Permanent magnet motors lead way to better power efficiency, safety on cranes, winches

By Hege Kverneland, National Oilwell Varco

RECOGNIZED AROUND THE world as a leader in technology-driven drilling solutions, **National Oilwell Varco** (NOV) has kept its focus on commercializing permanent magnet motor technology and developing innovative applications for its use.

The Lifting and Handling Group's latest technological development is the new all-electric King Post Crane using permanent magnet motor (PM motor) technology with a new type of permanent magnet motor winch (PMW).

PM MOTOR TECHNOLOGY

The technology of the PM motor differs from the traditional squirrel cage AC asynchronous motor in that it uses permanent magnets to generate the magnetic flux to turn the motor, versus excitation by copper or energizing large copper winding in the rotor.

The benefits of the PM motor over an AC asynchronous motor are numerous, and one of the most beneficial is in the motor's power density. Power density, is how much power can be extracted from a given space. Typically, permanent magnet motors can produce as much as 30%-40% more power density than a conventional and similar-sized AC asynchronous motor. This provides the opportunity to increase performance with the same package size, or alternatively to reduce the motor size and weight and still maintain the original performance.

PM motors are already a proven technology, currently used in many non-oilfield applications. On oilfield equipment, NOV is beginning to see promising results in the field by applying PM motors and technology on drilling products. Systems have been introduced with man-riding winches, cranes and top drives, while developments are progressing well with drawworks and mud pumps.

These developments are at various stages of commercialization. However, as other industries have shown us, there is clearly value in utilizing PM motor technology beyond just the ability to have increased output from a motor in a slimmer footprint. Therefore, why would the oilfield need PM motors?

PM MOTOR ADVANTAGES

Using PM motors in lifting applications has unique advantages that are significantly applicable to the operational criteria of offshore cranes. Most salient is that the PM design has "integrated" braking capability in case of power failure. In the case of a complete power loss on the rig, the PM motor will create its own magnetic field and start working as a generator, if it is exposed to external loads. This process is achieved by short-circuiting the windings in the PM motor, directly or via resistors.

Normally, winches are equipped with a fail-safe mechanical brake that is automatically applied in case of a power failure. For PM winches, emergency lowering is simply managed by fully releasing the mechanical brake. The load will then start to descend in a slow and controlled manner without concern of heat generation in brakes or clutches, or in the PM motor itself. Resistors and fail-safe switches installed in the control system ensure that the emergency lowering is performed in a safe and controlled manner, without risk of a "free-fall" situation. This feature of the PM motor can also be used as an extra dynamic emergency brake.

The King Post Crane, using permanent magnet motor winch technology, minimizes weight on the drilling vessel, with its primary structures made exclusively of high-strength steel. It also improves HSE, with a braking feature that makes emergency lowering much safer.

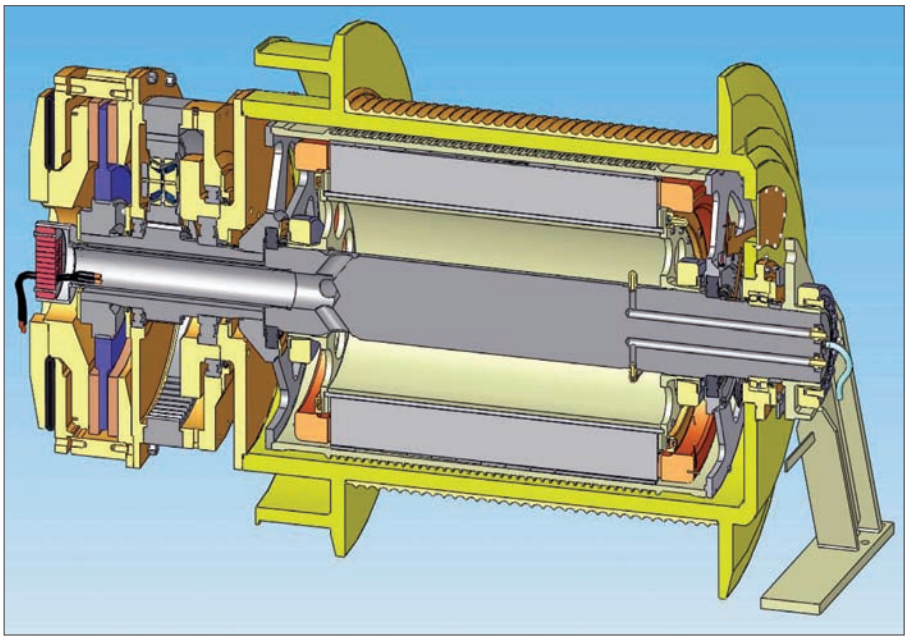
MAN RIDING

One of the first PM motors that NOV introduced to the offshore drilling industry was a small PM motor used in a man-rider winch application – PMW-150 Manrider Winch. It uses a small "inside-out" PM motor, meaning that the outer housing of the motor is the rotating part while the shaft is stationary, in contrast to standard motors where the shaft is the rotating part.

