Modified automated pressure-control technology offers smaller footprint for land MPD operations

By Don Reitsma, Paul Fredericks, At Balance; Roger Suter, M-I SWACO

THE VALUE OF automated managed pressure drilling (MPD) technology in offshore operations can be measured by the impact it has had on economic drillability. It has demonstrated the ability to solve real world pressure problems that have blocked redevelopment of deepwater depleted fields and exploration of hazardous shallow gas. As its offshore use continues to grow, automated MPD is also emerging as an onshore drilling solution for operators seeking the same practical benefits: eliminate lost circulation and ballooning, reduce NPT time, and drill technically challenging wells.

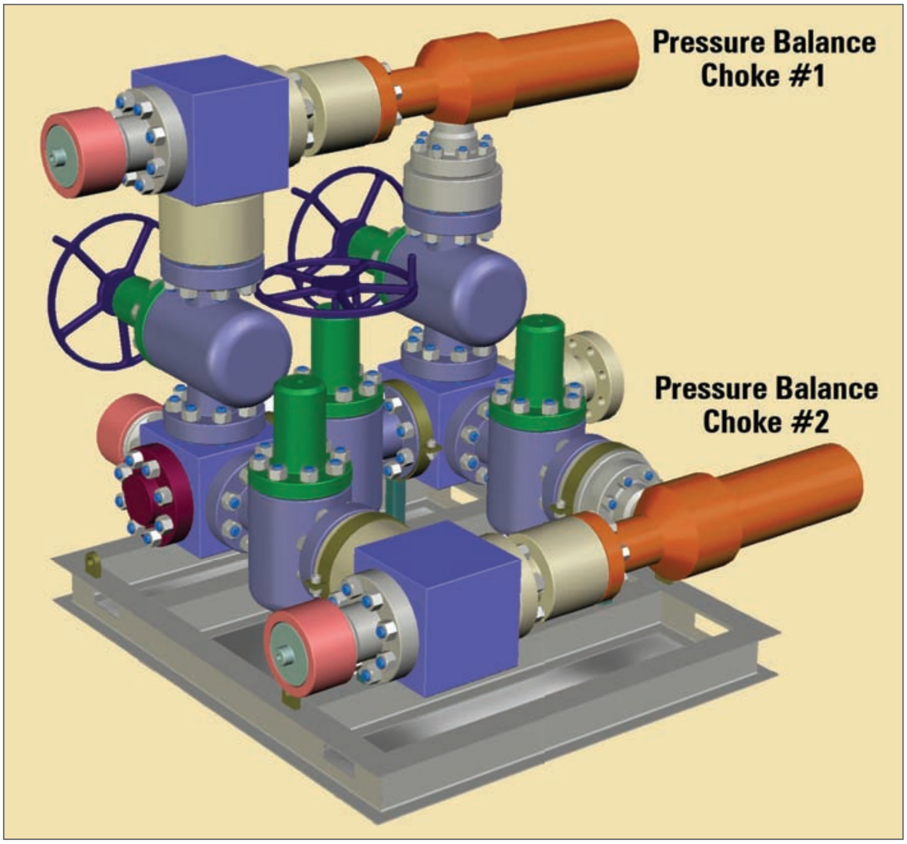
In the context of this article, an automated MPD system is one that automatically manages backpressure to control the BHP at a predetermined setpoint in the well. It has the ability to dynamically stabilize BHP during routine transitions and unexpected fluctuations due to changes in pump rate, rotary speed or pipe movement. It also has a real-time hydraulics model integrated with safety-critical, process control technology to maintain BHP within narrow limits.

An automated MPD system designed for offshore operations embodies features that make it cumbersome and unwieldy on land. Mobility rules on land, where trucking, road conditions and terrain can stymie an otherwise effective service. Onshore conditions favor small systems, quick deployment, safe handling and easy installation.

Previously, onshore operators seeking automated managed pressure drilling had to use offshore MPD systems or underbalanced drilling systems, neither of which are optimal long-term solutions for MPD on land. **At Balance** has developed an MPD system for land based on its offshore Dynamic Annular Pressure Control (DAPC) system. In development since last year, the system recently completed its fourth trial, in which it successfully controlled BHP through a depleted zone drilled with a liner.

