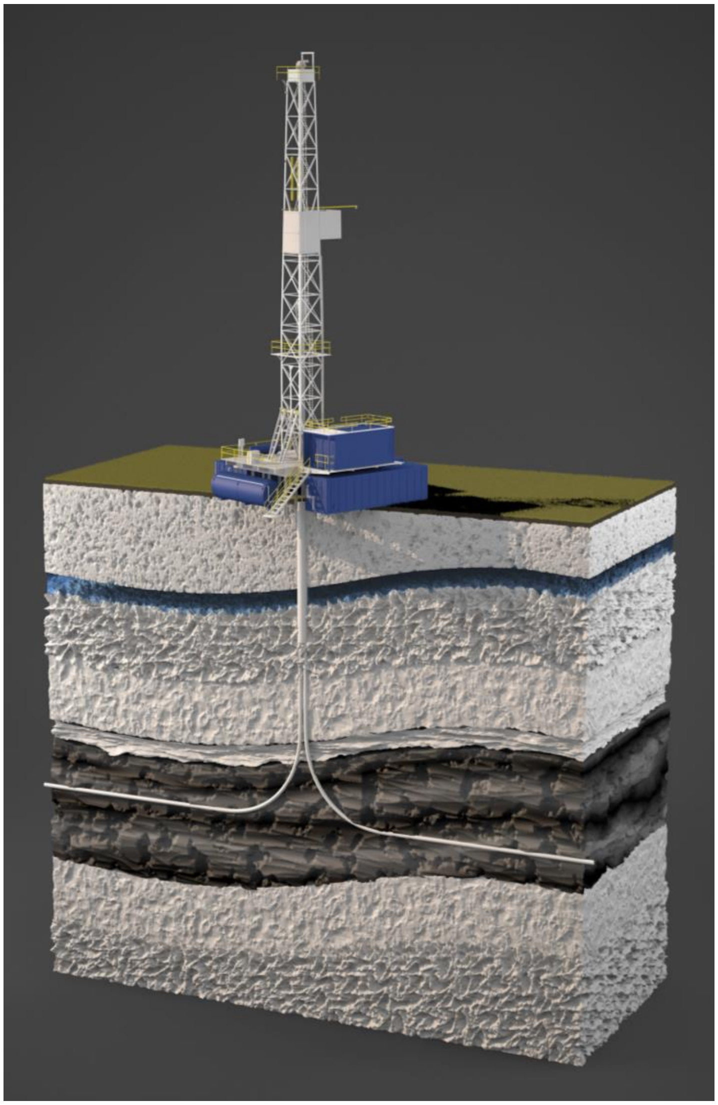

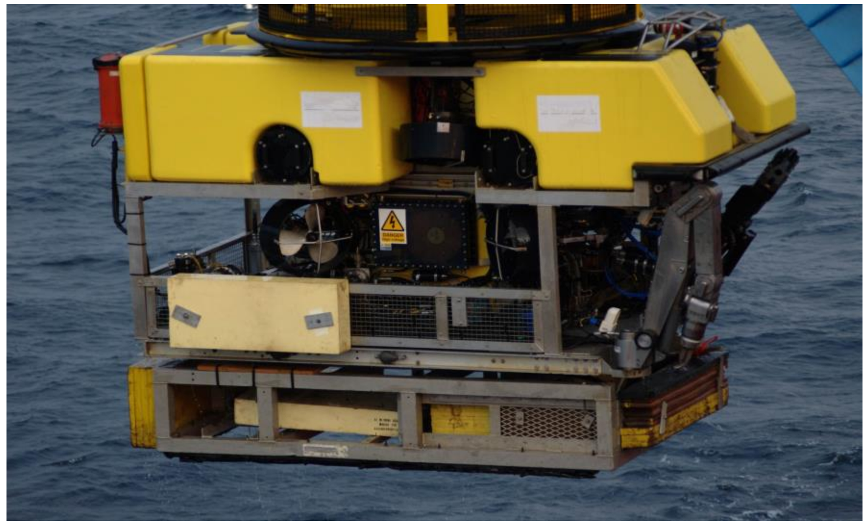

Oil Industry Moving from Hydraulic to Electrical Motor Systems

KOLLMORGEN

Because Motion Matters™

White Paper

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Hydraulic motors have traditionally been used for providing power in challenging oil drilling and production applications because they are relatively inexpensive and have a high power density. But in recent decades, electric motors have gotten considerably smaller due to improvements in permanent magnet materials and more efficient electro-magnetic designs, among other significant factors.

Furthermore, the environmental risks caused by hydraulics such as leaking and venting have become a more critical consideration. Other weaknesses of hydraulic drives include their weight, complexity and high maintenance requirements. These challenges are being addressed by a new generation of electric motors that provide improved levels of power density through higher energy magnet materials and sophisticated electro-magnetic design optimization.

The new generation of electric motors does away with hydraulic hoses and couplings, which are the only way that hydraulic power may be transferred from the HPU [Hydraulic Power Unit] to the load. These hoses and connections are the main source of hydraulic fluid leaks and maintenance headaches. Electric motors use simple wires instead of hoses or lines so they are less prone to failure and require little or no maintenance. As a result, electric motors and drives are frequently being utilized in the next generation of remotely operated vehicles (ROVs), subsea production systems, downhole tools and many other oil and gas applications.

Remotely Operated Vehicles (ROV)

The ROV industry has been a leader in the move from hydraulic to electric motors. An ROV with hydraulic actuators has a considerable number of parts, including the HPU, couplings, valve packages and fluid lines. A malfunction in any of these components could create potential environmental problems based on hydraulic fluid leaking. Another concern is that the electrical power carried by the umbilical to the vehicle has to be converted to hydraulic power which results in a considerable loss of energy. The use of transformers, either at the tether or on-board the ROVs, to convert from the typical 4,160 VAC top-side distribution power allows the use of these safer and environmentally friendly electric motor systems to be employed.

