THE UNIVERSITY of TULSA

Department of Petroleum Engineering

DRILLING RESEARCH PROJECTS ADVISORY BOARD MEETING

November 10th, 2008

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 Yield-Power-Law Drilling Fluid Losses
In Naturally Fractured Formations

INVESTIGATOR: Reza Majidi

SPONSOR: TUDRP

OBJECTIVE:

- To develop a model for losses of Yield-Power-Law drilling fluids in fractures and validate the proposed model by field data and experimental observations.
- Quantitative analysis of drilling fluid losses in order to characterize the fracture.

PAST WORK:

- Literature review on modeling of drilling mud losses in naturally fractured formations.
- Development of mathematical modeling of fluid loss for Yield Power Law fluids.
- Include the effect of formation fluid properties in the model for YPL fluid.
- Field data analysis of the two loss events.
- Providing experimental setup in order to experimental study of Radial flow of YPL between parallel plates.
- Developing a model for ballooning process (deformable fractures)

PRESENT WORK:

- Experimental observation of the effect of yield stress on ultimate volume of losses.
- Improving the previous model for YPL fluids by including fluid leak-off through fracture walls

DELIVERABLES

- Generalized Model for flow of Yield-Power-Law fluids in fractures.
- Experimental results
- Semi-annual Advisory Board Meeting (ABM) reports and the Final Report.

PROJECT STATUSE:

Literature Review		95 %
Mathematical Modeling	YPL drilling fluid in a deformable fracture	95 %
Experimental study	Radial flow of YPL fluid between parallel plates	80%
Field Data Analysis	Not available-Some data borrowed from literature	90 %
final report		00 %

Modeling of Transient Borehole Failure Using Discrete Element Method

Yongfeng Kang

Study of 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 discrete element concept;
- To develop a computer program to simulate the transient borehole failure at simulated conditions;
- To verify the model with field data or published data.

STATUS OF PROJECT:

Task	Description	Percentage completed
Literature review	Traditional models	95%
	DEM	75%
Mathematical modeling of DEM	For 2D case For 3D case	95% --%
Computer Simulator Development	For 2D case for 3D case	95% --%
Final report		--%

RECENT PROGRESS:

- Simulation speed has been improved by carefully selecting the mathematical operations involved in the computation. Also the structure of the simulator has been tuned up to remove the computational redundancy.
- A new inner-boundary detecting algorithm has been developed and implemented.
- Mud pressure has been considered in the simulation. Simulation results show that higher mud pressure in the wellbore can support the borehole wall, resulting in a stable well for a longer time showing a good agreement with field observation.

FUTURE WORK:

1. Complete the mathematical model of DEM
2. Complete the DEM simulator for 2D case
3. Develop a friendly Graphic User Interface and output GUI.
4. Use real rock data as inputs for case studies under the 2D condition and verify with field data to improve the simulator
5. Step into DEM 3D case

Predicting Dynamic Barite Sag in Oil Based Drilling Fluids

Tan Nguyen

INVESTIGATOR: Tan Nguyen

OBJECTIVES

- Study the effects of oil based drilling fluid rheology on static and dynamic barite sag by using rotational viscometers;
- Experimentally investigate the combined effects of OBM rheology, annular velocity, drill-pipe rotation, eccentricity, and inclination angle on dynamic barite sag;
- Develop mathematical models for predicting dynamic barite sag in Yield Power Law fluid (YPL) in an inclined pipe.

SUMMARY

A new method to measure the change of barite particle concentration in shear flow was applied in this study. Two densitometers were installed at the inlet and outlet of the test section. The differences of these density measurements over time can be converted to the solid accumulation, which will be compared with results from a modeling that was developed for this purpose. The numerical-explicit method was used to solve a set of four coupled non-linear partial differential equations. The model predicts well in the first six minutes but over-predicts after that. The difference suggests the occurrence of erosion in the test section. The model needs to take into account the effects of bed erosion in order to have a better prediction.

