New-Generation Drill Barge for Deep HP/HT Wells

The full-length paper details the re-engineering of a conventional deep-drilling barge rig to deliver a new-generation high-pressure/high-temperature (HP/HT)/high-flow barge rig designed for increased reliability and specification for deep-gas-drilling programs in the U.S. Gulf Coast region. Upgrading the main power and distribution systems and high-performance pump configuration is discussed as well as auxiliary-system modifications.

Introduction

Although heavily explored since the 1920s, the onshore Miocene of south Louisiana has produced more economic discoveries in the past 10 years than the Flex Trend subsalt play. More-recent Miocene discoveries are deep, geopressured, and contain reservoirs that are not associated with seismic amplitude. Large discoveries have been on faulted anticlines found with the aid of detailed regional maps using well logs, biostratigraphy, and 2D-seismic data. Exploration of this play has expanded into the shallow-water shelf, which to date has produced more than 40 billion bbl of oil equivalent.

Optimizing drilling performance and well control for the well design requires the right drilling rig. New-generation jackup rigs are designed for shallow-water deep gas but have draft limitations in certain areas of interest. As exploration of deep targets expands in water depths from 6 to 18 ft, the availability and performance of ultradeep barge rigs becomes increasingly valuable. The marketable Gulf of Mexico (GOM) deep-drilling-barge fleet consists of 32 rigs. Of these, few are rated to 30,000 ft. Deep gas exploration is an area of particular interest for the barge-rig market because successful exploration results could drive demand higher and diversify specification requirements of the fleet.

Leveraging previous frontier rig designs and customer demand to mitigate the higher drilling risks of planned deep exploration targets, a project to upgrade *Barge Rig 76 B* in New Iberia, Louisiana, was undertaken to deliver a new-generation HP/HT and high-flow barge rig to execute these challenging drilling programs.

This article, written by Assistant Technology Editor Karen Bybee, contains highlights of paper SPE 99210, "Re-Engineering Barge Drilling for Deep Miocene HP/HT Frontiers in a Mature Basin," by ***F.J. Husband,*** *SPE,* ***G. Bitar,*** *SPE,* ***T. Begnaud,*** *SPE, and* ***T. Petticrew,*** *Parker Drilling Co., prepared for the 2006 IADC/SPE Drilling Conference, Miami, Florida, 21–23 February.*

Mud Pumps and System

Barge Rig 76 B previously operated three 5,000-psi A1700-PT pumps. However, rig power distribution was challenged to run all three pumps simultaneously. These were replaced with 2,200-hp W-2215 pumps each driven by two high-torque 752 DC traction motors and powered by four runs of number 535 cable. The pumps are rated for 7,500-psi maximum operating pressure and weigh 115,000 lbm each. The main structure in the pump room was modified to accommodate the increased weight.

The existing 5,000-psi piping and valves were replaced with 7,500-psi components. Most assemblies were prefabricated, tested, and painted at supplier facilities before installation and integration testing in the shipyard. This reduced installation time and final integration-testing time, and it streamlined troubleshooting. This was especially true for high-pressure piping that required specialized welding procedures, inspection, and pressure testing before installation. Equipment packages also were tested to maximum operating parameters at supplier facilities before installation on the rig. The low-pressure mud system was modified with a new suction manifold and associated piping.

Because of the anticipated higher penetration rates, simultaneous operation of three pumps, and large hole sections, modification of the mud-cleaning system was paramount. To achieve higher capacity and efficiency, a fourth shaker was added, existing shakers were refurbished, and conventional motors were replaced with high-G-force models. The mud-return-line diameter was increased for the higher anticipated mud flow. The mud trough also was replaced with larger-capacity flow areas.

Power Generation and Distribution

Rig power and distribution was optimized for uninterrupted, simultaneous operation of mud pumps, drawworks, and top drive. Engines were replaced with three turbocharged 2,850-hp, 900-rev/min units. The three new 16-645-E generators are equipped with remote detection to monitor stator and bearing operating parameters. On the basis of heat-dissipation and air-supply requirement for the turbochargers, ventilation, heat-removal, and water-cooling systems all were modified to meet the requirements of the new engines.

Digital switchgear and silicon-controlled rectifier (SCR) systems were installed because of advanced control and improved troubleshooting packages compared to the previous analog system. SCR controllers are preprogrammed with self-diagnostics and various operating modes, optimizing power performance and loading. With a rugged bus-system link from the SCR to the driller console, all previous cabling was replaced with a single run of fiber-optic cable. Increased air-conditioning capacity was required to improve efficiency and reliability of the SCR units, and to provide redundancy. The new system consists of four generator-control cubicles, five SCR cubicles, and one programmable-logic controller (PLC)/ service cabinet. To resolve previous overloading situations and improve reliability, 750-kVA transformers were replaced with 1,250-kVA transformers.

