Deep drilling

Explosion protection when conditioning drilling fluids for deep drilling

by Th. Arnhold

Deep drilling into the earth's crust is carried out both for commercial reasons such as exploration and production of natural resources like crude oil and natural gas as well as for scientific reasons, for example, the investigation of the composition of the earth's crust or to answer geothermal and geological questions. Development of crude oil or natural gas deposits is always preceded by long drawn-out systematic investigations. After a geophysical investigation of large areas, which frequently extend over several thousand square metres by seismic measurements, the promising structures discovered are further investigated by deep drilling into the geological structures. Frequently, hundreds of deep drilling operations are required up front in order to discover only a few deposits which are worthwhile developing.

Since the raw materials sought are flammable liquids and gases, the above-ground installation is considered as a hazardous area and must be equipped with explosion protected equipment in accordance with the zone classification. Owing to the hardness of the rock, the immense pressure and the high temperatures in the lithosphere, extreme requirements are made of the ‚tools' for drilling into our planet's lithosphere. Ultimately however, drilling into several hundred metres of rock functions on the basis of the same principle as drilling into a piece of metal on an upright drilling machine. The drilling derrick is the drilling machine: it accommodates the drive for the drill bit and supports the drill stem. This stem must be withdrawn fully from the bore hole each time in order to change the drill bit.

Two types of drill bits are used: firstly, cone bits on which several steel cones tipped with carbide studs rotate against each other and which are used chiefly to achieve drilling depths. The second type is the diamond drill bit, which looks like a toy castle whose crenellated turrets are crowned with diamond chips. The carbide metal of the crenellation wears away over time and diamond chips break off, but these are replaced immediately by new sharp chips which emerge. One important component of the drilling system is the well fluid, the tasks and conditioning of which we intend to discuss in the article which follows, also with a view to explosion protection.

Tasks of well fluids

When drilling, particular attention is paid to the well fluid, since it is required to perform a number of tasks. The most important are as follows:

- Driving, lubricating and cooling the drill bit,
- Transporting the drilled rock to the surface,
- Maintaining the stability of the bore hole,
- Sealing the bore hole against the penetration of substances such as oil, gas or water,
- Transmitting information on the rock.

The well fluid must have quite specific properties matched precisely to the rock, changing as little as possible during use in order to be able to perform these tasks precisely. The well fluid must thus be conditioned in such a manner that its composition and properties remain stable.

The well fluid is influenced only by the drilled solids which it takes up – apart from thermal or, under certain circumstances, also chemical influences, e.g. when drilling into salt. Either new well fluid can be supplied constantly or the well fluid can be conditioned continuously, i.e. cleaned to remove the drilled solids, in order to reverse changes to the fluid composition.

In basic terms, the fluids used can be subdivided into oil-based and water-based fluids and these, in turn, can be subdivided into unweighted or weighted fluids. Since the fluid contains a wide variety of additives for achieving specific properties, such as specific gravity, viscosity and water loss, the rock drilled can be removed only by precise classification of the solids contained in the fluid. Continuous conditioning of the well fluids is thus a complex, multi-stage process.