DESIGN OBJECTIVES

The three main components of the DAPC system are a choke manifold, an on-demand backpressure pump and an integrated pressure manager. Additional equipment includes flow meter, control cabin, maintenance container and generator.



MPD systems for offshore use are often too cumbersome for land. The above shows an engineering drawing of a compact choke manifold for the land DAPC system. The two redundant pressure balance Super AutoChokes are in an "L" configuration to reduce the overall footprint. Manual gate valves reduce the hydraulic power requirements.

In the offshore manifold, there are three chokes: two redundant main chokes and one auxiliary choke. The auxiliary choke is used to manage pressure during transitions from rig pumps on to rig pumps off, and several hydraulically operated valves.

After reviewing the requirements for onshore MPD operations, three principal design objectives were identified for the land system:

1. Improve response speed and accuracy.

2. Reduce the footprint.

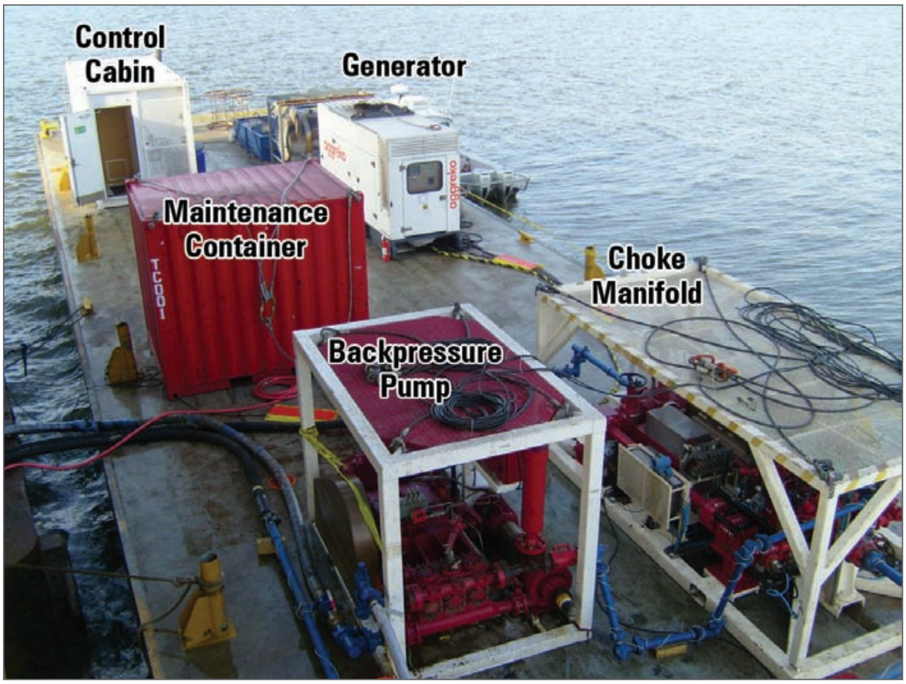
3. Improve system mobility for rapid deployment.

Early on, the development team focused on the two components with the greatest impact on response speed and accuracy — the choke and process control system. It was clear that these components were not only key to improving speed and accuracy but also size and mobility.

THE CHOKES

The first stage of development started with a review of choke technology. The DAPC manifold currently uses position chokes, which are typically used in MPD systems. They provide precise gate position according to their published CV curve and continuous pressure control, and they can be reliably operated with hydraulic or manual force. However, their maximum stroke speed is limited to 17-20 seconds due to mechanical design and the method used to measure choke position.

In their search for a faster acting choke, the team turned to the pressure balanced Super AutoChoke (SAC) from **M-I SWACO**. The SAC has the ability to automatically regulate pressure and



The offshore DAPC system is seen rigged up on a barge in Louisiana waters. The pump and manifold are each rated for Div 1 Zone 2 operations and skid-mounted on DNV-certified crash frames. The control cabin is purged and A60 certified.

close very quickly — in 5 seconds or less. A prototype manifold was built with two SACs but without the transition choke leg. It included manual gate valves to reduce the hydraulic requirements.