Unique Rig Features

The 18-ft hull allows operation in high wind and waves. Conventional barge rigs are designated "right handed" or "left handed" on the basis of the starboard or port location of the heaviest-capacity crane. *Barge Rig 76 B* is equipped with two 40-ton hydraulic cranes positioned on both sides of the deck. This allows lifting operations on either side of the barge in high-wind or -wave conditions, reducing downtime and facilitating safe hoisting on the windward side of the vessel.

While there are a number of barge rigs capable of drilling in shallow waters, only a few in the GOM are capable of drilling deeper than 20,000 ft because of deep large-hole casing programs and high pressures required to drive bottomhole assemblies. A key element is drillpipe size. In deep wells, pressure loss in the drillstring significantly affects hydraulic force available at the bit. Because pressure loss in 5$^1/_2$-in. drillpipe is 38 to 40% less than in 5-in. pipe for the same flow rate in deep sections, 5$^1/_2$-in. drillpipe is deployed on the rig. The higher-pressure flow system on *Barge Rig 76 B* safely delivers the required flow with 5$^1/_2$-in. drillpipe, precluding the need for a 6$^5/_8$-in. string often used for high flow and associated special handling equipment. *Barge Rig 76 B* combines 7,500-psi fluid ends, 6$^1/_2$- to 9-in. liners, and 2,200-hp W-2215 triplex pumps to deliver flows of 1,200 to 1,500 gal/min. The larger-sized pumps enable either simultaneous three-pump or two-pump variation, while still delivering the required performance.

Total mud volume is 1,200 bbl in the pits and a 300-bbl mud-processing system for a total of 1,500 bbl. The configuration is unique in that 200 to 1,200 bbl can be isolated, depending on operations required. In the event more volume is required, additional supply barges can be contracted to expand mud-storage capacity. Dual, high-pressure standpipes increase reliability with redundancy, but also provide a means to service the standpipe outside the critical path when changing over fluids.

Typical casing programs in deep wells include long sections of 13$^5/_8$ in., which requires high-capacity hookload. *Barge Rig 76 B* is designed with sufficient structural capacity to allow simultaneous casing load and drillpipe setback. This feature eliminates the need to lay down pipe when the intermediate string is run. If a problem occurs while running casing, there is no need to lay down the string and then pick drillpipe back up because it is set back in the derrick. Increased crane capacity also allows the rig to lift a completely assembled drive hammer to run 36-in. conductor, whereas most barge rigs have to rig up the hammer in sections because of crane-capacity limitations.

PLCs in combination with a digital SCR system reduce interlock wiring, which optimizes space and improves the troubleshooting process. The engine design was built with the objective of delivering 1,200- to 1,500-gal/min flow rates, 6,500-psi operations, 24,000 ft-lbf of torque, simultaneous operation of three large pumps, and all auxiliary drilling equipment running. The design included turbocharging all three engines. This allowed installation of three 2,850-hp engines vs. four 2,100-hp models, effectively reducing space requirements and system maintenance. Any reduction of equipment packages and associated lower net weight improves barge draft for maneuvering in shallow inland waterways.

All new digital control and SCR components were installed in the same space as previous analog control systems, avoiding additional space requirements. Power-monitoring and fault-indicator stations are centralized in the SCR house. These digital SCR systems have been in use in deepwater operations, but *Barge Rig 76 B* is the first barge rig with this feature. Digital power control allows switching generators without affecting drilling operations.

Initial Results

After final testing and commissioning of upgrades, the first deep exploration well was drilled with the modified rig at Louisiana State Lease 340 in Iberia Parish, close to the JB Mountain and Mound Point offset discoveries. The formations are characterized by reactive shale and alternating sand layers. Oil-based mud was used starting in the intermediate section. The bottomhole assembly included a rotary-steerable directional system with measurement-while-drilling/logging-while-drilling real-time transmission. Deep Miocene wells are considered hydrogen sulfide (H_2S) operations once the intermediate string is set. All personnel on board underwent H_2S and breathing-apparatus training on site. For well control, drilling started with 30-in. blowout preventers, then reduced to 16$^3/_4$ in. in the intermediate section.

While drilling the first well, some problems were experienced with the newly installed top-drive torque boost, SCR-ventilation system, and choke manifold flanges. SCR-system overheating was solved by rearranging air-fan configurations. Equipment problems were addressed with on-site supplier and shore-based technical support. Wellbore problems encountered while drilling included tight spots and lost returns, which were addressed with reaming runs and high-viscosity-gel sweeps. The initial well was drilled under the planned time with no lost-time injuries or environmental incidents.

A second deep well was drilled with the rig in South Marsh Island 224. Underreamers and extended-power downhole motors were used to execute the casing program and improve drilling performance in this vertical well. Mud motors were run in vertical sections allowing relatively low rotary speed at the rotary but more than 200 rev/min downhole at the bit. This reduces wear on the top drive and drillpipe in addition to increasing penetration rates. A 9$^7/_8$-in. motor was used in the intermediate section in combination with a short-gauge polycrystalline-diamond compact bit for high-performance drilling. Since commissioning the rig and starting drilling operations in first quarter 2005, the rig has operated 144,000 total man-hours with a total recordable incident rate below the average for the area. **JPT**