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 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 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 a mathematical model for 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

DELIVERABLES

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

PROJECT STATUSE:

Tasks	2009						2010						
	2	4	6	8	10	12	2	4	6	8	10	12	
Literature Review	×	×	×	×	×	×							90%
Mathematical Modeling			×	×	×	×	×	×	×				100%
Computer Simulation				×	×	×	×	×	×	×			100%
Analysis of Results							×	×	×	×	×		100%
Final Report										×	×	×	100%

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	100%
Verification and Improvement	For 2D case	100%
Final report		100%

RECENT PROGRESS:

I performed an energy analysis with a beam to verify the simulation result with the fundamental physical law of conservation of energy. The results show a very good equivalent on the input energy – the work done by the external force, and the output energies—the internal energy change stored in beam (in compression and/or tensile strains), the energy dissipation by the damping force and the kinetic energy during the transient process.

This energy validation analysis successfully provides a general verification of this discrete element method and also this developed simulator.

FUTURE WORK:

1. Dissertation – to be submitted in May 2011.

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.

Progress

- Analysis of experimental data obtained from Anton Paar MCR301 are completed, and equation coefficients of the developed model are determined
- Stress values obtained from the developed model are used in the frictional pressure loss calculations, and the results are compared with the DTF experimental values for different temperature, flow rate and aging time values in order to verify the accuracy of the model
- M.Sc. thesis is completed

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

CURRENT WORK:

- Implement a 3-D model capable of determining static solutions for BHA configurations and force distributions in the presence of a reamer.
- Develop an algorithm to simulate the penetration of the cutting surfaces.
- Determine the performance of different BHA configurations.

FUTURE WORK

- Perform a sensitivity study on modifiable geometric parameters like the position of the stabilizers and reamer.
- Implement a torque model and study the effect of rotation.
- Introduce wellbore friction, both axial and transverse.
- Link modal analysis results to transient analysis

DELIVERABLES

- Semi-annual ABM reports and a Final Report.
- A drill-ahead model that has the ability to simulate a drillstring with a reamer penetrating the formation.

PROJECT STATUS:

Task	Description	Progress
Literature Review	Examine the current literature in the appropriate resources	80%
Analysis Technique Selection	Evaluate different analysis techniques for the current problem. Result: ABAQUS FEA using the Explicit solver	100%
2-D Model Implementation	Build a 2-D Model in ABAQUS	100%
3-D Model Implementation	Perform static analysis. Determine static contact constraint forces, determine natural frequencies and deformation shapes.	90%
Develop Drill-Ahead Model	Program a user subroutine to calculate bit and reamer rates of penetration based on state variables (WOB, RPM, Torque, etc)	80%
Generate Performance Maps	Investigate the inclination angle, WOB, penetration parameter, and BHA configuration affect BHA dynamics.	60%
Modeling of BHA with Rotation	Include inertial and rotary effects and solve the equations of motion	0%
BHA Optimization	Determine the optimal configuration and loading to minimize variations of WOB, WOR and dynamic side forces.	0%

Experimental Study of Torque Reducing 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 challenges in the management of torque. This project is an experimental study to examine and quantify the effects of mechanical lubricants on torque reduction. This is the final report for this project. It outlines the recent progress including tests conducted on the High Temperature Lubricity Tester (HLT) at MI SWACO in Houston, designing and testing of prototype lubricity apparatuses: Drag Lubricity Tester (DLT) and Torque Lubricity Tester (TLT) at TUDRP. Results and analysis of the data obtained on the Small Indoor Flow Loop (SIFL).

Objectives

- To experimentally determine the effect and performance of solid additives as mechanical lubricants on torque reduction in extended reach drilling.
- To experimentally determine the performance of different mechanical lubricants based on its characteristics (shape, size).
- To design and build a prototype lubricity testing devise for evaluating the mechanical lubricants.

Summary

In the previous reports, results from four equipments were discussed. To evaluate the effects of mechanical lubricants, experiments were conducted on two industrial instruments (Lubricity Evaluation Monitor Next Technology (LEM NT) and Stickance Tester) that are conventionally used to evaluate liquid lubricants. A few preliminary tests were also conducted on TUDRP's large outdoor Low Pressure Ambient Temperature (LPAT) flow loop and Small Indoor Flow Loop (SIFL).

Another industrial apparatus, the High Temperature Lubricity Tester (HLT), which is very similar to the LEM NT except it has a horizontal orientation, was used at MI SWACO Houston facility. The results of the Stickance Tester prompted us to build a plate-on-plate device. Two prototype apparati, the DLT and TLT, were designed and built at TUDRP to evaluate the lubricants. The design is based on the physics problem of moving mass. In the DLT, sliding friction is determined by measuring the acceleration of a sliding object on a fixed surface. In the case of TLT, rotating friction is determined by the weight required to initiate rotation of an inner pipe in a fixed outer pipe. Both the apparati measure the coefficient of friction, which allows evaluation of the performance of each type of mechanical lubricant. For conducting experiments at simulated drilling conditions, the SIFL was used.