These challenges may in many applications be overcome by ROVs driven by electric motors. These electric motors are much safer and greener because they have no need to derive power through potentially leaky couplings and fluid lines. Electric motors do require pressure compensation fluid for subsea operation in order to balance the pressure inside the motor housing and prevent seawater penetration. But the amount of fluid is a small fraction of what is required for hydraulic drives and the elimination of couplings and tubing greatly reduces the potential for leakage and increases reliability. Electric motors also improve ROV reliability because they eliminate the need for the HPU, solenoids, directional control valves, hydraulic couplings, filters, pressure sensors, accumulators and other moving hydraulic system parts inside the subsea control module. The result is a much simpler design that increases reliability and reduces system downtime.

> All-electric ROVs can provide compliance with zero tolerance of fluid emissions regulations and provide the best solution for environmentally sensitive areas.

Additional benefits can be achieved by providing electric motors for the actuators and torque tools on ROVs used to perform functions such as opening and closing valves. The advantages of electric motors also benefit electric drive thrusters used for primary propulsion and steering. In fact, electric thrusters actually have led the way for this technology because they enable large through-bore motor designs which hydraulics motors cannot emulate.

Once the decision has been made to move to electrically driven thrusters, moving to electric motor driven torque tools and actuators allows the elimination of the HPU and other hydraulic components, thus reducing the cost and weight of the ROV, and increasing operational uptime and environmental compliance. For example, electric thrusters and actuators were used on the Jason Jr., the ROV used to investigate the Titanic wreckage in 1986.

Kollmorgen has worked with Woods Hole Oceanographic Institute researchers on the Jason Jr. and other deep sea vehicle projects.

Subsea Production Systems

Electric motors also offer advantages in valve and actuator control of subsea production systems. Replacement of hydraulic motors with electric motors on subsea production systems helps eliminate the need for HPUs and other components which reduces the cost and risk of operating production systems. Another advantage of electrically driven systems is that they provide increased quantity and quality of data. Hydraulic drives provide only inferred feedback through the hydraulic flow while electric motor driven systems deliver real-time feedback through the motor controllers. The elimination of hydraulics also eliminates the need to replace and dispose of fluids and maintain redundant drive systems, thus providing substantial cost reductions relative to hydraulic subsea systems.

Kollmorgen collaborated on the first ever all-electric sub-sea production system. This all-electric tree has been operating in the North Sea since 2008.

The use of electric motors provides the potential for a compact, high density design by integrating a frameless electric motor into the valve. Frameless motors are comprised of a separate rotor and stator without bearings, housings, or feedback devices. These components are intended as a kit to be designed into and become a direct part of the valve or actuator mechanism itself. When the system operates as a closed loop servo, the feedback device may also be designed into the mechanism.

A modern, power dense electronic drive amplifier runs the motor and manages the feedback device as well. System diagnostics from the electric motor, feedback, and drive amplifier will provide performance details and data that the hydraulic system equivalents cannot match. This data provides operators with improved control over their production processes along with higher reliability.

Downhole Tooling

Downhole tooling provides an entirely different set of motor challenges. Typical applications for downhole electric motors include formation testing, Measurement While Drilling (MWD) and Log While Drilling (LWD) systems, and even driving small HPUs. Downhole tool manufacturers would like to convert their downhole applications to electrically driven systems because it is often difficult to find space for an HPU (the associated lines and other parts in proximity to the point of use of the tool). The challenge in utilizing electric motors downhole is the high temperatures and pressures involved in at working depths.

The typical industrial electrical motor operates in 40C ambient conditions and the heat generated by the motor raises the winding temperature by as much as 115C (to an ultimate temperature of 155C) as a result of the losses created when producing useful power at the motor shaft.

Typical downhole conditions, on the other hand, are at considerably higher temperatures (typically 170C to 200C) which, with a conventional motor, would result in winding temperatures well above 240C, the point at which many of the components of a typical high temperature brushless DC motor fail or seriously degrade in performance. For example, insulation material such as slot liners, end turn insulators and magnet wire varnish start to lose their dielectric or insulating capacity around this temperature. The result of this breakdown in insulation is often motor failure due to winding short circuits.

A new generation of high-temperature motors is addressing this challenge by allowing the motor to perform in ambient temperatures at or above 200C and pressures of 30,000 PSI. The new generation of Kollmorgen HP / HT downhole motors provides pressure compensated, flow-through oil, or free air design, debris-tolerant design, High Pressure / High Temperature compatible connectors and specialized alloys for enhanced corrosion and abrasion resistance.

Kollmorgen state-of-the-art HP / HT downhole motors incorporate a proprietary high-performance insulation system that withstands extremely high pressure and high temperature.

Conclusion

Hydraulic motors have long been entrenched in oil and gas applications because of their high power density. Today, electric motors are closing the gap, enabling many applications to use electric motors on retrofits and new system designs. While the initial cost of electric drives tends to be somewhat higher than hydraulic drives, maintenance costs are considerably lower which typically results in a lower total operating cost. Also, in applications where a discharge of less than a litter of hydraulic fluid is considered to be a "reportable event", the use of electric motors will inevitably become the standard means of power to motion conversion.

Designers of oil and gas equipment are looking for the smallest, lightest, simplest solution with the least impact on the environment. While the best solution will be different for every application, it's clear that the trend in the industry is favoring electric motors.

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 70 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For more information visit www.kollmorgen.com, email mailto:support@kollmorgen.com or call 1-540-633-3545.