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New Technology Drilling Rig

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ABSTRACT

Geothermal drilling operations pose some extra requirements for drilling rigs. These are above all sound insulation, small and flexible rig sites. In geothermal drilling, well and casing sizes are bigger than in oil and gas operations making the drilling operation more expensive and technically more challenging. Apart from this, all requirements of oil and gas operations also apply for the drilling rig and equipment.

The Herrenknecht TI-350 drilling rig meets both requirements. Standard technologies for rigs are improved and surpassed especially by adopting off-shore drilling technologies for onshore use. Examples are pipe handling and hands-off technology. Sound insulation is implemented in the rig design and the drilling equipment leading to silent drilling operations in inhabited areas. The rig can be set up in inner city locations with its small size footprint and flexible layout.Please check that you put your name(s) in the second and third page headers.

1. INTRODUCTION

The latest discussion about the accelerating climate change reveals once again the exigence to reduce the emission of carbon dioxide world wide. Also, natural resources are getting more and more expensive and are running short in the long run. The development of new sustainable energy resources is one of the major tasks of today and the near future. Geothermal heat offers one solution for energy generation according to the principles of sustainability and environmental compatibility. As for economical efficiency, it is worth paying close attention to the technological side, as half of the expenses of a geothermal project are due to drilling. Improving drilling technology and drilling equipment means rising efficiency and lowering costs. Therefore, Herrenknecht Vertical GmbH has developed a new semi-automatic deep drilling rig which meets the economical and technical requirements of the industry and also the special requirements of geothermal drilling.

2. GENERAL REQUIREMENTS FOR DRILLING RIGS

The general requirements for drilling rigs depend on the specific job requirements like drilling depth, casing diameter, well design etc. Also special requirements have to be met when drilling for oil and gas (blowout preventer and special safety equipment) or in specific environments, like the desert or the arctic.

In general, cost and safety are the main requirements for drilling operations. Low drilling costs and safer drilling operations can be achieved by major technical break-through in drilling technology or by small steps in some of the involved technical equipment and processes. Some of these steps have already been taken in offshore drilling and can be transferred onshore.

Process stability and operational safety are the key issues in drilling. The drilling process and all associated activities have to be executed successively or in parallel so that no unnecessary delays or disruptions endanger e.g. the stability of the well.

The amount of energy needed for the drilling process is about 10 to 30% of the total cost of the operation costs of the rig and is predominantly needed for the mud pumps. Energy savings can therefore be achieved by improving the mud circulation system. A smart energy management, where only the amount of energy needed is made available can also reduce the cost. To guarantee a safe and effective drilling process even in special situations the available power capacity should not be too small for the planned well.

Handling of drillpipe, casing and the bottom hole assembly on the rig floor and around the rig is the part of the drilling activity that affects the safety and the efficiency the most. Therefore there is a trend to automatize and optimize handling as far as possible. Offshore rigs have already implemented “hands-off” technology and semi-automatic and automatic systems while the automatization standard of onshore rigs is still low.

3. SPECIAL REQUIREMENTS FOR GEOTHERMAL DRILLING

To tab geothermal energy in Germany, boreholes of 2,500 up to 6,000 m depth have to be drilled. This is, depending on the geological situation, where geothermal rocks and reservoirs with a temperature of above 120°C can be found – the minimum temperature for most power generation projects from the actual economical point of view.

So far, drilling rigs of the oil and gas industry have been used to develop geothermal reservoirs. These are not perfectly designed for the requirements of geothermal projects. Geothermal deep drilling rigs have to meet a broader range of technical solutions than oil and gas drilling rigs.

Geothermal reservoirs need to be developed with **large casing diameters**. These allow high flow rates combined with **low energy costs**. Most of the energy costs are due to pumping the thermal water from the reservoir to the heat exchanger at the power plant on ground surface.

Well sites have to be close to the customer, in order to be able to offer heat at a reasonable price. This proximity to residential areas makes **effective noise control** most

important. Additionally, inner-city projects and projects close to the city have to cope with a limited availability of space. Inner city drillsites can furthermore be unfavourable in its layout. Thus, it is necessary to keep the **required space** for the drilling rig as small as possible and its layout as flexible as possible.

A great portion of the drilling costs is needed for energy. Especially when developing a renewable energy source, **energy efficiency** as well as an environment-friendly supply of energy are to be preferred to standard solutions.