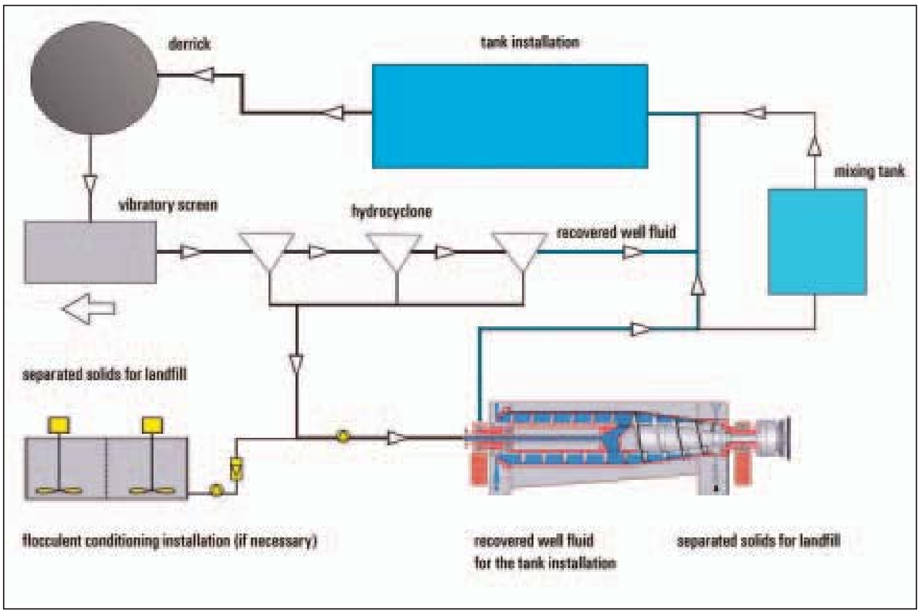

Figure 1: Well fluid recovery installation

Advantages of conditioning the well fluid with centrifuge installations

Normally, so-called mud pits are used as a storage area for storage of the well fluid for onshore drilling. However, today's environmental protection legislation makes it more and more difficult to provide adequately large mud pits for storage of well fluids. In addition, it must be borne in mind that these pits ultimately need to be eliminated fully again. Consequently, storage of well fluid incurs substantial costs. In the case of offshore installations, creating a storage area is, by the very nature of things, far more difficult. Frequently, it is necessary to transport the entire well fluid in tankers over large distances and to finally dispose of it after use. This incurs high costs.

Centrifuge installations which recycle the well fluid and greatly reduce well fluid consumption are used to reduce the need for storage space and thus save substantial costs. This allows a major saving in storage and transport costs.

Other advantages of targeted solids monitoring by use of a centrifuge installation are the higher safety and speed of the drilling process, the reduced wear on the drill bit, avoidance of unnecessary entrainment of drilled rock as well as faster and more precise information on the composition of the drilled rock strata.

Task of the centrifuge installation

With all types of well fluid, the task of the centrifuge installation can be described as separating off a specific solids fraction from the fluid and thus restoring the characteristic parameters of specific gravity and viscosity. This results in the task of recovering the liquid phase and rejecting the solids for low-weighted or unweighted fluids and recovering ballast material and rejecting the remaining solids in the case of highly weighted fluids. The entire process for conditioning well fluids is a multi-stage process, which is shown in simplified form in Figure 1:

Separation of the solids

Some of the drilled solids are separated off via vibratory screens. Currently, vibratory screens which can be used industrially with screen plates approximately up to 125 µm mesh width are used. The effectiveness of these screens for separation of solids lies in the order of approx. 10–30 % of the drilled solids.

Desilting installations

Hydrocyclones have proven successful for many years now for removal of further solids from the fluid. These installations allow the entire fluid stream to be treated. Centrifugal force in the hydrocyclones separates off solid particles with a size down to 10 µm dependent on grain size, specific gravity of the particles, viscosity and specific gravity of the fluid in the underflow. One disadvantage involved with this process step is that a substantial quantity of fluid is also separated off together with the solids.

Centrifuge installation

The disadvantages of a conventional desilting installation can be eliminated by downstream connection of a solid-bowl scroll-type centrifuge (Figure 2). The desilting underflow is separated in the centrifuge into the recovered fluid and the relatively highly concentrated solid.

The essential part of the decanter centrifuge is the rotating part which consists of a cylindrical-conical bowl (2) with a conveyor scroll (6) inside which rotates at a differential speed. The rotating part is driven by electric motors via belt transmission. Feed enters the bowl through a central feed pipe (1). Through ports in the scroll body, feed passes into the bowl where separation by centrifugal force takes place. Inside the bowl the product is separated into a liquid phase (3) and a solid phase (5). The discharge of the liquid is done by gravity (4). The essential part of the decanter centrifuge is the rotating part which consists of a cylindrical-conical bowl (2) with a conveyor scroll (6) inside which rotates at a differential speed. The rotating part is driven by electric motors via belt transmission. Feed →

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In the case of a highly weighted fluid, the solid separated off by the centrifuge contains the highest share of the valuable barite which determines the fluid properties. This barite should be fed back to the fluid. In the case of an only weakly weighted fluid or unweighted fluid, the solid separated off by the centrifuge contains almost only drilled rock and is thus discarded.

The liquid separated off is fed back to the fluid at this point. Flocculation aids are also used more and more frequently as a separation aid for cleaning well fluids. All solids contained in the fluid can be removed from the fluid, if flocculation aids are used. The decanter is able to achieve values, which allow separation of the particles down to 2 µm 2particle size contained in the fluid.

Heavy spar recovery by means of centrifuge installations

As already mentioned above, centrifuges are used on the highly weighted fluids in order to recover the highest share of the valuable barite for recycling into the circulating fluid. This is done in two consecutively connected centrifuges. The heavy spar is separated off as recyclable solid in the first stage of the centrifuge installation. The liquid phase is cleaned and fed back to the fluid in the second stage of the centrifuge installation. The fine particles separated off with the smallest grain share of heavy spar are discarded from the solids. These installations can also be used for unweighted fluids. In this case, the solid separated off, containing almost only drilled wet rock cuttings is discarded.

The liquid of the fluid separated off is cleaned and recycled.

