UNDER THE SEA

Dr. Andrew Jaffrey, Cameron, USA, explains how a new technology gives drillers advanced information about the real time condition of their subsea drilling operation which can be used to help minimise downtime.

Today's drilling environment is harsher and more demanding than ever before, with operations in deeper waters and at greater pressures. To perform in these environments, drillers require technologies that help make their operations safer, more efficient and more reliable in order to reduce costly downtime.

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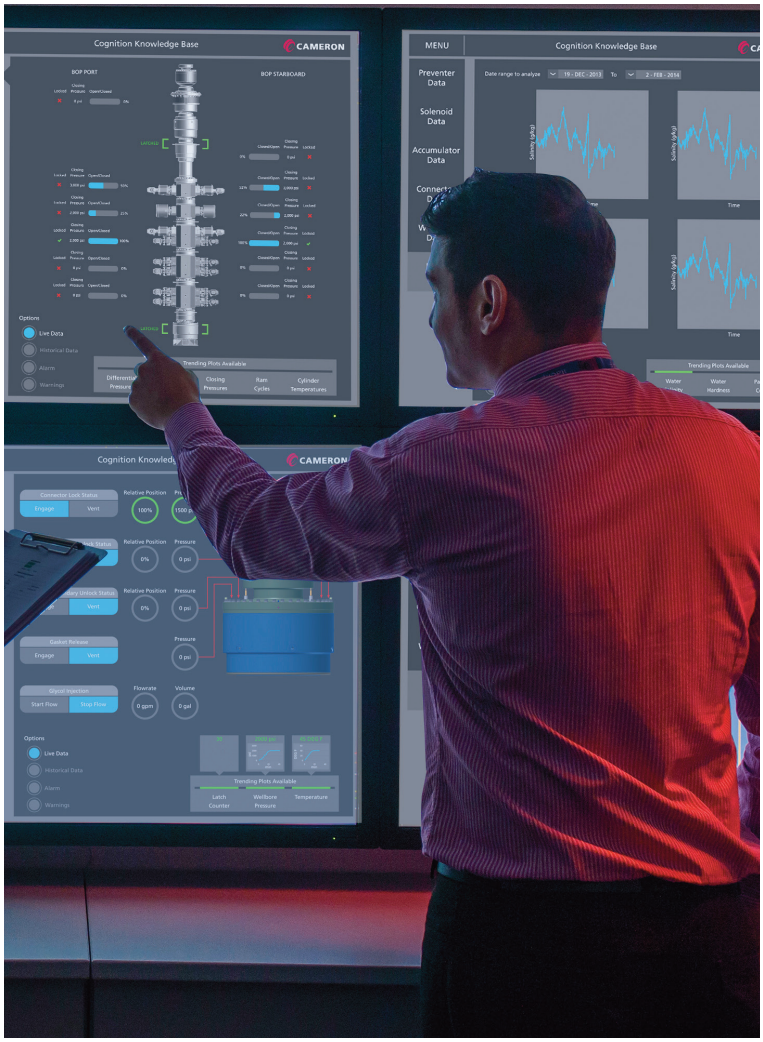

Figure 1. *Condition monitoring software such as the Cognition Knowledge Base provides drillers with easy-to-interpret information about the condition and performance of their subsea drilling equipment and operation, which can allow for predictive maintenance that helps reduce downtime.*

What is condition monitoring?

Condition monitoring has been applied in a number of fields for many years, particularly those involving rotating machinery such as pumps, turbines and jet engines. By measuring equipment performance and then comparing to baseline data, it is possible to identify undesirable trends and inefficiencies. For example, if a component or sub-system is operating outside its specification or working harder than it should, these trends can alert the operator to current or potential problems. Consequently, steps can be taken to prepare for appropriate investigation, repair, or replacement in a proactive, rather than reactive, manner. An everyday example in which condition monitoring is becoming ubiquitous is the 'service due in [x number of] miles' notification from in-car computers. These indicators might not only consider the number of miles driven but also the way in which the ehicle has been driven, since this influences the maintenance schedule.

It is clear from the proliferation of condition monitoring and predictive maintenance technologies in other industries that such technologies are considered good engineering practice. As such, applying a similar approach to the subsea drilling industry can have significant benefits including reduced costs, increased reliability, and improved safety. Predicting when items might be in need of repair or replacement can save considerable time and money, especially in an environment where downtime is very expensive. Given the remote and hostile nature of the subsea drilling environment, it is essential that the equipment deployed in deepwater drilling operations is as smart as possible to enable better management. Cameron's Cognition Stack™ Instrumentation Infrastructure package and other condition monitoring technologies start to address that requirement.

Monitoring the condition of a subsea blowout preventer (BOP) to more intelligently perform maintenance and respond to emergencies is of great importance to Cameron's drilling customers.

One example of where a condition monitoring solution can have a significant impact on BOP operations is Cognition's ability to monitor the solenoids that are critical to the operation of the subsea control system. Currently, because of the lack of visibility on solenoid performance, it is normal for some solenoids to be replaced each time the BOP is recovered from subsea. In some cases, an operator might replace 20% of the solenoids. The only measure that is usually available to determine which solenoids need changing is how long each has been in service, not the performance of each solenoid. This time-based maintenance practice may result in a scenario where shortly after the stack has been redeployed, solenoids that were not replaced (but should have been) fail. If the combination of failures was severe, the BOP would have to be recovered for unscheduled maintenance, resulting in costly downtime. Monitoring the performance characteristics of solenoids by their unique signatures and comparing them with known tolerances makes it possible to identify the units that are not operating as they should. This information can signal to the operator which units should be considered for replacement during the next scheduled maintenance period and demonstrates the benefits of predictive maintenance based upon condition monitoring.

