic solutions.
- Implementing an executable script to interface with the finite element software for automatic model generation and analysis.

DELIVERABLES

- Semi-annual reports.
- Extracting results using the finite element analysis model ABAQUS.

PROJECT STATUS:

Subject	Description	Progress
Literature Review	Examine the current literature in the appropriate resources.	60%
Analysis Technique Selection	Evaluate different analysis techniques for the current problem. Result: ABAQUS Finite Element Analysis.	100%
2-D Model Implementation	Build a 2-D Model in ABAQUS of the bottom hole assembly with a reamer and stabilizers.	100%
2-D Model Verification	Verify the static results of the model against analytical solutions or other known solutions. Develop non-linear boundary conditions.	80%
2-D Dynamic modeling	Modeling of the BHA adding linear perturbation steps and obtains natural frequencies and mode shapes.	100%
3-D Model Implementation	Perform static and buckling analysis, include contact constraints, determine mode shapes.	0%
3-D Dynamic Modeling	Implement a time-forward integration scheme to solve to the dynamic response of the bottom hole assembly with a reamer	0%

Experimental Study of Torque Reduction Additives for Extended Reach Drilling

Investigator: Amar Vankadari, TUDRP

Introduction

With the change from vertical to highly inclined and horizontal extended reach wells, we face unique challenges in the management of torque. This project is an experimental study to examine and quantify the effects of solid additives on torque reduction. The University of Tulsa Drilling Research Projects (TUDRP) Low Pressure Ambient Temperature (LPAT) flow loop and Small Indoor Flow Loop (SIFL) facilities will be used to simulate ERD and conduct the experiments.

Objectives

- Experimentally determine the effect of solid additives on torque reduction in ERD.
- Experimentally determine the optimum volumetric percentage of solid additives required at various specified drilling conditions.
- Experimentally determine the performance of various solid additives on torque reduction based on the characteristics (shape, size, density) of the additives.

Summary

Project can be envisaged in three stages, measurement of torque with solid additives, with and without cuttings and with only cuttings. Three drilling parameters: weight percentage of solid additives, flowrate and RPM are included into the test matrix. In the previous report, results were discussed on the baseline experiments performed on LPAT flow loop with water as drilling fluid with and without cuttings. Baseline tests and experiments with solid additives have been conducted on SIFL and results are discussed in detail in the report. Tests also have been performed on Lubricity Evaluation Monitor Next Technology (LEM NT) and Stickance Tester with all the four solid additives at MI-SWACO facility, Houston, Texas.

Future Work

- Continue experiments on solid additives, with and without cuttings on the LPAT and SIFL.
- Develop a model to determine the levels of cuttings as a function of torque. The model will include the effect of the additives.

Project status (completed)

Literature review	60%
Facility Modification	70%
Experiments and test data analysis	40%
Final Report	10%

Deliverables

- Recommendations for better management and reduction of torque under different drilling conditions using solid additives.
- Advisory board meeting Progress Reports and a Final Report.

Experimental Study and Modeling of Barite Sag in Annular Flow

INVESTIGATOR: Yahya Hashemian, PhD Student

SPONSOR: TUDRP

OBJECTIVE:

- Develop a model for barite sag in annular flow to predict the effects of fluid annular velocity, eccentricity, pipe rotation and inclination angle.
- Experimental studying of annular flow to investigate the above effects on barite sag.

SCOPE OF WORK:

- Modeling: Using continuum approach (Eulerian method) differential equations of continuity and momentum for solid and liquid phase needs to be solved numerically on an eccentric annulus with inner pipe rotating, to get velocity profile of liquid and solid and also solid concentration change with time.
- Experimental study: Using the large indoor flow loop available at TUDRP for running experiments on annular flow.

RECENT PROGRESS:

- Flow loop developed from pipe flow to annular flow with ability to rotate inner pipe.
- Small sample of drilling fluid prepared.
- Rheology tests on the sample of drilling fluid.

FUTURE WORK:

- Preparation of mud making facility in TUDRP and prepare mud for tests.
- Start running barite sag tests on flow loop.
- To continue developing of mathematical model.

DELIVERABLES

- Semi-annual advisory board meeting progress report
- Experimental data set
- Modeling
- Final report

TIME TABLE:

Task	2009	2010			2011			2012
	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring
Literature Review	×	×						
Modeling		×						
Experiments		×						
Final Report								

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 bit life. A bit performing the best in one location in most cases does not show the same performance in a different application. This is due to the different cutting mechanisms with different formations. Similarly, a bit performing the best in a certain application will not do the same if the cutter geometry is changed. Therefore, there is a need to study the effect of the PDC bit geometry on drilling efficiency and aggressiveness for different rock types under different pressure conditions.

OBJECTIVE:

- To develop a mechanistic model that considers the effect of cutter back rake and side rake angles on PDC single cutter-rock interaction process.
- To study experimentally the effect of back rake and side rake angles on MSE of PDC cutters at the TUDRP single cutter research facility.

SCOPE OF WORK:

- Theoretical: A mechanistic model that considers the effects of back rake and side rake angles on cutter-rock interaction will be developed.
- Experimental: The cutter-rock interaction forces and MSE at atmospheric and different confined pressures are calculated for four different PDC cutters with back rake angles of 10, 20, 30 and 40 degrees. The effects of negative and positive side rake angles will be studied in the next stage. Two types of rock samples-Carthage marble and Mancos shale-are used during the experimentation.

