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Automatic Calibration of Real-Time Computer Models in Intelligent Drilling Control Systems - Results From a North Sea Field Trial

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Abstract

Many real-time decision support systems for drilling operations, or advanced drilling control systems, are based on computer models calculating wellbore pressure and mechanical forces on the drillstring. Closed loop control systems, for example for Managed Pressure Drilling, or advanced offshore or onshore decision support systems are examples of systems that may involve such real-time calculations. To obtain a high degree of accuracy in these calculations it is crucial that all parameters describing the system are as correct as possible. Uncertain model parameters may be tuned against measurements. Both surface measurements, like standpipe pressure, hook load and torque, and downhole pressure from Measurement While Drilling tool may be used.

Recently, a field trial of such a real-time system with advanced computer models has been performed during a drilling operation in the North Sea. An advanced drilling control system were implemented and tested. The control system includes real-time calculation of both hydraulics and mechanical forces. Key model parameters were tuned using different estimation techniques.

The presented methodology for calibration of real-time computer models lead to a more accurate estimation of the status of the well flow and the stresses on the drill-string compared to standard methods, which may be crucial for the performance of real-time decision support systems or advanced drilling control systems. The performance of the calibration methods is studied using results from the North Sea drilling operation. Although the presented results are obtained from a conventional drilling operation this methodology has a broad range of applications. Benefits by this approach are seen by more accurate calculations of downhole hydraulics and stress which are of major importance for safety and economic reasons during drilling operations involving real-time decision support systems or advanced drilling control systems.

In the near future application of wired pipe technology will supply advanced real-time systems with more reliable downhole measurements and the possibility of distributed sensors. Given the appropriate calibration techniques, this step-changing technology will lead to better accuracy of estimated state and also forward simulations.

Introduction

When petroleum reserves are found in areas with narrow sub-surface pressure margins, the wells being planned are more challenging to drill. Due to these challenges, the drilling crew requires more information about the well during the actual drilling operation. Information from the process are typically gathered from sensor at the platform level, such as standpipe pump pressure and main pump drilling fluid volume rate.

In addition to these topside measurements, there are also Measurement-While-Drilling (MWD) sensors available that collects data from the bottom hole assembly (BHA), giving information about downhole pressure and temperatures. Data from the MWD-system are typically not available in situations with low or zero drilling fluid flow rate, due to the mud pulse telemetry system that require a certain fluid flow rate to be in operation. In addition, data such a downhole pressure measurements are typically transmitted only every 30 second. A new high-speed telemetry system is now commercially available, giving the possibility of accessing the data at a higher rate and with less transmission noise, [1] and [2].

The need for even more information about the downhole situation has led to development of detailed hydraulic models that can be calibrated using available measurements. Such detailed models require input of the current operating condition of the various rig equipments, such as drilling fluid temperature, drilling fluid density and drilling fluid volume rate. In addition, less dynamic values such as the well geometry and drillstring layout should also be known to be able to perform the fluid flow rate