The motor's permanent magnets are fastened to the inside of the rotor drum, creating a permanent magnetic field, while the electrical windings are on the stationary part. The power cables to the PM motor go through the shaft and into the stator windings, and the torque from the PM motor is transferred into the winch drum. As a result, this patented design by NOV makes the winch small and compact compared with standard electrical winch designs.

KING POST CRANES

After the successful application of PM motor technology with man-rider winches, NOV has now developed a winch design for King Post Cranes that utilizes the same technology, only on a much larger scale.



One significant benefit of PM motor over AC asynchronous motor is power density. Permanent magnet motors can produce as much as 30-40% more power density than a conventional and similar-sized AC asynchronous motor.

The reduced number of components installed on the permanent magnet motor winch makes the overall design simple and serviceable, which leads to less maintenance and easier troubleshooting. Above, compare the "engine room" on an electrical crane (left) with the "engine room" on a hydraulic crane.

Developed for semisubmersible and drillship applications that often operate in the harshest offshore environments, NOV's PM motor-driven King Post Crane is believed to be the first of its kind designed in compliance with both the API 2C 6th Edition and EN 13852-1 crane codes.

The crane is designed to minimize its weight on the drilling vessel, and the primary structures are made exclusively of high-strength steel. The steel selection further specifies high charpy impact values and a low design service temperature (-20°C). This allows the crane to operate in the harshest cold weather drilling zones that are often regulated by government agencies.

To meet the demands of the EN 13852-1 crane code and allow for operation in high sea state environments, NOV has developed a unique winch design. This standard calls for an automatic overload protection system (AOPS), which requires a means to release the load automatically in a matter of milliseconds should the crane hook snag during load transfer between the rig and the vessel along side it.

In response, NOV's patented technology and control system again utilizes the "inside-out" PM motor located inside the drum of the winch.

The requirements are met without using additional mechanical components on the winch as a clutch or a

similar mechanism, since the complete system is designed to have low inertia. The motor's high output torque affords a low gear box ratio, which, when combined with the low inertia rotor, makes the winch very responsive to emergency overload conditions and forms the basis for the cranes compliance to EN 13852-1 code requirements for the AOPS and MOPS (Manual Overload Protection System). Therefore, the permanent magnet winch used on this crane is designed to fulfil the requirements both according to API and EN regulations requiring high torque, high rotation speed and high accelerations.

Improving HSE is another advantage of using a PMW, compared with "traditional" hydraulic- and electric-operated cranes. Two independent mechanical braking systems are installed on the PMW, but in addition, there is a third braking feature due to use of PM motor. In case of power loss, the aforementioned PM motor feature to act as a generator (dynamo) will kick in, and the motor will produce a dynamic braking torque reflecting the actual load in the hook.

This feature is used in connection with emergency lowering operations, making emergency lowering much safer. "Free-fall situations" on a PM motor-driven King Post Crane are not possible, even if all mechanically brakes are fully open.

The reduced number of components installed on the PMW makes the overall design simple and serviceable, which again leads to less maintenance and easier troubleshooting. Also, since the PM motor is located inside the winch drum and is liquid-cooled, the noise generated by this winch is significantly lower than a winch using a standard AC asynchronous motor.

Lastly, the balance of the crane's electrical system consists of state-of-the-art AC variable frequency drives (VFD), which provide for high system efficiency and a high power factor to minimize power consumption off the rig power grid. Crane control is accomplished using NOV's PLC-based crane control software, complete with system diagnostics capabilities that are easily accessed from the operator's display screen. Each hoist function and each of three swingers is supplied with an independent VFD, and each can be reassigned in the event of a drive failure.

The control system consists of dual independent PLCs and a communication link to exchange configuration data to the active PLC. Therefore, the crane's electrical system as a whole provides for safer, quieter, cleaner and more environmentally friendly operations compared with traditional hydraulic systems.

CONTINUED APPLICATION

The PM motor, the PMW, the King Post Crane and its control system have been thoroughly tested, both separately and as a complete system, and the cranes are now installed on a rig at the shipyard, ready for operation.

While the application of the PM-driven cranes in the oilfield is still in its infancy, PM motor technology itself has already been proven, and its future applications are still developing for other equipment. With clear advantages in size, reduced noise and fundamental design, it will only be a matter of time before PM motor technology becomes more commonplace in the oilfield.