READY FOR ELECTRIC MOTION CONTROL?

Moving to electric products and systems for your downhole tools requires unique solutions, design expertise and collaboration

Oil and gas exploration pushes the envelope for electric motion control equipment. Subjected to extreme environmental conditions from -40 °C (-40 °F) to +240 °C (+464 °F), standard, industrial-grade electrical equipment simply cannot survive in this environment.

Engineers who design and develop motion control products for extreme environments have evolved into a unique breed of specialists. The combination of specialized knowledge of materials capable of withstanding the rigors of the environment and the associated manufacturing processes required for assembly require a unique expertise. In addition, conventional engineering design and simulation techniques typically used for the design process are only as good as the data used to model the behaviors of the materials.

1. Industry trends point toward going electric

The increased global demand for both oil and gas has driven up the price for these commodities, improving the business case for exploration in both remote and/or environmentally hostile locations, reopening previously shuttered brownfield locations, and exploiting previously unconventional sources, such as extracting oil from tar sands and hydro-fracking. Rising energy prices and innovations in advanced drilling technology have made it economically viable to invest in areas once overlooked. The technologies used in these advanced downhole drilling tools have revolutionized oil exploration, both onshore and offshore. Current industry demand for advanced drilling tools is high, as these minimize many risks associated with deep hole drilling, increase productivity, and reduce non-productive time.

Innovations in electric actuators used to perform this advanced downhole drilling have improved drilling techniques by combining remote navigational control for drills located miles deep in the bore hole, while obtaining downhole sensory data in real time. This requires that the downhole tools can perform a range of functions, including real-time data sensing and active directional control. While very sophisticated, this instrumentation and actuation must also be rugged to survive a combination of high temperatures, high pressures, gases, fluids, and steam that falls outside of the normal industrial equipment ranges.

Reliability of these systems over the operational lifetime is extremely critical to the economics of drilling operations. Downtime is extremely costly and the logistics of managing repairs in these remote locations around the world are challenging. To put it into perspective, according to industry sources, the average cost of drilling could be up to $1 million per day offshore and about $250,000 per day on shore. Thus, systems must be designed to minimize non-productive time and ensure long-life performance.

2. Downhole technical challenges benefit from electric solutions

Today's most advanced drilling systems utilize electric directional steering motion control systems that guide mud-powered main drills. While many drilling operations still employ hydraulic steering systems, an increasing number of operators have begun to exploit the benefits of an intelligent electric actuator to enable directional drilling. The advanced downhole directional steering systems are integrated electromechanical assemblies that employ custom-engineered brushless servo motors and electronic sub-assemblies housed in sealed enclosures.

Advanced downhole production systems can require electronics that operate in the wells with a long life expectancy (especially in the order of years for production systems) and high reliability, without requiring an unacceptable large form factor. These must operate reliably in extreme temperatures and be packaged to prevent any contaminants from contacting sensitive electronics and mechanics.

This is where mechatronic design experience can be invaluable. Deciding which solution is most appropriate for these applications requires specialized expertise in designing downhole actuators that incorporate all the elements of survivability, information connectivity, and power sourcing.

3. Specialized engineering for downhole applications

Manufacturers of advanced drilling systems need a sophisticated motion control system that is highly "fit for purpose". This usually implies special-purpose designed servo motors, the associated electronics, mechanical