Project status (completed)

Literature review	95%
Facility Modification	100%
Experiments and test data analysis	100%
Final Report	95%

Experimental Study and Modeling of Barite Sag in Annular Flow

INVESTIGATOR: Yahya Hashemian, TUDRP

OBJECTIVE:

- Mathematical modeling of barite sag in annular flow to predict the effects of annular velocity, eccentricity, pipe rotation and inclination angle.
- Experimental study to investigate the above effects on barite sag.

SCOPE OF WORK:

- Modeling: Considering laminar flow in a horizontal concentric annulus with no pipe rotation velocity profile of a single phase fluid was obtained numerically. Considering barite particles having the same axial velocity as liquid, Stokes' falling velocity was assigned to each particle. Having two components of velocity, the time needed for particles to reach bottom was obtained and a corresponding new density was calculated.
- Experimental study: Effects of flow rate and inclination angle on barite sag using four different flow rates and inclination angles.

RECENT PROGRESS:

- Preliminary mathematical modeling is accomplished.
- First data set of experimental work.

FUTURE WORK:

- Mathematical modeling development considering particle size distribution and apparent viscosity of fluid at each point of annulus.
- 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:

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 its durability. 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 interactions 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:

- Developed a mechanistic model for the cutter-rock interactions.
- Experimentally tested the effects of back rake angle on MSE of PDC cutters under atmospheric conditions.

CURRENT WORK:

- Experimentally test 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:

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 processes.
- An experimental database of the rock cutting process with different back rake and side rake angles under atmospheric and elevated pressures.
- Semiannual Progress Reports and a Final Report.

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:

Literature review	40 %
Casing Dynamics	45 %
Particle Mechanics	0 %
Computer Model	20 %
Model Verification	0 %
Final report	0 %

Recent Progress:

- Semi-analytical model for casing in vertical well, including the effect of friction and casing weight.
- Analytical model of fluid-structure interaction to determine induced pressure on casing and wellbore in quiescent fluid.

Future Work:

- Numerical modeling of casing dynamics using FEM.
- Integration of fluid-structure model into the dynamic model.
- Literature review of particle mechanics study.

Study of Yield Power Law Fluids Transitional Flow Regime in Pipes

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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:

- Construction of rotating pipe viscometer
- Developing data acquisition system
- Conducting sample experiment test with water

Future Work:

- Adding two additional pipe and a torque meter 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)

Literature Review	50 %
Facility Modification	70 %
Fluid Characterization	0 %
Experimentation	10 %
Modeling	10 %
Final Report	0 %

Pressure Signature of Gas Influx

Investigator: Ali Karimi

Sposnosr: TUDRP

Objectives

- Early detection of gas and its location by analyzing pressure behavior along the wellbore
- Predicting annular pressure profile when gas influx enters the wellbore
- Predict bottom-hole pressure or surface pressure (depending on the boundary condition) during gas influx
- Predicting gas and liquid fractions along the wellbore, total gas volume and pit gain vs. time
- Obtaining gas and liquid velocity distribution in the annular space.

Current Work

- Introducing a reservoir and a wellbore (single and two-phase) models
- Introducing a solution procedure for wellbore flow model
- Predicting annular pressure profile, pressure profile at the sensors, pit gain, and velocity distributions from the developed program.
- Introducing a method for early gas detection based on pressure profile curves along the wellbore.

Future Work

- Using a mechanistic model developed for the flow in the annulus
- A more sophisticated time-dependent model for reservoir-wellbore interaction
- Considering ROP
- Taking the wellbore geometry into account

Deliverables

- Advanced influx simulator to observe pressure profiles, detect gas influx and determine its location, volume and movement in the wellbore.
- Matching the model with field data obtained from wire drill string technology
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report.

Project Status

Work Time	2010			2011			2012			Project Status
Deliverables	1-4	5-8	9-12	1-4	5-8	9-12	1-4	5-8	9-12	
Literature Review										30%
Mathematical Modeling										15%
Computer Simulations										10%
Field Data Analysis										0%
Final Report										0%

Buckling & Axial Force Transfer of Buoyancy Assisted Casing

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

Tasks	*Status*
Literature review	70%
Experimental facility design & construction	80%
Experimental data acquisition	-
Data analysis	-
Analytical work	10%
Final report	-

RECENT PROGRESS

To carry out the experimental research, a horizontal buckling facility has been constructed and almost completed. The length of the section that will be tested is 86 feet. Considering the materials and sizes selected for the inner pipe, the expected number of pitches that will be developed during experiments is 4, at least. Experiments will be conducted by varying tubular size and material inside the constraining cylinder with ID of 2”, fluid density in the annular section, rotation and loading speed of tubular.

FUTURE WORK

- At first stage, facility construction will be completed to conduct experiments.
- Analytical study on estimating buckling behavior and axial force transfer of buoyant tubulars in horizontal wellbores will be conducted considering the results from experiments. The expressions for buckling phenomena are directly proportional to bending stiffness and effective weight, this implies that any amount of axial compression force buckles the string immediately as the effective weight of tubular approaches zero. Our approach is to adjust the density of the fluid in order to obtain nearly weightless tubular for 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 and a Final Report

EXECUTIVE SUMMARY
Investigation of cuttings transport in 30~60 degree inclined wells

Investigator: Feifei Zhang, TUDRP

Introduction:

As more ambitious wells are being drilled today, the challenges we are facing require a better understanding of cuttings behavior in the well bore and more accurate predictions of cuttings transport. The cuttings behavior in 30~60 degree inclined wells is special compared to other inclination angles for the following reasons: 1. Above 30 degrees, more particles are forced toward the low side of the annulus and there are dramatic changes in particle behavior; 2. Cuttings beds begin to appear over 30 degrees; 3. At 40~50 degree beds slide downward and may cause stuck pipe as the flow rate decreases.

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.
- Design a series of experiments to study cuttings movement and use these experiments to examine the reliability of the model.

Scope of Work:

The proposed project includes both modeling and experimental work to understand cuttings behavior in 30~60 degree inclined wells. This work can be done in three stages: 1. Build a model based on particles mechanics and convection diffusion to describe particle behavior; 2. Build a model based on layer mechanics to predict the behavior of cuttings beds; 3. Conduct a series of experiments and match the models to the results of the experiments.

Deliverables:

- Modeling particle and cuttings bed behavior in 30~60 degree inclined wells.
- Experimental observations of cuttings transport behavior in 30~60 degree inclined wells and matching the model with experiment results.
- Semi-annual Advisory Board Meeting Progress Reports.
- Final Report.

Tentative Time Table:

	2010		2011						2012	
	9-10	11-12	1-2	3-4	5-6	7-8	9-10	11-12	1-2	3-4
Literature Review	■	■	■	■	■	■	■			
Facility Modification		■	■	■						
Experiments					■	■	■			
Modeling		■	■	■	■	■	■	■		
Data Analysis							■	■	■	
ABM Progress Reports					■		■			
Final Report								■	■	■

Determination Of Viscoelastic Properties Of Drilling Fluids

INVESTIGATOR: BINH BUI

PROBLEM STATEMENT

Most drilling fluids, especially colloidal suspensions and polymer solutions, have viscoelastic properties. Understanding the viscoelastic properties of drilling fluids is of great importance to accurately calculate pressure loss, hole cleaning, cutting transport and suspension of particles, fluid loss control and minimum formation damage. In many cases, the elastic effects are by an order of magnitude larger than the viscous effects. However, we still try to model the effects by viscosity alone and ignore elastic effects. This can lead to significant errors in drilling fluid calculations.

PRACTICAL APPLICATIONS

Determine flow regime.

Calculate frictional pressure loss.

Evaluate cutting transport and cutting suspension ability of drilling fluids.

Reduce fluid loss and fluid invasion into the formation.

Calculate the pressure peak upon starting flow.

OBJECTIVES

Enhance our understanding of viscoelastic properties of drilling fluids and their effects on drilling fluid planning and design.

Measure the linear viscoelastic range (G' and G" values) for drilling fluids at different temperatures, aging times, densities and viscosifying componets.

Develop a database for describing viscoelastic parameters of drilling fluids for practical use.

Propose correlations or models for faster calculation of viscoelastic parameters using a computer.

PROJECT SCOPE

Literature study of viscoelastic properties of drilling fluids and the importance of these properties.

Measure viscoelastic properties of different drilling fluids at varying temperatures and aging times using the Anton Paar Physica MCR 301 Rheometer.

Develop correlations or a model or a database for characterizing and predicting the viscoelastic properties of drilling fluids.

APPROACH

Three stages, including both theoretical and experimental aspects.

Stage one: Literature study on the viscoelastic behavior of drilling fluids and their applications. Set up experimental equipment and collect samples.

Stage two: Measure the viscoelastic parameters of the samples under various conditions.

Stage three: analysize experimental data, propose conclusions and recommendations for determining viscoelastic properties of drilling fluids.

TENTATIVE SCHEDULE

Task \ Time	2010		2011						2012	
	8-10	11-12	1-2	3-4	5-6	7-8	9-10	11-12	1-2	3-5
Literature study										
Experiments and data analysis										
Develop correlations or models										
Final report										