THE UNIVERSITY of TULSA

Department of Petroleum Engineering

DRILLING RESEARCH PROJECTS
ADVISORY BOARD MEETING
May 11th, 2009

EXECUTIVE SUMMARIES

Executive Summaries

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Modeling of Yield-Power-Law Type of Drilling Fluid Loss in Naturally Fractured Reservoirs

Reza Majidi

Modeling of Drilling Fluid Losses in Fractured Formations

INVESTIGATOR: Reza Majidi

SPONSOR: TUDRP

OBJECTIVE:

- To develop mathematical models for fluid losses in fractured formations.
- 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. The effect of drilling fluid rheology on minimizing the losses was studied.
- Including the effect of formation fluid and fluid leak-off in the model for YPL fluid.
- 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.

FUTURE WORK:

- Continue of the modeling in order to distinguish between induced and natural fractures.
- Examine the validity of the provided model with field data. (if available)

DELIVERABLES

- PhD dissertation “Modeling of YPL Drilling Fluid Losses in Fractured Formations.
- VB Program which allows for analysis of mud losses in fractures.
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report.

PROJECT STATUSE:

Past work	Modeling of Natural Fractures	100 %
Literature review	Distinguish between Natural and Induced fracs.	50%
Modeling of Induced fractures	Incorporate the fracture compliance	00 %
Field Data Analysis	Not applicable/available	00 %
final report		00 %

Modeling of Transient Borehole Failure Using Discrete Element Method

Yongfeng Kang

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 the transient borehole failure at simulated conditions;
- To verify the model with field data or published data if available.

STATUS OF PROJECT:

Task	Description	Percentage completed
Literature review	Traditional models	95%
	DEM	80%
Mathematical modeling of DEM	For 2D case For 3D case	95% --%
Computer Simulator Development	For 2D case for 3D case	98% --%
Verification and Improvement	For 2D case for 3D case	30% --%
Final report		--%

RECENT PROGRESS:

- The current simulator was verified with a simple cantilever beam, and the results showed a very good agreement with the analytical solution;
- Pore pressure effects were integrated into the model;
- Simulations were conducted to show the effects of the pore pressure. The results indicates that pore pressure increases the risk of instability. It also shows that a higher permeability formation has a higher risk of instability due to the pore fluid.

FUTURE WORK:

1. Exclude the force of pore pressure due to grain-to-grain contact area;
2. Run the simulation using the new, more powerful TUDRP server. Use more grains for a longer time in 2D case studies and improve the simulator;
3. Use lab/field data as inputs for case studies under the 2D condition and compare the results with lab/field data to improve the simulator
4. Step into the DEM 3D model if possible.

Predicting Dynamic Barite Sag in Oil Based Drilling Fluids

Tan Nguyen

INVESTIGATOR: Tan Nguyen

OBJECTIVE

- Study the effects of oil based drilling fluids rheology on static and dynamic barite sag by using rotational viscometers;
- Experimentally investigate the combined effects of oil base drilling fluids rheology, annular velocity, drill-pipe rotation, eccentricity, and inclination angle on dynamic barite sag;
- Develop mathematical model(s) for predicting dynamic barite sag in Newtonian oil based drilling fluids in horizontal configuration.

SUMMARY

The new Large Indoor Flow Loop (LIFL), which has a 4’’ diameter and 35 feet long transparent test section, was used to conduct tests. The experimental results, which are presented in mass accumulation per unit volume of the test section (for comparison purpose), obtained from the LIFL and the Small Scale Flow Loop (SSFL) will be presented and compared in order to confirm whether or not the results from the SSFL can be extrapolated to obtain results from larger scale flow loop. The results reveal that the data from the small scale flow loop can be used to extend to the larger scale flow loop in the early time at which the settling stage still has a dominant impact compared to the equilibrium stage. However, once the equilibrium stage is approached in the SSFL, the results from the two flow loops are different; particle accumulation per unit volume of the test section in the LIFL is always higher than that in the SSFL.

In this report, the model will examine in depth the effects of solid concentration, flow rate, hindering of particles, and critical solid concentration on barite accumulation in the test section. The modeling results are significantly improved after taking into account the hindering effects and critical solid concentration.

