Automated OPERATIONS

Angelo Calderoni, Drillmec, explains how automated operations are improving drilling standards and efficiency.

The increased risk and complexity of drilling operations in extreme environments has boosted industry demand for highly efficient HSE technologies.

The operational costs of building rig yards represents an important consideration for oil companies and contractors alike, together with expenditure associated with personnel safety. This includes the cost of education and training, and rig yard infrastructure to facilitate a risk management approach on the yard and asset related costs.

Improvements in efficiency and HSE standards can be achieved by using high-tech drilling rigs and equipment which lower a well's break-even point in total safety.

In top oil producing countries, the drilling industry is often negatively associated with land and air pollution, noise pollution, harsh working conditions, and various other hazards. These factors represent a challenge to operations from a legislative and regulatory point of view. Companies are thus forced to invest resources, time and money to meet the various requirements of the market they are operating in.

The aforementioned factors are often an entry barrier for smaller companies which might be required to invest huge resources to comply with the standards of a specific territory. For instance, companies may have to upgrade old drilling rigs in line with new specifications and offer training courses where staff practices have become outdated.

This is why the need for tailor-made and flexible equipment, in compliance with major international standards is stronger than ever.

Overview

Drillmec developed a new technology in the mid-1990s to benefit customers and mark the next step in the evolution of the drilling rig. The HH-Series (hydraulic hoist), a new semi-automated hydraulic drill rig was born. The new rig design meant the size of the drilling crew could be reduced and drilling efficiency was improved during rig up and rig down operations, which reduced the rig's environmental footprint.

All of these features have been made feasible due to the combination of hydraulic concepts and advanced electrical components, which made the rig design compact, easy to use and safe to operate through several remotely controlled operations.

The new design included features such as:

- An integrated drilling tower comprised of: mast, tilting top drive, drawworks and all the ancillary equipment.
- Pull down capacity.
- Reduced weight.
- Foldable mast: easier transportation and movement.

Since the rig was introduced, end users appreciated the advantages generated by the new features. In fact starting from the introduction of the first 220 000 lb prototype, manufactured and launched in July 1996, the rig series offered models ranging between 120 000 - 1 300 000 lb of hook load capacity passing through different generations, and accounting for more than 200 HH-Series rigs worldwide.

Nevertheless, history shows that one of the more dangerous operations is drill pipe and tubing handling, which exposes operators to unpredictable risks and dangers. To date, numerous articles have discussed this topic.

Building on automation

Building on its previous semi-automatic pipe handling concept, the Drillmec Automatic Tripping System (DATS) was developed. This is a new hardware and software system that enables pipe handling operations, tripping, drilling and reaming to be performed automatically, without the intervention of the driller.

The two main advantages of an automatic rig are: increased security (due to the elimination of human error and the absence of personnel in hazardous areas), and improved operational efficiency, achieved mainly through tripping time reduction.

The DATS system has a user friendly interface. At the start of the operation the software is given the well's main information such as current and target depth, bit position, well diameter and the number and type of drill pipes stored in the pipe rack. Once this step is completed, the start button kicks off the operation, which can be activated either from the driller's cabin or remotely, via a workstation or a mobile device.

Before starting operations, the software checks the autonomy of the rig (i.e. if it is possible to reach the target depth with the available drill pipes and the actual rig conditions such as oil levels, maintenance status, alarms, etc.) in order to ensure that the task can be performed safely.

Major subsystems and automatic pipe handling sequence

The system that manages all the of rig's activities consists of six major subsystems: vertical pipe rack, vertical pipe handler, mouse hole, hoisting system, top drive and power tong.

All subsystems are fully integrated in the software and inserted into an anti-collision system.

The vertical pipe handler is the telescopic arm that picks the pipes from the vertical pipe rack and inserts them in the mouse hole (and vice versa).

Different sensors are also implemented into the mouse hole and mast's rig: the first is composed of a hydraulic clamp, installed below the drill floor and with a presence sensor linked with the clamp opening. The hoisting of the rig is instead performed by the main hydraulic cylinder placed inside the mast and is regulated by the presence of two redundant encoders that indicate the exact location of the top drive in relation to the drill floor.

Moreover the top drive performance, such as rotational speed and torque, and its tilting movement (capable of positioning it in line with the mouse) are monitored continuously.

Finally, the power tong itself is equipped with sensors, which detect the tightening torque, the vertical stroke and the position (working position/parking position) in order to avoid a collision with the other drilling tools.

During the trip in, and in the reverse mode for the trip out, the rig automatically performs several operations by engaging all of the aforementioned subsystems and, through the integration with the Drillmec Data Acquisition System (DAS), where all information and drilling parameters are displayed on the touch screen monitors located in the driller's cabin and on any remote device connected to the system, via a secure data network.