THE MATRIX OF TEST VARIABLES:

Back Rake Angle	Side Rake Angle	Confining Pressure	Rock Type
10 deg 20 deg 30 deg 40 deg	-20 deg -10 deg 0 deg 10 deg 20 deg	0 psi 250 psi 500 psi	Mancos shale Carthage marble

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.
- A final report and a M.S. thesis

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 probably 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. (Modified from original objective: Carry out experiments to investigate casing dynamics in a wellbore.)

Project Status:

Literature review	20 %
Casing Dynamics	15 %
Particle Mechanics	0 %
Computer Model	5 %
Model Verification	0 %
Final report	0 %

Recent Progress:

- Literature review on lost circulation mitigation in casing/liner drilling and main variables affecting the phenomenon.
- Literature review on general drillstring modeling.
- Preliminary model for casing in a vertical well assuming a helical shape for the casing column.

Future Work:

- 3D dynamic torque model.
- Casing dynamics using FEM.
- Literature review and modeling of fluid-structure interaction.

EXECUTIVE SUMMARY
Pressure Signature of Gas Influx

Investigator: Ali Karimi, TUDRP

Introduction:

Combination of MPD and wired drill string technology, especially in HPHT or deepwater drilling, offers new ways to achieve safe well control and successful drilling of wells that would otherwise be un-drillable and/or present unacceptably high risk. Hence, developing a simulator to model pressure profile in the well on the basis of obtained data from wired drill pipe system and afterwards predicting location and volume of a gas influx will provide a powerful tool that can be resulted in faster and more precise decisions in the well control operations with MPD and accordingly prevents associated problems and cost related issues.

Objectives:

- To predict the pressure and velocity distributions as a function of time in the wellbore.
- Early detection of a gas influx, its location, volume and rising velocity in the well-bore and hence reducing hole stability problems, formation damage and expenses involved in non-productive time.
- To distinguish between non-influx and influx-related mud return flows
- Improving MPD by better handling of formation influx during drilling operations.

Scope of Work:

1. Applying conservation of mass, momentum and energy equations to predict pressure distribution in each control volume.
2. Applying multi-phase flow mechanistic modeling in the wellbore.
3. Considering solubility of gas in the oil/synthetic based drilling fluids.
4. Validating model by available field data from wired drill-pipe telemetry.
5. Extending the model for high angle wells.

Deliverables:

- Advance influx simulator to observe pressure profiles, detect gas influx and determine its location, volume and movement in the well bore.
- Matching the model with field data obtained from drill pipe telemetry
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report.

Tentative Time Table:

Work Time / Deliverables	2010			2011			2012		
	1-4	5-8	9-12	1-4	5-8	9-12	1-4	5-8	9-12
Literature Review									
Mathematical Modeling									
Computer Simulations									
Field Data Analysis									
Final Report									

EXECUTIVE SUMMARY

Study of Yield Power Law Fluids Transitional Flow Regime In Pipes

Investigator: Goktug Kalayci, TUDRP

Introduction:

As drilling depths and wellbore lengths increase, challenges concerning drilling fluids have become more and more significant in recent years. To control narrow operation window, wellbore pressure control has played a much more important role. Due to inaccurate estimation of friction pressure drop, many problems may occur. Despite developments in the drilling industry, the problem of calculating friction pressure drop accurately still exists. Even though experiments have been conducted on transitional flow, a complete knowledge of Yield Power Law fluids in this regime has not been reached yet. The main aim of this study is provision of better understanding of transitional flow regime of Yield Power Law in pipes considering rotation and temperature effects.

Objectives:

- Better understanding of behavior of YPL fluids at transitional flow regime between laminar to turbulent flows in pipes considering the 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 proposed 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 one will include the flow in pipes and the second one will consider pipe rotation. In both stages temperature effect will be considered.

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 the friction pressure losses due 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.

Tentative Time Table:

Time / Tasks	2010			2011					
	7-8	9-10	11-12	1-2	3-4	5-6	7-8	9-10	11-12
Literature Review	■	■	■	■	■				
Facility Modification	■	■	■						
Fluid Characterization		■	■	■	■				
Running Experiments			■	■	■	■	■		
Modeling		■	■	■	■	■	■	■	
ABM Progress Report		■			■			■	
Final Report								■	■

Buckling & Axial Force Transfer of Buoyancy Assisted Casing

INVESTIGATOR: Mehmet Arslan, TUDRP

INTRODUCTION: As global demand for oil and gas increases, a strong demand for extended reach wells has emerged over the last two decades to meet the world's demands in a cost effective manner. Due to the excessive drag levels encountered, running long casing strings in extended reach wells having long horizontal departures is one of the most critical of all well operations. Buoyancy assistance allows successful completion for cases where a significant reduction in drag is required. However, floatation methodologies also result in a dramatic reduction in the effective weight of casing and that increases the susceptibility of string to be buckled by lower axial loads than the ones expected in conventional runs. The main purpose of this study is to investigate the effect of buoyancy on the buckling behavior and axial force transfer of casing strings in horizontal wellbores experimentally and analytically.

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

SCOPE of WORK:

A close examination and more thorough understanding of the buckling phenomena and axial force transfer of nearly weightless tubulars inside a horizontal constraining cylinder will be provided. A horizontal buckling facility that allows axial load to be applied in an increasing path, rotation of inner pipe and fluid flow through an annular section will be used. The forces necessary for buoyancy assisted tubulars to generate sinusoidal and helical configurations and axial load transfer will be measured. Tests will also be conducted at different loadind speeds and RPMs to examine the effect of rotation on buckling behavior and axial load transfer.

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 and a Final Report

PRELIMINARY TIMETABLE: