White Paper

WINDINGS
Electromagnetic Solutions

From Evolution to Revolution

Electric Motors in Oil and Gas Exploration

For more than 50 years, **Windings** has provided engineered electromagnetic solutions for critical applications in Aerospace, Defense, Automotive and Oil & Gas industries. As a full-service provider, Windings is a leader in the design, test, manufacture and support of custom electric motors, generators and related components including rotors, stators, lamination stacks and insulation systems.

From Evolution to Revolution: Electric Motors in Oil and Gas Exploration

The Arc of History Undergound

When the first known spring-pole well was drilled in the United States, Thomas Jefferson was president. With gravity and impact, using manila hemp rope and wooden rods, David and Joseph Ruffner achieved a well depth of 58 feet.

It was in the 1980s that the next literal breakthrough in drilling would take place: hydraulic fracturing. Horizontal drilling and fracking allow oil and gas drillers to reach and extract reserves that would otherwise be too technically difficult or economically impractical to explore. These methods extend the scope of drilling operations from a single site beyond what is possible with multiple vertical wells. But with new technology and new capability came new challenges.

Feedback in Real Time

To maximize productivity and reliability, directional drilling depends on data gathered by two methods: measuring while drilling (MWD) and logging while drilling (LWD). With MWD, sensors provide data to help drilling rig operators track and manage their progress. Collected data can also be used in analysis and reporting, performance assessments, and benchmarking for similar operations. Developed to augment or replace wireline logging, LWD is generally used in geosteering and evaluation of geological formations.

Improvements in sensor technology have increased MWD and LWD accuracy, giving operators more control over tool trajectory and therefore more flexibility in plotting the tool path. Immediate feedback during drilling operations helps verify tool orientation, reservoir content, lithology indicators, and well positioning. This has direct implications for rate of penetration, a key metric in exploration. This is consistent with the premise—and the promise—that directional drilling can be both efficient and effective.

Power Means Potential

Newer sensors require more power, for which the industry has relied on batteries. As battery technology has improved, tooling engineers have pushed the limits of power consumption. Each has driven the other, but the industry may have reached a point of diminishing returns.

Lithium ion batteries are commonly used today due to their high power density, reliability and tolerance for high temperatures. However, they do have drawbacks. The first is high initial cost compared to other technologies. Because lithium ion is classified as a hazardous material with risk of explosion, these batteries are subject to regulations on transportation and duty of care at disposal. These vary by country, further complicating logistics for oil and gas companies with international operations. And perhaps most important for drilling applications, their limited available current requires frequent battery changes. That means suspending operations, retrieving the tool string and swapping batteries before work can resume. In other words, even the most advanced batteries still interrupt workflow.

To overcome the limitations and drawbacks of batteries, some companies are developing alternators / generators for downhole applications. Alternators provide consistent, unlimited power to the drill string as long as mud flow is present, creating a new standard for uptime.

The benefits are significant, with implications beyond powering MWD and LWD sensors. With the availability of continuous, uninterrupted power downhole, tool makers have started looking to migrate away from traditional hydraulic solutions to electric motors. This represents a major shift in thinking—and in engineering requirements.

New Opportunities

Hydraulic drilling equipment has been the industry standard for decades because of its low cost of operation, well known technology, simple maintenance and long service life. It has well known disadvantages, too: frequent leaks, high maintenance requirements with messy and labor-intensive tasks such as fluid changes, gasket replacement and seal replacement, and limited control with a lack of programmability. These drawbacks were regarded as inevitable; the prospect of electric power has inspired forward-thinking engineers to consider finding ways to offset or overcome them.

Electric motors have well defined and understood characteristics, but they have not been used extensively in drilling operations. To many in the industry, hydraulic equipment is synonymous with oil and gas drilling. Engineers and entrepreneurs who see electric motors as the future of drilling have a century of history to overcome. To be a practical replacement for hydraulic equipment, electrics will need to demonstrate a higher overall return. They must provide clear advantages in performance, reliability, and total cost of operation.