FUTURE WORK

- Continue modification of the Large Indoor Flow Loop.
- Obtain data using the LIFL to attempt to validate results of the modeling.
- Expand the model to include settling of barite particles in shear flow Yield Power Law fluids flowing in pipe

PROJECT STATUS

Tasks	**Percentage Accomplished**
Literature review	90%
Rheology tests	90%
Dynamic tests without pipe rotation with the SSFL	100%
Dynamic tests with pipe rotation with the SSFL	100%
Modifying the LIFL	50%
Dynamic tests with LIFL	0%
Model development	50%
Final report	0%

EXPECTED COMPLETION DATE

May, 2009

Modeling of Thermal Effects on Wellbore Stability

Duc Nguyen

EXECUTIVE SUMMARY

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	95 %
Wellbore heat transfer model	100 %
Mechanical friction effect	95 %
Wellbore stability model	80 %
Experimental investigation	30 %
Computer simulator	85 %
Final report	0 %

Recent Progress:

- Thermo-poro-elastic wellbore stability model that takes into account the effect of wellbore drilling fluid temperature and pore pressure changes on the formation temperature profile.
- Facility setup for experimental investigation.

Future Work:

- Complete the numerical model for multi-section directional wells with mechanical friction effects.
- Experimental investigation to estimate heat transfer coefficient.
- Complete the final report for the project.

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

Yuan Ma

Study of Effect of Downhole Mechanical Cleaning Devices on Cuttings Transport

Munawar Sagheer

Study of Effect of Downhole Mechanical Cleaning Devices on Cuttings Transport

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.

Experimental Study and Modeling of Transient Drilling Fluid Gelation

Heitor Lima

EXECUTIVE SUMMARY

Experimental Study and Modeling of Transient Drilling Fluid Gelation

Investigator: Heitor Lima, Petrobras

Introduction

The aim of this project is to develop a model that can predict the pressure required for restarting flow of a thixotropic drilling fluid after the fluid has been at rest. The effects of flow rate, temperature, aging time, and pipe rotation on gel strength breakdown are to be studied experimentally.

The problem is particularly important in deepwater and ultra deepwater drilling operations due to the low temperature the drilling fluid can reach inside the marine riser, causing its viscosity and gel strength undergo a high increase. Depending on the time the drilling fluid is left at rest during drilling operations (such as trips or casing runs), the energy required to break down the fluid solid-like microstructure when resuming circulation can be high enough to fracture the weakest formation in open hole and induce severe lost circulation problems (such as stuck pipe, blowout or even the loss of the well).

Objectives

The specific objectives of this study are: i) to experimentally investigate the thixotropic rheology of Yield Power Law (YPL) (synthetic/polymeric) fluids under different temperatures, shear rates and aging times in order to determine the effects of these parameters on rheological parameters; ii) to investigate experimentally the effects of pipe rotation on the breakdown of gelled YPL (synthetic/polymeric) fluids; iii) to develop a gel-breaking model for YPL (synthetic/polymeric) fluids taking into account temperature, shear rate, and aging time effects; and v) to present recommendations and guidelines for restarting pumps when using YPL (synthetic/polymeric) fluids where drilling conditions demand extra care.

Research Plan

The research was arranged into two phases, with a number of tasks to be accomplished in each phase. Due to time limitations, initially two types of fluids were tested, a polymeric fluid and a synthetic fluid, at the following conditions: i) Temperature (^{o}C): 04, 10, 17, and 24; ii) Shear rate (s^{-1}): 0.05 and 5.11 and iii) Aging time (min): 0.16, 1, 10, 25, 45, 70.

In **Phase I** it is investigated the gel strength development of a polymeric fluid (aqueous Xanthan Gum solution) and of a synthetic-based mud and consists of a literature review, theoretical studies, and rheological tests using two rotational rheometers (RS 300 and MCR 301). **Phase II** will investigate experimentally the effect of pipe rotation on gel strength breakdown at the pump restart using the dynamic test facility (DTF).

Deliverables

A final report comprising the methodology and experimental results of this study.

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

Sandeep Tammineni

EXECUTIVE SUMMARY

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

Investigator: Sandeep Tammineni, TUDRP.

Introduction

As the drilling industry still suffers from low rates of penetration there is a need for better bit design and understanding of appropriate selection of a bit for particular formation. This requires better understanding of the cutting process, including cutter-rock interaction.

The aim of this project is to develop a model that can predict the forces acting on the cutter by taking into account the heat dissipated due to friction, depth of cut and RPM. Experiments on the High Pressure Cell at The University of Tulsa will be carried out to attempt to verify the mathematical model. Experiments will be performed at different depths of cut and RPM to see their effect on Mechanical Specific Energy (MSE). Temperature measurements will be made at the cutter surface to allow calculation of the amount of heat lost while cutting.