Low costs are, of course, an advantage for all drilling operations and no special requisite for geothermal applications. But there is indeed a difference concerning the structure of the geothermal project companies and their ability to mitigate risk. While companies of the gas and oil industry mostly operate with a larger number of wells and can therefore handle drilling and exploration risks more easily, companies involved in geothermal projects only have a small number of wells, sometimes only one production and one injection well and therefore no ability to distribute the risk.

Generally, the exploration of geothermal energy often means drilling through hard rock formations like sandstones, limestones and base rock. In oil and gas the hard rock formations are not so often tapped. In geothermal drilling the well has to reach down to very high temperatures. The rig and the equipment have to cope with additional stresses for the drill pipes, casings and logging equipment.

4. TERRA INVADER 350 (TI-350)

On special request of the geothermal industry, Herrenknecht Vertical has developed a new semi-automatic deep drilling rig which not only exceeds the standard requirements of an onshore rig but also conforms to the special requirements for geothermal drillings.

4.1 Solutions for standard requirements

Offshore technologies have been involved in the development of this new drilling rig. Hands-off technologies help to enhance operational safety on one hand and to reduce labour costs on the other. The rig TI-350 is designed for 3,500 kN (350 metric tons) hook load, permitting a drilling depth up to 6,000 m.

4.2 Cylinder drawwork

Different hoisting systems are currently used on rigs. The most common for onshore rigs is the rope hoisting system. To decide for the best solution all existing systems were evaluated. Decisive attributes were among others the trip time, weight and complexity of the system, operation risk, energy use and “hands-off” potential. The drawwork using hydraulic cylinders proofed to be the best choice.

4.3 Pipe handling system

The new pipehandling system has been partly automated, so that the monkey board is no longer necessary. The pipes are

Figure 1: TI-350

stored horizontally and lifted off the rack up to the rig floor 9 m above the ground. The pipehandling is operated from the driller’s cabin with no personnel in the danger zone. The design, the stroke of the hydraulic system, remote control and automation make it possible to use doubles, which helps accelerating the drilling as well as the tripping process.

Figure 2: Pipe handler

Instead of being stored vertically on the rig floor the drill pipe is stored on a horizontal pipe rag. The number of stored drill pipe therefore is not confined to the area available at the rig floor.

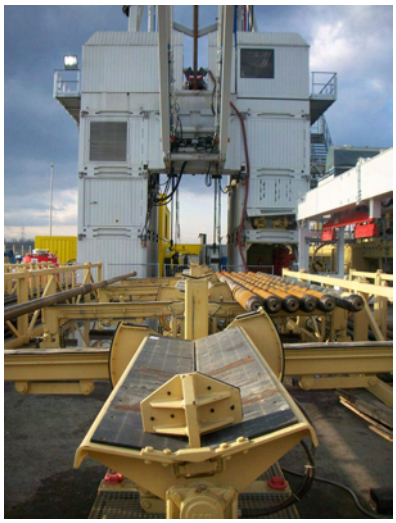

Figure 3: Horizontal pipe rack

The top drive is connected to a hydraulic system with low service costs. In contrast to the conventional rope-driven system the cylinder drawwork allows to put extra pressure onto the drilling pipes and the bit instead of being limited to the dead weight of the system. This helps speeding up the drilling process, especially during the first decametres and also during casing running in diverted wells. With the cylinder solution, collision protection is inherent to the system and because of the remote controlled hydraulic valve system braking is not dependent of several brake types anymore.

Figure 4: Top drive and elevator

Pipe handling system, hydraulic drawworks, hydraulic roughneck and the top-drive system account directly for improved safety and reduced labour costs: The rig can be operated by 3 persons per duty shift instead of 4-5 which is standard practice.

4.4 Iron roughneck

Iron roughnecks are standard in offshore drilling. The concept “offshore goes onshore” can be demonstrated perfectly here. The offshore roughneck is solid and heavy, designed for the offshore requirements.