FUTURE WORK

- Exploring dynamic barite sag of Newtonian and non-Newtonian fluids in annuli.
- Bed pickup (bed erosion) is strongly recommended for next steps of this study to have a better understanding of the undesirable density fluctuations during drilling operation. In addition to continuing the work with flow loops, tests conducted with a sag shoe are necessary.
- Studying dynamic barite sag with the presence of cutting.
- Investigating the effect of temperature on dynamic barite sag.

PROJECT STATUS

Tasks	Percentage Accomplished
Literature review	100%
Rheology tests	100%
Dynamic tests without pipe rotation with the SSFL	100%
Dynamic tests with pipe rotation with the SSFL	100%
Modifying the LIFL	100%
Dynamic tests with LIFL	100%
Model development	95%
Final report	90%

EXPECTED COMPLETION DATE: July, 2009

Modeling of Thermal Effects on Wellbore Stability

Duc Nguyen

Modeling of Thermal Effects on Wellbore Stability

Investigator: Duc Nguyen, TUDRP

Introduction:

Wellbore instability is a costly problem, and is especially challenging in high pressure high temperature wells. Deep and deviated wells are becoming more and more common; one needs to understand the behavior of formation rock in order to control the stability of such wells. The responsible factor is the state of stresses, which is influenced by mechanical (in-situ), hydraulic (pore pressure change), and thermal effects. The purpose of this study is to investigate the effect of temperature on wellbore stability under combined conditions (heat transfer with flowing drilling fluid, heat sources generated by mechanical friction, effect of pore pressure on formation temperature profile).

Objectives:

- Enhance our understanding of the thermal effects on wellbore stability.
- Develop a heat transfer model that takes into account the effect of mechanical friction.
- Create a (thermo-poro-elastic) simulator to predict and analyze wellbore stability problems.
- Verify some parameters used in the model by means of experimental investigation.

Project Status:

Literature review	100 %
Wellbore heat transfer model	100 %
Mechanical friction effect	100 %
Wellbore stability model	95 %
Experimental investigation	60 %
Computer simulator	95 %
Final report	85 %

Recent Progress:

- Wellbore hydraulics model for YPL fluid to predict flowing drilling fluid pressure.
- Wellbore stability model that incorporates all sub-models (wellbore trajectory, drag and torque, wellbore heat transfer, wellbore hydraulics).
- Simulation run set up and optimization.

Future Work:

- Finish the computer simulator.
- Carry out parametric study and sensitivity analysis.
- Complete the final report for the project.

Study of Effect of Downhole Mechanical Cleaning Devices on Cuttings Transport

Munawar Sagheer

Study of Effect of Downhole Mechanical Cleaning Devices on Cuttings Transport

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INVESTIGATOR: Munawar Sagheer

OVERVIEW:

With the increase in horizontal and extended-reach drilling, greater emphasis is being placed on effective removal of drilled cuttings out of the well bore. The problems associated with in adequate hole cleaning such as excessive torque, drag, and mechanical pipe sticking have been recognized by the drilling industry for along time. Efficient cutting transport is an important issue in drilling highly deviated and horizontal wells.

Several solutions have been suggested in the literature to address the challenging issue of efficient hole cleaning. These include controlling the drilling fluid rheology and hydraulics, introducing a viscous pill while circulating the drilling fluid, appropriate combinations of drill pipe rotation and eccentricity, adjustment of flow rate, etc. Recently, hydro-mechanical hole cleaning devices (MCDs) have been developed to enhance cutting transport efficiency.

These tools are introduced in the drill string with different spacing arrangements. The tools, or subs, have a modified outer periphery (like blades) and are introduced in the drill string while drilling. While rotating the drill pipe, the blades agitates and scoops the cuttings bed and helps bring the cuttings into suspension. At the same time, the circulation of the drilling fluid allows the suspended cutting particles to be readily carried away, thus leading to better hole cleaning.

RESEARCH OBJECTIVES:

Specific objectives of this research are:

1) To investigate experimentally the effect of MCD on cutting transport under various operating conditions;
2) To evaluate and compare the performances of MCDs;
3) To study transport mechanisms of MCDs under various operating conditions;
4) To simulate the performance of MCDs in large boreholes by using reduced scale testing specimens; and
5) To present an experimental data base for further technology developments.

PRACTICAL APPLICATION:

- Effective removal of drilled cuttings out of the well bore during horizontal and extended-reach drilling.
- Minimize the problems such as excessive torque, drag, mechanical pipe sticking and high ECD due to inadequate hole cleaning.