Figure 1. *Drill floor and pipe handling view.*

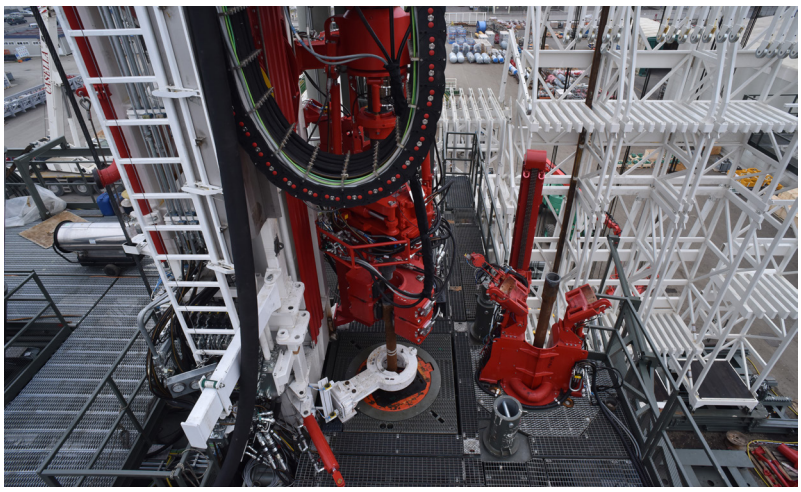

Figure 2. *HH300 in the Drillmec yard.*

Security management and introduction to automatic connection

One of the more essential steps for rig automation is the connection and make up of drill pipes. This operation is complicated and can ultimately lead to drill pipe being damaged without the intervention of the driller.

These difficulties lie in the proper detection of the vertical position of the thread, the correct use of the torque and the vertical load management to be applied between the two threads.

Drillmec has developed an efficient and safe system, which is based on the following three parameters:

- Vertical top drive compensators' position.
- Hook load detected by the load cell.
- Speed and torque of top drive.

After a high speed descent, the top drive is switched to slow descent mode when approaching the connection of the drill pipes, in order not to damage the threads; subsequently, the top drive performs the rotation in the preset number of turns.

The successful connection is signalled by indicators between the unloading of the compensators, the decrease of the hook load and the increase of resistant torque for a given degree of rotation.

Should the system detect an error in the connection, the operations would go in the reverse order (by loosening and lifting the top drive). DATS will go for a maximum of two more attempts, after which, in the case of a new anomaly, it will stop and require the intervention of the driller.

The 'connection teaching' function introduces a safety feature, since it enables the system to check the exact position of the thread and report any anomalies, with the one set under the system registry; this function can be programmed to be executed at regular intervals or at each connection.

Security and fault management

During the creation and implementation of the DATS software, a thorough risk analysis was performed in order to classify all of the possible causes of system malfunctions and identify applicable solutions, in order for the system to be able to manage faults autonomously and safely, with no error margin.

As a result of this research, the following steps are performed in case of defect or malfunction:

- The system independently applies two or three possible solutions to resolve the issue (following preset procedures in the software system checked during the risk analysis).
- If the problem is not resolved, the rig will stop in a safe position (hold safe). For example, if there is an encoder fault that regulates the descent of the main hydraulic piston of the mast, the rotation of the top drive and the circulation of the mud is kept active.
- Prompts for the intervention of an operator, locally or remotely.

All electrical sensors are redundant and, in case of a malfunction of one of those, the system is able to self-degrade. This means that it may decide to decrease its performance (for example the lifting speed), to reduce the risks during operation, without having to shut down their ongoing activity and in the meantime advise the operator of the anomaly.

Rig activity is recorded in a 'black box', which stores all on-board data collected from each of the sensors present in the system, there is also the 'event data recorder', which records the major events and the related telemetry.

Finally, the 'message' functionality allows the signalling of information on all display devices, from simple information messages (such as the completion of an activity), to warnings (for example, the exceeding of preset temperature or pressure thresholds of a component), and also anomaly or malfunction alarms, which require the intervention of the driller.

Future development and modernisation

The goal in drilling automation is to eliminate manual handling operations, which are repetitive and risky for both personnel and for the well, in order to minimise problems linked to carelessness typical of long and repetitive manoeuvres.

As an evolution of the super-single rigs, which were designed to increase safety and reduce accidents, Drillmec has introduced the AHEAD rig series. This series is designed to combine hydraulic concepts and power for higher performance with less impact, automation for better control and continuous monitoring, whilst maintaining a conventional rigs' versatility and heavy duty capability.

The AHEAD rigs are able to handle 90 ft stands in an unmanned drill floor and bring the DATS concept to its ultimate feature: an advanced, fully-automated offline system performs stand make-up/break-down, and casing joints handling too.

Lastly, a complete drilling package integrated in the rig, called HoD (Heart of Drilling), provides the AHEAD series with continuous communication with the bottom hole. Combining continuous circulation technology and a high-resolution flow rate monitoring system, the HoD allows uninterrupted bottom hole pressure control and management even while making-up or breaking-out drill pipe connections. This helps to prevent typical drilling problems related to formation pressure and increases drilling performance in all well conditions.