Between September and December 2006, it was tested with the DAPC controller at the Louisiana State University Well Control Center. In a series of tests with and without a backpressure pump, at pump rates up to 200 gpm, and during pump rate changes faster than the normal pump on/off times, the system was able to maintain the programmed backpressure with minimal fluctuations.

However, even though the pressure-balanced choke was very responsive, it was unable to trap 100% of the pressure during rapid pump rate changes, which confirmed the need for the backpressure pump.

Field testing started in early 2007, and since then, the system has managed pressure in four land-based Texas wells.

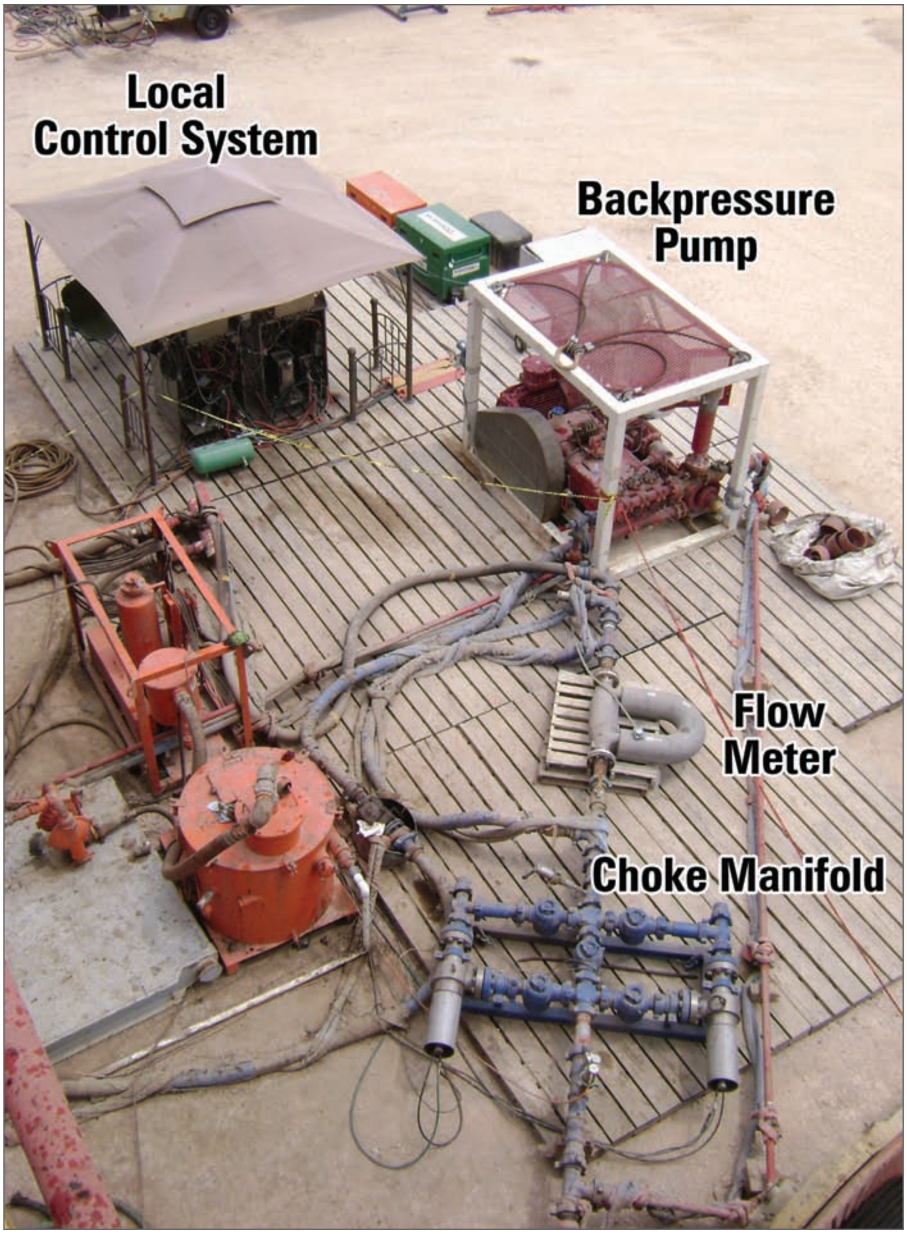
The first well was drilled in Wharton County, Texas, where the new manifold was combined with the DAPC control system to manage pressure in an 8.5-in. wildcat gas well over a 2,550-ft vertical interval drilled with oil-base mud down to 17,000 ft.

