Definition of MPD (SPE/IADC):
Managed Pressure Drilling is an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly.

Statoil has applied automated MPD at fixed platforms in the North Sea since 2007 and R&D is now working on qualifying an MPD solution for floating drilling vessels operating in the rough North Sea environment with severe heave motion. Two major activities have been identified:
1) A sealing device for pressurizing the annulus between the drill pipe and the riser
2) An automatic control system that can provide near constant downhole pressure at all times compensating for drill pipe motion, rotation and varying mud rates.

The seal and the control system are enabling technologies for closed loop drilling into challenging reservoirs from Mobile Offshore Drilling Units (MODU) in shallow to medium water depth subsea wells, and will in addition cut cost for drilling from fixed rigs at the Norwegian Continental Shelf and world wide. The potential is significant and is assumed to be in the billion NOK range for Statoil alone.

Sealing device
Statoil R&D has financed the development of a sealing device. The seal will be located on top of the subsea blowout preventer, such that the low pressure drilling riser is not exposed to well pressure.

The development is divided in two phases:
1) Develop a pressure control device (PCD) that can be used on drilling rigs on land and fixed installations – located on top of the blowout preventer on the rig.
2) Fully develop the riser pressure control device system (RPCD) for a (MODU).

The development is done in cooperation with Siem WIS AS, a company 60% owned by Siem Offshore, who holds the patent rights and will now start to market the PCD product with Statoil as a possible first user.

The sealing system includes direct lubrication to the sealing surfaces and gradient chambers to distribute the pressure over several seals. The operator will at all times know if there is a leak in the system. The body houses the seal cartridge and gives access to the sealing and gradient system.

Control system
Drilling has been dominated by manual control. Narrow drilling windows require a fast and accurate control of the downhole pressure that is difficult to achieve with manual control. Statoil R&D has developed internally a closed loop control system for MPD during the last two years. A mathematical hydraulic model of the well is used to estimate the downhole pressure in real time and a nonlinear control algorithm adjusts a choke on the mud return flow to provide near constant downhole pressure at all times compensating for drill pipe motion, rotation and varying mud rates.

A comprehensive test program was set up for two weeks testing at Ullrigg in week 46 and 47 in 2009. The objectives were to test both the sealing device and the control system with realistic normal drilling operations and critical operations similar to the testing that has been done for the automatic MPD operations at Kvitebjørn (from 2007) and Gullfaks C (2009).
Several extra tests simulating severe heave motion were added to gain experience relevant to MPD for floaters.

It was agreed by Statoil experts that a test of the PCD at Ullrigg, IRIS full size test rig in Stavanger, is equal to a pilot test on an offshore platform rig. The seal performed exceptionally and exceeded all expectations. The final wear out test was performed with drill string rotation of 200 rotations per minute and with drill pipe speed exceeding 3.6 km/hour (1 m/s), and pressure up to 100 bar. The seal was proven fit for purpose to be used in a PCD and an RPCD. The test of the control system was successful and proved that it is fit for purpose with ± 2.5 bar accuracy for most of the tests, and improved performance during connections and drill string movements. The test results gave valuable input to further improvements, in particular for compensation of heave motion.

Conclusion and further work
Further development of the seal is planned with phase 2, where the challenge is to make the seal fit into a drilling riser. Statoil intend to use the PCD version of the seal as an alternative to existing solutions in the market for platform MPD operations.

The control system will be developed further for industrial use with full functionality.

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