Cuttings Transport with Foam at Simulated Downhole Conditions- The Effect of Hole Inclination Angle

Jiafu Xu

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 and confirm Duan's measurement;
- Cutting Transport experiments to build a database for further analysis;
- A correlation relationship and a computer simulator to describe cutting transport with foam;

STATUS OF PROJECT:

Mission	Sub Mission	Percentage of Completion
Literature Review		85%
Foam characterization and stability study	Bench top experiments on foam stability study.	100 %
	Foam characterization with FGV	100 %
Cutting transport experiment with ACTF		0%
Correlation relationship development		0%
Modeling and computer simulator	Model building/selection， considering all possible variables	50%
	Computer simulator	30%

RECENT PROGRESS:

- Complete the bench top experiments on foam stability study;
- Maintenance of Foam Generator and Viscometer (FGV);
- Foam characterization experiments with FGV;
- Maintenance of Advanced Cutting Transport Facility (ACTF);

FUTURE WORK:

- Cutting transport experiments with ACTF;
- Model and computer simulator development;

The Effect of Depth of Cuts and RPM on Mechanical Specific Energy

Sandeep Tammineni

Effect of Depths of Cut and RPM on Mechanical Specific Energy

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Investigator: Sandeep Tammineni, TUDRP.

Introduction

The aim of this project is to investigate the effects of Depth of cut and RPM on Drilling Efficiency. With the help of the High Pressure Cell Facility at the University of Tulsa, experiments are performed at various depths of cut and RPM to investigate their effects on Mechanical Specific Energy (MSE) which is a term used for the measure of Drilling efficiency. A mathematical model will be developed and evaluated with the help of experimental results. Temperature measurements at the surface of the cutter will help in quantifying the heat generated in the cutting process.

As the drilling industry aspires for effective ways to increase drilling efficiencies in hard formations, there is a need for better understanding of the cutting process at the micro level. This will result in a better understanding of the factors that affect the rate of penetration.

Objectives

- To provide a mathematical model that predicts cutter forces by taking into account the effect of Depth of cut and RPM on Mechanical Specific Energy (MSE).
- To calculate the MSE at different depths of cut and RPM.
- To calculate the heat lost during the cutting process by temperature measurements at the cutter surface

Research; Scope of work:

The research is divided into two parts:

Part 1: A mathematical model that predicts the forces acting on the cuter taking into account the effect of Depth of Cut and RPM.

Part 2: Experiments to determine the effects on drilling efficiency of various depths of cut and RPM. Temperatures measurements will be taken at the cutter surface using a submersible thermometer. This will allow us to calculate the amount of heat dissipated during the cutting process. Design and manufacture of a new sample holder, and installation of a new thermometer are modifications to the High Pressure Cell Facility.

Deliverables:

1. Mathematical model for predicting the forces at the cutter surface.
2. Experimental results of this study.
3. A Final Report.

Experimental Study on Gelation Phenomena of Synthetic Drilling Fluids

Muzaffer Gokdemir

Experimental Study on Gelation Phenomena of Synthetic Drilling Fluids

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Investigator: Gorkem Gokdemir

The aim of this research is to develop a hydraulic model to determine the pressure in the annulus, incorporating the effects of temperature and aging time on gel strength of Synthetic Based Mud (SBM) and refined with the help of experimental results. Experiments will determine the gel strength of SBM at different temperature and gelling time values. The Dynamic Testing Facility (DTF) will then be used to measure the pump pressure at startup after periods of resting.

Objectives

- To measure the gel strength of SBM with different gelling times and temperatures by using rheometers.
- 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: Using Haake RS 300 Rheometer and Anton Paar Physica MCR301 Rheometer, determine gel strength of synthetic based mud at different temperatures and gelling time. Dynamic testing facility (DTF) will be used to investigate the pump pressure overshoot in the annulus.
Stage2: A hydraulic model of the annulus will be modeled considering the effect of gel strength, temperature and aging time.

Recent Progress

- Literature review on time dependant fluid behavior, yield stress phenomena and measurement techniques, thixotropic and viscoelastic behavior, mathematical models of gel breaking pressures.
- Experimental work on gel strength of SBM with different temperature values and aging times in 0,05 1/s and 5,11 1/s shear rate values.

