New regional structural understanding in the Norwegian Sea

AM17
Automating Rig Operations

Sarah Scharfenberg, Herrenknecht Vertical GmbH, Germany, shows how automated hydraulic rig solutions are increasing operational efficiency in challenging projects. Hydraulic rig technology has always been linked to automation and market applications where customers and projects require tailor-made solutions instead of conventional rigs. Innovation and up-to-date technology, particularly in terms of safety, automation, and process control, are key factors for drilling contractor competitiveness and success in challenging projects. Herrenknecht Vertical technology focuses on these factors.

The company’s product portfolio is comprised of project-specific solutions for onshore and offshore rigs and equipment as well as comprehensive engineering and services. Each rig package is specifically adapted to contractor and project requirements, and is designed based on a wide range of field-proven equipment. The hydraulic rigs are either equipped with a cylinder or rack and pinion hoisting system for doubles or super singles, combined with different substructure concepts. The hands-off pipe handling allows for the elimination of dangerous work in hazardous areas, such as work in the derrick with similar tripping speeds as conventional derrick designs. Horizontal or vertical automated pipe racking systems are integrated; adding different levels of automation and minimising the crew size. All of the company’s rigs are designed to: offer energy savings through the application of a central hydraulic drive concept, enable fast rig moves, and provide enhanced uptime and efficiency. The automated pipe
handling solutions are also available as stand-alone equipment or upgrade packages for conventional rigs, enhancing the safety and efficiency of existing rig fleets.

**Combining automation and hydraulics**

The hydraulic rig design features a precise and sensitive hoisting and rotary system (Figure 1). Compared to conventional draw works, the direct-acting hydraulic cylinder system is able to give a direct feedback of the hole conditions to the driller by small pressure changes in the cylinder. This enables the driller to identify potential stuck pipe incidents and to better control the WOB. Furthermore, the system enhances the completion length of laterals by overcoming the static friction through a fast controlled run-in-hole and sensitive fast hoisting stop to avoid additional string tension. The dampening effect of the cylinder hoisting system prevents top drive damage, caused by jarring or shearing for example, thus minimising maintenance costs. It has a snubbing capability thanks to the ability to push the string. Distributing the hook load directly into the substructure through the cylinders and the horizontal racking system allows a very slim timbered mast instead of massive derrick structures. Reducing mass is beneficial, not only in terms of transportation and surface pressure, but this also means reduced exposure to winds, allowing for continued operations in harsh environmental conditions where conventional rigs would have to shut down for safety reasons.

The cylinder rigs are equipped with an automated pipe handling system consisting of a horizontal-to-vertical pipe handler and a horizontal catwalk, which positions the tubulars for the hand-over position of the pipe handler. The pipe handler transfers the tubulars to the well centre where they are handed over to the hydraulic elevator and the joint-to-joint connection is made up by the iron roughneck, before the driller takes control of running in hole via joystick. The system is able to handle drill pipes as doubles as well as casings up to 24½ in. and 4.5 t, enabling precise and safe positioning of drill string and casing, even under extreme weather conditions. The implementation of hands-off pipe handling allows for the elimination of work in hazardous areas, improving safety significantly; the position of the derrick man is completely eliminated and during standard operations, no manual intervention is required at the rig floor, reducing the need for exhausting physical and repetitive tasks.

The rig can be equipped with a horizontal or vertical racking system; the grade of racking automation is adapted to the project requirements. From tubular provision to the catwalk by forklift, to a remotely controlled rail-based gantry crane with pipe boxes for doubles (Figure 2) or vertical racking, different advanced systems can be realised for individual project requirements.

The rig and pipe handling is controlled via PLC from a modern driller’s cabin. Installed in the driller’s cabin is the ‘Drill-Pro’ drilling instrumentation and data logging system by Bohr Instrument Services. During standard operations, single-man control is possible. The driller is able to choose different drilling modes, such as constant ROP, WOB or pump pressure. Drilling data and rig parameters are collected from sensors by the PLC-based acquisition system and can be monitored remotely, e.g. from the Tool Pusher’s office. Remote access for fault diagnosis and support from manufacturer’s headquarters is possible. Additionally, preventive maintenance software is easily implemented in the system for equipment diagnosis. This results in an overall improvement of the drilling procedures in a safe way.

The rigs and their core components, such as the hoisting system, top drive and pipe handler, are based on a hydraulic drive concept. A central hydraulic power unit (HPU) provides and distributes the hydraulic power to the respective component depending on the capacity required, allowing for a reduction in total installed power and

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**Figure 1.** TI-350 Slingshot with telescopic hydraulic cylinder hoisting system and automated pipe handler.

**Figure 2.** Automated onshore pipe rack system with pipe boxes and gantry crane (TI-350 Slingshot).

**Figure 3.** TI-250 Test rig at Shell’s R&D centre.
providing a high level of redundancy. A key aspect of the design is the comprehensive energy management concept, which aims to increase operational lifetime and enable online maintenance of the HPU. The rigs can be operated from the grid or with generators. When operating from the grid, the generators only have a backup function in case of higher capacity requirements. This means that both diesel consumption and emissions are reduced.