Explosion protection

As already mentioned at the start, the entire above-ground section of the production installation, i.e. also including the installation for conditioning the well fluid, must be classified as a hazardous area. Figure 3 shows a centrifuge (decanter) manufactured by Flottweg GmbH & Co. KGaA.

Flottweg is a Bavarian company founded in 1932 which has been developing centrifuges, including decanters for the chemical and petrochemical industries, for over 50 years now.

The electrical control of the installation, which allows the decanter-bowl speed, the differential speed and the pit depth, amongst other parameters, to be varied can be seen in the foreground. The lower section – the flameproof enclosure – accommodates the motor protection switches, control transformers, contactor relays and miniature circuit breakers. A 100 W heating plate prevents formation of condensation inside the flameproof enclosure, which may be caused by major fluctuations in ambient temperature, controlled by a thermostat. The flameproof enclosure also contains a level tester, as ‚associated electrical apparatus', with intrinsically safe inputs and outputs for determining the fluid height inside the barite conditioning installation.

The control box with type of protection Increased safety ‚e', arranged above the flameproof enclosure, contain the flameproof main switch, various control switches and pushbuttons, in addition to the emergency stop pushbutton. Indicator lamps and ammeters signal the operating states of the installation.

The overall control panel has the explosion protection marking EEx de [ia] IIB T6.

A motor with the explosion protection marking EEx de IIC T4 is used to drive the hydraulics.

After production at a location is complete, the entire installation is dismantled and loaded in separable individual modules onto trucks for further transportation to the next drilling location.

Highly flexible and effective installations

In addition to the rough operating conditions during drilling, which the installations must reliably withstand, there are thus further special requirements applicable to the installation and transport capabilities. In order to reduce assembly and dismantling times, all electrical installation sections are interconnected by means of explosion protected plugs and sockets. The individual installation modules must comply with the typical overall dimensions of 20 resp. 40-ft containers. This allows normal transporters to be used. The weight plays a particularly critical role in this.

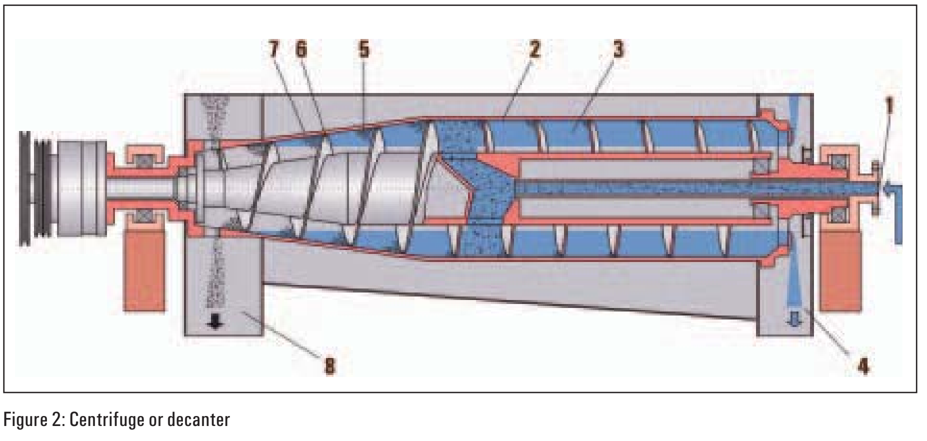

Figure 2: Centrifuge or decanter

Figure 3: Flameproof decanter control

In this respect, using the new CubEx IIB modular flameproof enclosure system manufactured by R. STAHL afforded major advantages. It was thus possible to save space and 350 kg weight in comparison with the previous solution owing to the compact design of the control panel.

At drilling locations, which have been operated with unweighted fresh water or salt water well fluids, most of the drilled solids, which were not separated by the vibratory screen were able to be removed from the fluid with the desilter – Flottweg centrifuge system. Approx. 1.5 metric tons of drilled solids were able to be separated off per cubic metre centrifuge discharge, depending on the size of the centrifuge and the throughput. In general, the volume concentration of the centrifuge discharge was around 50–60 % by-volume of solids. The specific gravity of the centrifuge discharge was in the order of approx. 2.0 kg/l or above. At various drilling locations, it has been possible to date to dispense either partially or entirely with transporting away exchanged well fluid owing to the use of the combination of ‚desilter and downstream Flottweg well fluid centrifuge'. Only the solids occurring in the centrifuge discharge with a remaining share of adhering well fluid had to be transported away into the mud pits.

By kind courtesy of the Flottweg GmbH und Co.KGaA company in Vilsbiburg.

Figure 4: Flottweg barite recovery installation, with sets of two decanters including control systems