Future Work

- More stress-overshoot test will be conducted with different aging times and temperatures range to confirm the hypothesis of gel strength value and to develop a gel-strength model including time and temperature effect.
- Dynamic test for pump start-up pressure will be performed in DTF i.e. measuring the gel break pressure by circulating non gelled mud.
- To validate the time dependant behavior of gelled fluids.

Deliverables

- Mathematical Model for predicting the gel breaking pressure along the well trajectory.
- Experimental results of this study.
- Final Report.

Modeling and Simulation of Simultaneous Drilling and Under-reaming

Travis Ellison

EXECUTIVE SUMMARY

Modeling and Simulation of Simultaneous Drilling and Underreaming

Investigator: Travis S. Ellison, Dept. of Mechanical Engineering

Problem Statement

By expanding the borehole significantly beyond bit diameter, concentric underreamers reduce the number of trips made down hole while drilling for oil. Furthermore, the larger hole and tight tolerance casing capabilities ease the processes of inserting and extracting drilling assemblies. However, the different locations of the reamer, bit, and stabilizers along the drillstring result in an uneven distribution of applied surface weight. This causes different stresses between the two cutting surfaces comprised of the bit and reamer. In some cases, the reamer can carry a much greater portion of the load than the bit, resulting in a shortened reamer life span. The opposite can also be true. In addition, the applied weight is of concern, for as it increases a corresponding increase in drillstring stiffness is observed. With these factors in mind, if the conditions are appropriate bottom hole assembly destabilization can occur. Therefore, a predictive numerical model is needed to address the issues concerning bottom hole assembly dynamics.

Research Plan

The commercial finite element code ABAQUS will be utilized to provide both static and dynamic solutions to drillstring mechanical systems. Currently, a 2-D model has been built to determine lateral deflection, side force, and axial load for a slick bottom hole assembly. The model uses beam elements with a cubic formulation and nonlinear geometry. Connectors will attach the bottom hole assembly to ground along the length of the assembly. These will be used to represent the boundary conditions at the bit and reamer locations. Eventually, a 3-D model and perhaps a 4-D model addressing inertial effects will be generated.

Deliverables

A robust and flexible numerical model with the capacity of modeling the dynamic response of a drillstring bottom hole assembly due to the following variables:

- Location and quantity of below reamer stabilizers.
- Location and quantity of above reamer stabilizers.
- Effect of surface weight on bit, inclination angle, and speed (rpm).
- Foundational hardness/stiffness interactions with the reamer and bit.
- Pilot BHA length.
- Pilot hole (bit) and reamer diameters.

Ultimately, an executable piece of software will be delivered to perform the modeling. The model will be mathematically verifiable in its formulation and flexible to adjust to match experimental data. Along with parametric studies, a final report in a M.S. thesis will be delivered.

Experimental Study of Torque Reduction Additives for Extended Reach Drilling

RESEARCH PROPOSAL

Amar Vankadari

Experimental Study of Torque Reduction Additives for Extended Reach Drilling

Investigator: Amar Vankadari, TUDRP

Introduction

In today's world of drilling engineering, extended reach drilling (ERD) has created the revolution in thought and reach by greatly reducing the importance of the vertical wells. With this change from vertical to highly inclined and horizontal extended reach wells we are faced with unique challenges in the management of torque and drag.

For Extended reach drilling (ERD) torque is a crucial factor. With the increasing depths, the requirement of torque also increases. There is a definite need to determine ways to reduce the torque. This proposal 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 facility will be used in experiments to simulate ERD in carrying out these studies.

Objectives

- Experimentally determine the effect of solid additives on torque reduction in extended reach drilling (ERD).
- Determine the optimum volumetric percentage of solid additives required at various specified drilling conditions.

Scope of work

The main objective of the proposed study is to measure frictional torque, which is due to contact force between the drill string and cuttings bed or well bore.

After operational tests involving use of solid additives in the LPAT facility, the project can be envisaged in three stages.

- Baseline measurements with drilling fluid and solid additives.
- Torque measured with drilling fluid and cuttings, including the addition of solid additives.
- Torque measured with drilling fluid and cuttings, but not including the addition of solid additives.

Three drilling parameters are incorporated into the test matrix to simulate practical drilling conditions: volumetric concentration of solid additives, fluid flowrate and RPM.

Deliverables

- Experimental data base, for better understanding of torque reduction using solid additives.
- Recommendations for better management and reduction of torque under different drilling conditions using solid additives.
- Advisory board meeting Progress Reports and a Final report.