The hydraulic rigs are also designed to ensure reduced noise emissions. The top drive is typically one of the main noise sources on a rig, spreading noise widely due to its height, but due to its hydraulic drive, the Herrenknecht Vertical top drive is extremely quiet. Another typically noisy element is the vertical pipe racking in the mast, which is eliminated on the hydraulic rigs. Additionally, the hand-over of drill pipes from the pipe handler to the top drive or elevator takes place in a controlled way, and is carried out smoothly and silently. These rigs are therefore amongst the quietest rigs on the market, which makes them viable for use in conservation areas or close to urban settlements. This made it possible for Shell’s R&D Department to use a Herrenknecht Vertical rig for drilling and completion tests next to an office building (Figure 3).

Fast-moving hydraulic onshore rig concept

Rounding off the product portfolio on the lower end of the hook load range, Herrenknecht Vertical has combined its experience in automated hydraulic drilling rigs with its parent company’s expertise in rack and pinion hoisting systems to design the new TI-200 Rack & Pinion rig (Figure 4). The rig includes all the advantages of the automated, hydraulic rig concept with a robust, modular rack and pinion hoisting system. The rig, which is significantly smaller and lighter in terms of hook load and rig component dimensions, has been developed for project applications where the rig move is a critical part of operation, but the local infrastructure is poor in terms of site access and availability of rig move equipment such as cranes. With a hook load of 200 t and a super singles mast, the rig is capable of drilling down to approximately 4000 m (13 200 ft). The rig is fully self-erecting without the need for cranes; it can be assembled with a 7.5 t forklift near the ground. The mast, which has a total length of approximately 33 m (108 ft), can be divided into three segments; this is where the rack and pinion system has an advantage over cylinders, which cannot easily be split into short units. The mast base section has an integrated trailer for transportation and the rig floor with driller’s cabin is self-erecting by means of a slingshot mechanism. Main components, such as the rotary table, iron roughneck, and top drive, are permanently fixed to the mast and stay ‘on board’ for transportation. The three mast sections are assembled in a lowered position and afterwards erected by a hydraulic cylinder that is an integral part of the trailer. Backyard components such as central HPU, PCR, mud pumps and mud tanks are fully trailerised and can be easily moved by standard oilfield trucks. Whilst a major design focus is on quick transportation and erection, the safety aspect has never been forgotten; the rig comes with a space-saving, vertical cassette-type pipe rack beside the rig, equipped with a two-stage pipe handling system between the vertical racking boxes and the well centre. Placing the pipe rack next to the rig reduces the rig surface pressure and the load in height, allowing for a lighter mast and substructure. Non-standard drill string components are handled via the power catwalk in front of the rig. As with all Herrenknecht Vertical drilling rigs, the TI-200RP is controlled from a modern driller’s cabin. Recently, two rigs of this type have begun operations in Latin America for oilfield development in the Patagonian desert with wells of more than 3000 m (9840 ft) MD, allowing the tailor-made rig concept to prove its benefits.

Setting industry standards

Even more so than onshore, the offshore sector is seeing an increase in automation. With the TI-250 Cantilever rig installed on the jack-up platform SWIFT10 (Figure 5), operating for Shell in the North Sea, Herrenknecht Vertical provided the offshore drilling and workover rig with the industry’s highest grade of automation.
The approach of this offshore rig package was to bring offshore work packages to shore, reducing operational costs and exposure to hazards. Another design criterion was weight reduction of the drilling package for a lighter cantilever design, which resulted in a pocket MODU design. These commitments led to the introduction of the unmanned horizontal pipe racking and handling system (Figure 6) that not only eliminates labour from the racking floor but also reduces the cantilever bending moment due to the compact design. The racking system consists of boxes, which are designed to stack tubulars in yokes that are used for both transport and handling. Pipes are only handled manually onshore for storage, and their position within the boxes is digitally recorded. The prefilled boxes are then lifted to the racking floor. After uploading the tally list to the rig PLC system, the tripping procedure can be fully controlled from the driller’s cabin. A gantry crane at the racking floor lifts the yokes with pipes to the horizontal catwalk, which positions each pipe by pipe to the pipe handler pick-up position, from where the horizontal-to-vertical pipe handler takes over. During operation, entry into the racking system is forbidden and is prevented by a fence with access control. In case of unauthorised access, the whole system slows down. During the pipe handling process, the driller only has a supervisory role, releasing each step of the PLC-controlled process by button.

This high grade of automation not only provides benefits in terms of safety and reliability, but it also enables cost and time savings in terms of personnel and logistics, which have an even greater impact in offshore operations. Expressed in figures, the Herrenknecht rig concept contributes to total well costs savings of up to 40%, as proven by a customer, SWIFT Drilling BV.

**Pushing towards full automation for offshore applications**

Based on over five years of automated offshore activities without LTIs, Herrenknecht Vertical continues to develop new rig and equipment applications together with drilling contractors and operators. The scope of the company’s activities spans from further automation in terms of pipe racking and robot handling of joints and bits on the drill floor and remote control of the driller’s cabin from shore (Figure 7), to new rig concepts for the growing P&A market. In this application field, the lightness and compactness of hydraulic rig solutions are well suited for offshore well intervention operations. The universal applicability of the direct-acting hydraulic hoisting system allows the full range of intervention jobs – including live interventions – to be carried out, which is of significant importance in today’s low oil price environment.