This area is notorious for its narrow margin between pore pressure and fracture gradient, which prevented all but one of five previous wells from reaching their planned casing point. Without MPD, other operators were forced to use high mud weight to control gas influx and deal with the resulting high equivalent circulating density (ECD), which caused lost returns in all five of the previously drilled wells, kicks in two, stuck pipe in one, and a well control event in one that eventually had to be sidetracked.

During this job, the DAPC system's role was to stabilize the pressure during the transition from drilling to connection and accurately control the BHP during the connection. The transitions were complicated by the direct drive mud pumps, which would go from zero to 225 gpm in a matter of seconds.

Over the interval, the mud weight, which ranged from 16.0 ppg at the start to 16.8 ppg at the end, was used to maintain the ECD at or just above pore pressure. During connections, the DAPC system was used to control the BHP within 0.1 – 0.2 ppg of pore pressure. While positive and negative pressure spikes did occur due to the instantaneous flow on and off from the direct drive pump, the system proved capable of stabilizing the pressure in less than 30 seconds.

From beginning to end, the average time to make a connection went from 10-12 minutes at the start to 3-4 minutes at the end, demonstrating the system's fast-acting capability.



The prototype automated MPD system, rigged up on a south Texas land location, shows the compact manifold with two pressure-balanced chokes, coriolis flow meter, backpressure pump and local control system. Not shown are the accumulator, generator, and DAPC control system, which was housed in the crew's trailer on location.

The operator reached his planned casing point with minimal influx during the connections, and although partial losses did occur for a short time, primarily due to unnecessary mud weight increase, there were no well control events, stuck pipe or losses.

In the next phase of testing, the system was deployed to a land rig located in Hidalgo County, Texas (as seen in the photo above), where it was used to manage pressure in three Frio gas wells.

The third well in the program was an industry first because it was the first time an automated MPD system was used to manage pressure while drilling in with a liner. Liner drilling allowed the operator to reduce the mud weight and immediately case off the depleted sands while keeping the higher-pressure gas sands open.

The DAPC control system and pressure-balanced choke manifold were used to automatically manage the pressure in an 8.5-in. hole drilled with a 7-in. liner through a gas sand that was expected to be depleted between 2,000-4,000 psi.

Using the DAPC system to manage pressure, the operator drilled the liner to the planned casing point, and while drilling avoided the losses experienced in conventionally drilled offset wells. However, after successfully drilling the liner to the planned casing point, a loss of rig air caused the chokes to open, which resulted in a gas kick. After going into well control mode and circulating out the gas, the rig successfully cemented the liner in place.

There were many lessons learned during this drilling program, all of which were applied on each subsequent well. Over the course of the three wells, improvements were made to the manifold operation, pressure control procedures and surface piping.

In future wells, the operator will continue to drill in with liner and manage pressure with the DAPC system, which will be upgraded with a redesigned compact choke manifold and process control system.

PROCESS CONTROL SYSTEM

Concurrent but separate development projects have been under way to improve the speed and accuracy of the process control system.

In the first development stage, process improvements were made to the existing control system to give it more direct control of the pressure with the manifold. With direct control, the system no longer needs the transition choke leg, which enables faster transitions and connections and more accurate control.

Used on more than five jobs in the Gulf of Mexico, the new control system has been able to reduce the transition and total connection times by a factor of three. In addition, the system improved its ability to control BHP in much smaller windows, between two to three times smaller than was possible with the previous control system.

In another long-term development project, under way since last year, more extensive work has been done to improve the efficiency, speed and modularity of the process control system specifically for the land-based system.

The new land-based DAPC system will include faster-acting pressure-balanced chokes, a more mobile and compact manifold, and a faster and more accurate process control system. With it, At Balance will be able to deliver the benefits of automated MPD to land drilling operators anywhere in the world.