Condition monitoring data provides drillers with better information to base decisions on. For example, Cognition measures the position of the piston inside each subsea stack accumulator. This information can be used to calculate the volume of control fluid available in each accumulator, which then leads to the ability to identify leaks in the pipework associated with the accumulator and even whether the leak is on the fluid side or gas side of the piston. The sensor used to determine the piston's position also measures the temperature and pressure of the fluid. These pieces of information help in multiple instances: 1) by identifying if particular bottles are low on fluid or pressure and therefore need investigation and maintenance, 2) by supporting 'what-if' scenarios for the operator in determining whether sufficient control fluid is available to execute particular functions such as closing

a ram, and 3) on return to the surface, the accumulator bank can be interrogated to ensure that all accumulators have been discharged and that none of the pistons have stuck, which is a potentially dangerous condition if not accounted for.

Keeping an eye on the BOP

Cognition offers a new way to monitor subsea BOP stack functions from the surface while the stack is deployed subsea. The package provides a network of new sensors, resilient communication paths to transmit sensor data to the surface and the analytics, alerts and alarms to turn the data into insights about the condition of the subsea BOP that empower operators to manage their assets more cost-effectively.

The condition monitoring technology is composed of five main elements.

1. An array of sensors captures data from the subsea BOP. Typical measurements include ram operator position, control fluid condition, stack accumulator bottle fluid volume, solenoid performance and connector unlatch pressure. Customers may add whatever sensors they wish (from any manufacturer), as the package has been designed to accept any industry-standard sensor output.
2. A subsea network of sensor interface boxes (SIB) aggregates data from more than 80 sensors to capture subsea stack operation data. The package has four SIBs and each stores data from the system, providing redundancy.
3. Wireless stingers provide inductive data and power transfer between the lower stack and the lower marine riser package (LMRP). Removing metal-to-metal contacts can result in a more reliable long-term operation than traditional wet-mate connections and greatly simplifies alignment requirements.
4. The package provides four redundant ways to transmit data from the subsea BOP to the surface, increasing data availability in an emergency. The data retrieval paths are: 1) data-over-power via the main umbilicals (which minimises adoption costs in retrofit installations); 2) acoustic; 3) ROV connections (both wet-mate and inductive); or 4) via the system's black box recorders. The subsea black boxes record and store at least three weeks of time-stamped data from all sensors plus the BOP control system. In the event of an incident, the black boxes can be recovered by ROV for forensic data analysis and provide a comprehensive view of subsea system behaviour prior to an incident.
5. On the topside, the 'Cognition Knowledge Base' application provides advanced analytics, alerts, alarms and reports that synthesise both real time and historic BOP data into useful information. These data, along with information from other drilling equipment on the rig, can be gathered and presented to the appropriate offshore or onshore personnel.

The information gathered is fed to a master database, which is replicated onshore. The data can be made available in a variety of ways, including as a feed to the operator or contractor, and can then be processed with analytics either by the customer or service provider.

Cognition was conceived to provide a means of supporting the installation of sensors across the whole BOP and to allow this infrastructure to be added to both existing equipment through retrofit, as well as to new-build stacks. A key design goal was for the system to be separate from the BOP control system to maintain the integrity and security of critical safety functions. As a passive system, it delivers additional insight to help reduce downtime.

An important component of condition monitoring technology is the ability to conform to customer needs while having enough redundancy in case of emergencies. For instance, the system was designed to be modular so customers can choose how to configure the package to match their risk profile and specific information requirements. There are options available for redundancy of equipment and ROV connection for emergency incident management. This modularity has been combined with scalability so that even starting from a basic installation, it is a very straightforward process to scale the subsea sensor network to accommodate more sensors, network access points, equipment redundancy, etc.

Decisions to act on information and recommendations from condition monitoring solutions are still at the discretion of the individuals utilising these solutions in drilling operations. The monitoring systems cannot require action to be taken, but provide justification for those decisions and actions.

Industry impact

For some parties, the benefits of condition monitoring systems are increased knowledge that can lead to reduced downtime therefore reducing costs; to others, the benefits are more related to increased operational reliability and safety that comes from the ability to manage equipment in a more informed and proactive manner.

The drilling industry is in the early stages of adopting condition monitoring and predictive maintenance. As a result, the volume of data needed to maximise the accuracy of predictive analyses is not yet well-established. As more rigs are equipped with information capture solutions and more data are gathered to expand the core database, the predictive algorithms will be continually improved with the greater opportunity to mine the data for non-conformance indicators. Upgrading analytical software such as the Cognition Knowledge Base will ensure that clients benefit from the most up-to-date refinements in predictive processing.

Further benefits are seen from using the central repository of Cognition data and the results from the analytical processing of the information. Linking this to other business systems such as procurement can help bring greater efficiencies to entire operations. For example, if condition monitoring and procurement systems are linked, then when the system determines that parts will need to be replaced in the next maintenance period, those parts can be pre-ordered so they are available at the start of that period. In the first instance, the authority to place such orders will reside with the appropriate drilling personnel, with the option to allow integrated systems to automatically take care of future orders.

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