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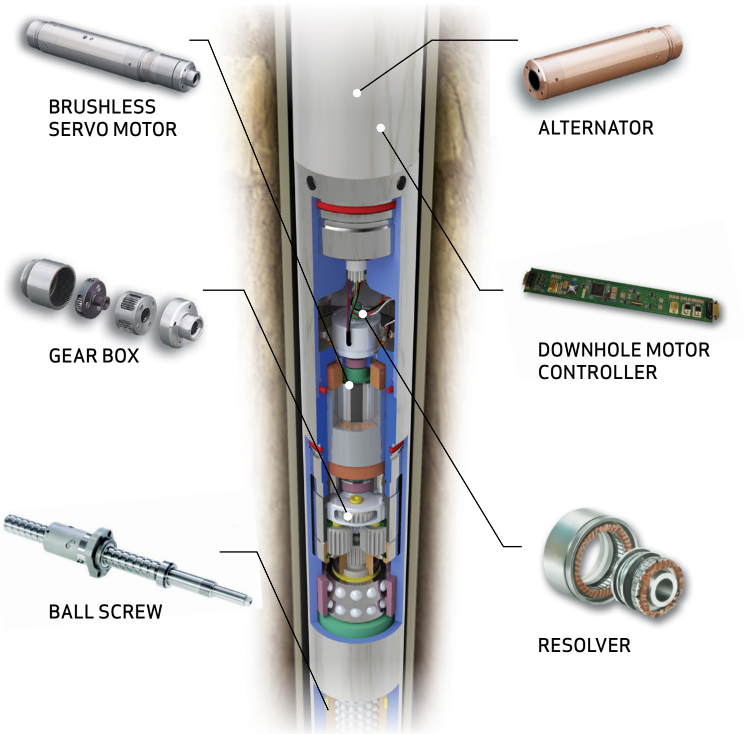
gearing and power screws. These elements must meet the environmental requirements for these applications as well as stringent performance specifications. Most manufacturers do not have in-house resources and expertise for designing these sophisticated subsystems and are looking for suppliers that can also guarantee reliability in their manufacturing and testing processes. Another criteria of successful suppliers is proven expertise in implementing real-world solutions in HPHT (high pressure, high temperature) applications.

Designing motion control solutions for advanced drilling requires some specialized engineering skills, not widely available. Designers must know how to both design the solution properly and package the integrated system to survive for extended periods in these extreme environments. These design applications require specialized, often-proprietary software tools that combine physics-based models and empirical data collected over decades of experience with systems subjected to harsh ambient conditions. The empirical knowledge accrued from field-experience using electric tools allows specialists to develop more accurate mathematical models that simulate the mechanical, magnetic and thermal behaviors.

Conventional engineering design techniques can be applied at high temperatures. However, electronic devices, magnetic materials, and mechanical systems exhibit behaviors in these ranges that require specialized knowledge to properly implement. These behaviors include nonlinearities and unmodeled dynamics. Manufacturers of magnets or semiconductor components often do not publish the device or material specifications in these temperature ranges, requiring system designers to develop empirical knowledge garnered in situ and laboratory testing environments to develop a better understanding of how these materials behave at temperature extremes.

For instance, permanent magnet brushless motor design represents a particularly significant challenge since the magnetic properties of the stator windings and rotor magnets cannot be modeled using textbook analysis. Additional expertise is required to design and package the motor to meet the performance requirements and survive the extreme environments. Brushless servo motors, using insulation materials on the stator windings, are specifically designed for these applications. Vendors regard this as proprietary intellectual property. Motor design, proper material selection, and manufacturing processes all join together to create a highly robust motor with the appropriate form factor and reliability for demanding upstream oil and gas applications.

Motion control components for downhole applications incorporate software-based modeling, specialized materials and high performance design to ensure ruggedness and reliability in extreme environments.



Example of typical components designed and engineered specifically to create an optimal solution for extreme downhole environments

4. Choosing the right solution

Increasing scarcity of minerals, metals, oil, gas, and other commodities will push exploration and production in ever more remote and harsh environments. The ability to put electric systems down hole, whether in the sub-zero temperatures or sweltering heat, has changed the economics of drilling and production. Producers have become dependent upon instrumentation and downhole intelligence. As the search for resources ventures into ever-more-hostile environments in which the sophisticated electronics and mechanical devices often do not perform well or survive for very long, intelligent actuator systems will be at the forefront. This leads to an increasing demand for engineering capabilities and rugged, specialized systems.

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Moog Downhole Electric
Mobium/PDF/Rev.-, January-2014. Id. CDL40514-en

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