FLUID POWER
a Critical Factor in OFFSHORE ENGINEERING

When you are standing at the gas pump fueling up (insert your preferred vehicle type here) do you ever wonder how the gasoline or diesel got there? Most are aware that the gas station doesn't make the fuel, but rather it is processed from crude in a refinery and that it was the product of drilling either on land or increasingly, offshore. Have you ever really thought about how the oil is drilled for and the equipment used to bring it to the surface? Have you ever considered the technology that makes this happen?

Pipe Racker

By Rance Herren, CFPS
National Oilwell Varco

Offshore drilling– where the drilling rig is not physically situated over land first – began around 1891 in the shallow freshwater of a man-made reservoir in Ohio. Saltwater wells were first drilled around 1896 in the Summerland fields of California on top of piers extending some 300 feet from the beach into the Santa Barbara Channel. Over the next few decades and as technology increased, offshore drilling continued in such places as the Canadian side of Lake Erie and Caddo Lake in Louisiana. Shortly after the turn of the century, the first coastal wells began appearing off the gulf coast of Texas and Louisiana. Through the ensuing decades, drilling activity grew in the shallow continental shelf areas in the Gulf of Mexico, particularly in the waters off the Louisiana coast. To that point, however, all of the wells drilled were well within the sight of land.

In 1947, the Kerr-McGee Corporation drilled the first well out of the sight of land from a built-for-purpose fixed barge and platform in 20 feet of water. Within a couple of years, over a dozen fields were discovered in the Gulf of Mexico marking the beginning of the modern offshore drilling industry. Today, offshore drilling in locations hundreds of miles from shore and in thousands of feet of water are routinely and extensively found in the Gulf of Mexico, Newfoundland and Nova Scotia, the coasts of Brazil and Venezuela, the North Sea, Persian Gulf, Southeast Asia, Russia, and West Africa. New seismic technology allows geologists to accurately locate oil reservoirs that have been previously undetectable. Advances in rig design and drilling techniques allow wells to be drilled in locations at one time considered impossible due to the difficulty of reaching them and the prohibitive high cost associated with such an endeavor. Increasingly, these oil reservoirs are being found in offshore areas known as ultra deep water – depths of up to 10,000 feet before the drill bit contacts the ocean floor with drilling distances thereafter of over two miles. The effort to recover crude from these depths is enormous, but new technology and innovation continue to make this possible.

Perhaps the most enduring of technologies used in the drilling for oil and gas is fluid power. There is scarcely a piece of equipment found on any offshore rig that does not include hydraulic and pneumatic technology of some sort – from the most basic circuit manually operating a fluid motor driven winch to ultra-sophisticated closed-loop position, velocity and force feedback systems – controlled via SCADA (Supervisor Control and Data Acquisition) platforms and communicating over digital bus networks complete with zone management and anti-collision detection. Equipment utilizing hydraulic and pneumatic systems, coupled with variable frequency drives, electrohydraulic controls, motion controllers, electromechanical actuators, and programmable logic controllers are becoming commonplace in the industry. Coupled with other advanced technologies, fluid power is most often the control medium of choice. Modern drilling rigs are textbook examples of mechatronics in all of its glory.

In offshore drilling, there are many types of equipment used in the drilling process, both above and below the waterline. Rig floor equipment is used to handle the drill pipe and actually create the well bore. Modern offshore drilling rigs typically utilize what is commonly known as a Top Drive. The top drive provides the rotational power to turn the drill string – which are multiple sections of pipe that are connected together with the drilling bit attached at the opposite end. Although in most offshore applications the main rotary drive is electro-mechanical, top drives are rich with hydraulic and pneumatic systems; some even have fully integrated and self-contained hydraulic power units.

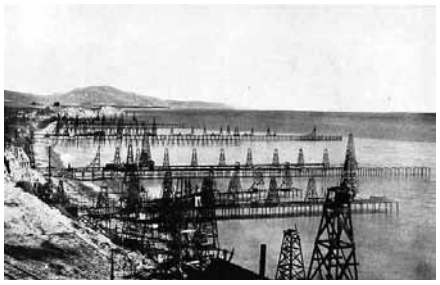
Iron Roughnecks are machines used to join one piece of drill pipe to another using low speed, high torque motors in what is commonly called a "spinning wrench" to spin in and shoulder a connection. The final part of the sequence uses hydraulic cylinders in a wrench of sorts to clamp on and torque the connection to a predetermined value. Although many modern iron roughnecks are manually controlled, a large and increasing number of designs are fully automated and include closed-loop electrohydraulic controls to minimize cycle time and to increase efficiency and repeatability.