Objectives

- Provide a mathematical model that predicts the effect of depth of cut and RPM on MSE.
- Calculate the MSE at different depths of cut and RPM.
- Use temperature measurements at the cutter surface to allow the calculation of heat lost while cutting.
- Provide a video of the cutting process to help understanding of the cutter-rock interaction.

Research Plan

Below is a review of the research plan, which is divided into two parts:
Part1: A mathematical model predicting the forces acting on the cuter, taking into account the effect of depth of cut, RPM and heat lost during the cutting process.
Part2: Experiments at different depths of cut and RPM to see its effect on Mechanical Specific Energy (MSE). Temperature measurements will be made with the help of a submersible thermometer to calculate the amount of heat dissipated during the cutting process.

Progress

The design of the new sample holder has been completed. The sample holder is in the process of being manufactured. The submersible thermometer was received and has been installed.

Deliverables

A final report comprising of a mathematical model and experimental results of this study.

Experimental Study on Gelation Phenomena of Synthetic Drilling Fluids and their Effects on Downhole Pressure Peaks in Ultra Deep Water Scenarios

RESEARCH PROPOSAL

Muzaffer Gokdemir

EXECUTIVE SUMMARY

Experimental Study on Gelation Phenomena of Synthetic Drilling Fluids and its Effect on Downhole Pressure Peaks in Ultra Deepwater Scenario

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

Introduction

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.

The problem is particularly important in deepwater and ultra deepwater drilling operations where the mud column inside the riser have tendency to form severe gel buildup aggravated by the low temperature observed at sea bed, causing its viscosity and gel strength to increase. The energy required to break the fluid microstructure can be high enough to fracture the weak formation in the open hole inducing lost circulation.

Objectives

(1) To measure the gel strength of SBM with different gelling times and temperatures by using rheometers.

(2) To measure the effect of breaking gel strength on pump pressure, this can be determined using the Dynamic Testing Facility (DTF) at TUDRP .

(3) To provide a hydraulic model to predict the pressures along the well trajectory, using the experimental results to validate and refine the model

Research Plan

The research is divided into two stages:

Stage 1:, Determine gel strength of synthetic based mud at different temperatures and gelling time, using ThermoHaake RS 300 Rheometer and Anton-Paar Physica MCR 301 Rheometer. The 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 developed considering the effect of gel strength, temperature and aging time.

Deliverables

A final report comprising the mathematical model and experimental results obtained from this study.

Modeling and Simulation of Simultaneous Drilling and Under-reaming

Jeremy Daily

EXECUTIVE SUMMARY

Modeling and Simulation of Simultaneous Drilling and Underreaming

Investigator: Jeremy Daily, Dept. of Mechanical Engineering

Problem Statement

Concentric underreamer tools have the ability to reduce the number of trips down hole by drilling final diameter holes following a pilot hole. The larger hole provides the ability to use tight tolerance casings and provides an easier hole to insert and extract drilling assemblies. However, the two different cutting surfaces distribute the surface applied weight on bit in different proportions according to the stiffness of the different rock formations and cutting abilities. The consequence of the different proportions is the potential for destabilization of the bottom hole assembly during the drilling process. An important issue is understanding the effect of the distribution of the applied weight from the surface to the two cutting surfaces. Therefore, a predictive numerical model is needed to address the issues concerning the dynamics of the bottom hole assembly.

Research Plan

A flexible finite element model using the commercial code ABAQUS will provide solutions to both static and dynamic drillstring mechanics problems. A 2-D model has been built and verified in ABAQUS that shows agreement for lateral deflection under axial load, natural frequencies, and mode shapes. The model uses cubic beam elements with non-linear geometry and linear springs representing the boundary conditions at the location of the bit and the reamer. The project is in the beginning phases and shows great promise and is ready for a graduate student to implement the 3-D model.

Deliverables

A flexible numerical model capable of modeling the dynamic (harmonic) response of a drillstring bottom hole assembly due to following variables is the overall goal of this phase of the project:

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

The model should be verifiable in regards to the mathematical formulation and tunable so results can match experimental data. Ultimately, an executable piece of software will be delivered to perform the modeling.