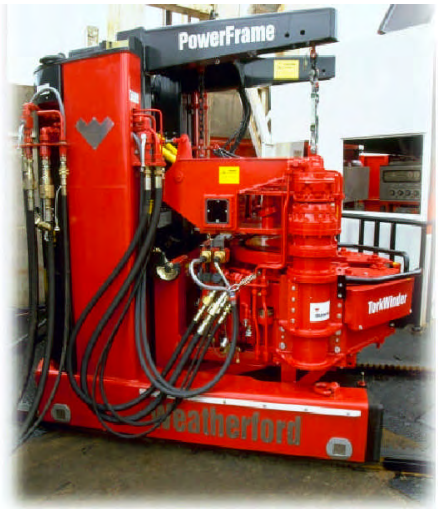

Figure 5: Iron roughneck offshore

The onshore roughneck is built in a way to suffice onshore requirements resulting in a smaller and a more compact construction. The main requirements of a fully automatic operation (hands-off technology) lead to a safer and more stable process of connecting and disconnecting the drill pipes. It also allows for maximum efficiency in pipe handling needing less time for each pipe connection.

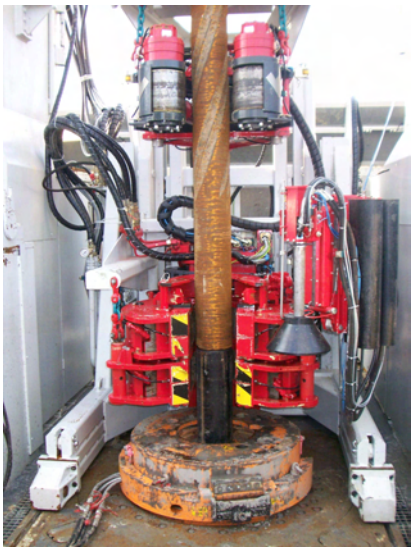

Figure 6: Iron roughneck onshore

4.5 Energy efficiency

The rig can be mains-operated or supplied with power from generators. Parallel use is also possible. An efficient energy management system provides with power only in case of need.

Approximately 80% of energy consumption of the drilling process is used by the mud pumps. The mud lifts the cuttings to the surface. The inside diameter of the drill pipe directly affects power consumption: a larger diameter of the borehole allows higher flow rates for the tapping of thermal water. Terra Invader 350 can operate with wide drill pipes. Apart from lowering costs saving energy helps preserving the environment, an important point when developing a renewable energy source.

4.6 Solutions for geothermal requirements

With a height of 52 meters and a weight of 370 metric tons the rig requires an area of only 9 by 10m, the complete rig installation requires 30 by 80 meters, whereas the site for a common rig measures 80 by 100 meters. The different parts of the rig can be placed very flexibly around the well. Facing reduced availability of space for the rig-up / rig-down and the site itself, TI-350 is very place saving and shows great flexibility.

In geothermal projects, where wells in the vicinity of residential areas are necessary and also to protect the personnel on the rig site, the TI-350 is equipped with extensive sound insulation. Based on simulation, sound sources had been identified beforehand. The main focus has been put on the mud pumps, the generators and the hydraulic cylinders. The rig is supplied with integrated sound reduction provisions. While the mud pumps have been covered up completely, the generators with 1,540 kVA have been fitted each with optimized exhaust silencers and optimized air supply. The containers for the generators themselves have been equipped with an effective sound insulation, too. With all these measures in place, now, at a distance of about 120 m, the sound of the drilling process won't exceed the sound level of a TV or radio.

5. FURTHER DEVELOPMENTS

After the TI-350 rig had been tested and stimulated successfully by the positive response of the geothermal and drilling industry, steps for further development have been taken.

A smaller dr
load of 220

of 3,000 m where shallow geothermal reservoirs can be tapped to produce power or/and heat. High enthalpy reservoirs outside Germany are often located in reach of this smaller rig. CO_2 injection reservoirs for so called emission free coal power plants in Germany are mostly located at a depth between 1,000 and 3,000 m in depleted oil and gas fields or brine aquifers.

An even smaller rig with a hook load of about 150 to 180 t will be designed with growing demand.

All new rigs will be designed on basis of the experience and technical solutions developed for the TI-350 rig with alterations, modifications and new technical solutions if required.

New drilling concepts and tools will lead to a change in the requirements for the rig and its equipment. Electric impulse fragmentation is currently under evaluation to be used in hard rocks like granite. HotDryRock geothermal applications need to be drilled deep base in rock formations. This new technique will require a new or modified mud system including a new treatment system for solids and mud.

The first T-350 was equipped with an electrical top drive. Future rigs will be supplied with a hydraulic top drive currently under development. It will emit less noise and air lifting will be possible.

Herrenknecht Vertical GmbH is actively involved in the development of some of the new drilling concepts and tools, supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Figure 7: TI-350 tested on the factory premises