Moving drill pipe to and from storage areas and the well center requires the use of various types of pipe handling equipment. These can range from simple belt driven conveyors using radial piston or gerotor motors to complex cylinder actuated horizontal to vertical systems and multi-axis robotic racking machines that manipulate pipe about the drill floor. Again, using closed-loop electrohydraulic and mechanical systems, these machines are maximized for efficiency and safety.

Drill ships and semi-submersible drilling rigs have motion compensation equipment fit with multiple accumulators and banks of auxiliary nitrogen gas bottles to control very large bore and stroke hydraulic cylinders. The accumulators provide for high instantaneous flows and shock absorption, stroking the cylinders to compensate for vertical movement of the rig due to wave-induced heave so that the weight of the drill string on the bit at the bottom of the well bore remains relatively constant.

The challenges of offshore drilling are numerous. Not the least of these challenges are any of the otherwise normal installation, commissioning, maintenance, or repair issues that any piece of mobile or industrial machinery is likely to have. Now consider dealing with those same kinds of issues when that equipment is situated offshore, anywhere from a few to several hundred miles, where even procuring a simple o-ring to repair a leaky valve becomes a major ordeal. The logistics can be incredible. Equipment used in offshore applications is routinely subject to the most demanding requirements in the harshest of environments. Once on contract to drill, the rig and the supporting machinery are many times operating at a 100% duty cycle for days or weeks on end. The most sophisticated of rigs capable of drilling the deepest wells command rates of $400,000 to $500,000 (and historically even higher) per day. Rig uptime is critical, and the impacted cost of equipment failure can be staggering.

The technology driving the petroleum industry today is a direct re-



Top Left and Right: Early Offshore Drilling Rigs
Bottom Left: Top Drive
Bottom Right: Modern Offshore Drilling Rig

Top: Iron Roughneck
Right: Drill String Motion Compensator

sponse to the increasing worldwide demand for oil. The future of oil and gas drilling on land or offshore will continue to be layered with increasing challenges requiring more innovative solutions to problems, which in many cases have yet to be identified. The need for engineers, technicians, and service personnel with multi-faceted skill sets will create opportunities for talented and creative individuals and businesses interested in taking part. Where high-power density, flexibility, ease of control, and reliability are called for, hydraulic and pneumatic technologies will continue to play their vital role.

The types of drilling equipment and the technologies covered in this article are but a sliver of those found above the waterline, let alone those found sub-sea or down-hole. For those interested in learning more about the many facets of oil and gas exploration and the types of machinery and processes involved, several Web sites and publications are available:

American Petroleum Institute is an industry trade association representing the U.S. petroleum industry including exploration and production, transportation, and refining. The API develops equipment engineering and manufacturing standards and provides compliance certification.

Offshore Magazine is a monthly industry publication covering news, trends, and issues related to offshore drilling technology, exploration, and production.

Rig Zone is a Web-based magazine and resource focusing on both land and offshore drilling markets and provides subscribers with daily updates and weekly e-mail newsletters.

Offshore Technology Conference (OTC) is an annual trade show and conference held every May in Houston, Tex. OTC is the world's foremost event for the development of offshore drilling, exploration, and production, drawing over 55,000 attendees and 2,500 exhibitors from across the world.

In closing, I can't imagine anyone reading this article who has not been following the human and environmental tragedy that has happened as a result of the loss of the Deepwater Horizon off the southeast coast of Louisiana. Although the true cause leading up to this accident may never be known, the sudden and violent loss of life and the subsequent ecological damage is a stark reminder of the true power of Mother Nature and the respect that she demands. In the years to come, the global thirst for energy will only continue to increase and even as alternate sources are being pursued and developed, the demand for oil and gas will remain a significant part of the energy equation. To meet these crucial needs, the requirement for well-engineered, reliable, and serviceable equipment with the safety of operating personnel and protection of the environment will be paramount. To that end, fluid power will remain at the forefront of technologies that contribute to these efforts.

ABOUT THE AUTHOR: Rance Herren is the manager of Hydraulic Engineering for the Rig Solutions division of National Oilwell Varco, a global leader in technology-driven solutions for the petroleum drilling and exploration industry. He is based in Houston, Tx. Mr. Herren is a graduate of the Industrial Controls program at California State University Fullerton and the Electrical and Electronic Technician program at Chaffey College in Rancho Cucamonga, Ca. He is a Certified Fluid Power Specialist (CFPS) with over 23 years experience in the application of fluid power technology. He can be reached at rance.herren@nov.com.