Electric motors have been used for several years now to drive hydraulic pumps and provide torque for wireline traction wheels. Because they provide digital control and programmability, they already have an advantage over hydraulic solutions. Tool string engineers who recognize the possibilities for improved control are now looking for additional opportunities to electrify, including driving the drill bits themselves.

Technical Challenges

As well depth and length continue to increase, so do the ambient temperature and pressure. This places greater physical demands on electric motors. Winding insulation, bearing lubrication, gaskets and seals, and other features must be reinforced to withstand extreme heat and pressure.

Environmental conditions present a daunting range of challenges. Onshore pressures range up to 20k psi, while offshore pressures can be as high as 30k psi. Ambient temperatures are often 150°C; a few wells reach 200°C. Chlorides, salt water, and even microorganisms can corrode metals.

Technical expectations also test the limits of design and manufacturing. Some drilling engineers want smaller diameter well bores and shorter tool strings. Some prioritize high power density. Still others emphasize target motor life, and therefore prognostic health monitoring.

All these factors affect the cost of exploration and operations. The goal of overcoming each limitation is minimizing non-productive time. Total cost of ownership is an important gauge of value, constrained by actual usage. Reliable uptime is the most critical measure of productivity and profitability.

Mass Production and Custom Manufacturing

The best way, and sometimes the only way, for engineers to find the right motors for

the extreme conditions of horizontal drilling is to create them. Custom electric motors can solve seemingly impossible applications. That requires the engineering expertise and technical support of a custom manufacturer with advanced capabilities.

One of those capabilities may seem counter-intuitive: hand building. Mass produced products offer the lowest component cost due to highly automated manufacturing processes. However, these “catalog” solutions were designed for moderate industrial factory environments, not the harsh conditions present deep inside a well bore. Although the per-unit cost of hand construction can be significantly higher, for downhole tooling applications it provides the lowest Total Cost of Ownership (TCO) for several reasons:

- Unrestricted customization of overall design and material selection to maximize reliability under harsh conditions
- Higher achievable aspect ratio (L/D) to accommodate tight space constraints
- Higher achievable winding slot fill for maximum power density
- Automated manufacturing not justifiable due to relatively low number of units required

Windings is a leader in designing and manufacturing motor and generator solutions for the Oil & Gas industry that withstand the high temperatures, high pressures and caustic media present in modern oil wells. Windings has provided a wide range of solutions designed to survive in extreme environments that far exceed the capabilities of standard electric motors:

- Temperatures to 260°C
- Pressures to 15,000 psi
- Reliability > 2,000 hrs.
- Outside diameters from 2-1/8” to 6”+
- Aspect ratio up to 50:1 L/D
- Power range from <1 Kw to >15Kw
- Shock tolerance to 50g
- Electrical efficiency > 90%

For example, a mid-range, high performance electric motor from Windings designed to drive a tool string hydraulic pump has the following specifications:

- 3-1/8” OD, 11” long
- 5Kw
- 7N-m
- 8000 Rpm
- 200°C
- 2,000 hours of operation

To achieve these specifications, Windings’ engineers had to look beyond commonly used materials. They have approached these technical requirements much the same way oil and gas exploration is conducted: looking at the margins of what has been proven and pushing them a little further with each design.

The practice of building everything within one company, by hand, may be less competitive in some markets, but custom motors achieve performance levels well beyond those of mass-produced motors. The specifications listed above are only examples of previous responses to industry needs. They show the current range of custom capabilities today, and the benchmarks custom motor manufacturers and their engineers are working to exceed.

For more than 20 years, Windings has pioneered the development of electromagnetic solutions for critical upstream applications in the Oil & Gas industry. As a full-service provider, Windings is a leader in the design, test, manufacture and support of custom electric motors, alternators and related components engineered to survive and perform under the hostile conditions of downhole tooling.

For further information, please contact us!

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