Directional drilling

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Directional drilling (sometimes known as **slant drilling** outside the oil industry) is the science of drilling non-vertical wells. Directional drilling can be broken down into three main groups; Oilfield Directional Drilling, Utility Installation Directional Drilling (commonly known as H.D.D./Horizontal Directional Drilling/Directional boring) and in-seam directional drilling (Coal-Bed methane).

[edit] History

Several prerequisites enabled this suite of technologies to become productive. Probably the first requirement was the realization that oil wells (or water wells, but since they are shallower, most development was in the oil industry) are not necessarily vertical. This realization was quite slow, and did not really grasp the attention of the oil industry until the late 1920s when there were several lawsuits alleging that wells drilled from a rig on one property had crossed the boundary and was penetrating a reservoir on an adjacent property. Initially, proxy evidence such as production changes in pre-existing wells was accepted, but such cases fuelled the development of small diameter tools capable of surveying wells as (or during) their drilling.

Measuring the *inclination* of a wellbore (its deviation from the vertical) is comparatively simple—one needs a pendulum of some sort. But measuring the *azimuth* (direction with respect to the geographic grid in which the wellbore is running from the vertical) was more difficult. In certain circumstances magnetic fields could be used, but could be influenced by metalwork used inside wellbores, as well as the metalwork used in drilling equipment. The next advance was in the modification of small gyroscopic compasses by the Sperry company, who were making similar compasses for aeronautical navigation. Sperry did this under contract to Sun Oil (who were involved in a lawsuit as described above), and a spin-off company "Sperry Sun" was formed, which brand continues to this day, absorbed into Halliburton.

Prior experience with rotary drilling had established several principles for the configuration of drilling equipment down hole ("Bottom Hole Assembly" or "BHA") that would be prone to "drilling crooked hole" (initial accidental deviations from the vertical would be increased). Counter-experience had also given early directional drillers ("DD's") principles of BHA design and drilling practice which would help bring a crooked hole nearer the vertical.

Combined, these survey tools and BHA designs made directional drilling possible, but it was perceived as arcane. Some DDs allegedly took delight in making it sound more arcane than it actually was - using Ouija boards to perform calculations instead of slide rules for example. Actually the Ouija board performs simple trigonometric functions quickly and in a somewhat graphic format.[*citation needed*]

The next major advance was in the 1970s, when downhole drilling motors (aka mud motors, driven by the hydraulic power of drilling mud circulated down the drill string) became common. These allowed the bit to be rotated on the bottom of the hole, while most of the drill pipe was held stationary. Including a piece of bent pipe (a "bent sub") between the stationary drill pipe and the top of the motor allowed the direction of the wellbore to be changed without needing to pull all the drill pipe out and place another whipstock. Coupled with the development of MWD (using mud pulse telemetry or EM telemetry, which allows tools down hole to send directional data back to the surface without disturbing drilling operations), directional drilling became easier. Certain profiles could not be drilled without the drill string rotating at all times.

The most recent major advance in directional drilling has been the development of a range of Rotary Steerable tools which allow three dimensional control of the bit without stopping the drill string rotation. These tools (Well-Guide from Gyrodata, PowerDrive from Schlumberger, AutoTrak from Baker Hughes and GeoPilot from Sperry Drilling Services/Halliburton) have *almost* automated the process of drilling highly deviated holes in the ground. They are costly, so more traditional directional drilling will continue for the foreseeable future.

Until recently the drive toward reducing the high cost of these devices has been led from outside the "Big Three" oilfield service companies by entrepreneurs and inventors working essentially alone. With a recent acquisition by Halliburton, this is gradually changing and the drive to introduce a viable low-cost Rotary Steerable System is on.

[edit] Benefits

Directional wells are drilled for several purposes:

- Increasing the exposed section length through the reservoir by drilling through the reservoir at an angle
- Drilling into the reservoir where vertical access is difficult or not possible. For instance an oilfield under a town, under a lake, or underneath a difficult to drill formation
- Allowing more wellheads to be grouped together on one surface location can allow fewer rig moves, less surface area disturbance, and make it easier and cheaper to complete and produce the wells. For instance, on an oil platform or jacket offshore, up to about 40 wells can be grouped together. The wells will fan

out from the platform into the reservoir below. This concept is being applied to land wells, allowing multiple subsurface locations to be reached from one pad, reducing environmental impact.

- Drilling "relief wells" to relieve the pressure of a well producing without restraint (a "blow out"). In this scenario, another well could be drilled starting at a safe distance away from the blow out, but intersecting the troubled wellbore. Then, heavy fluid (kill fluid) is pumped into the relief wellbore to suppress the high pressure in the original wellbore causing the blowout.

Most directional drillers are given a well path to follow that is predetermined by engineers and geologists before the drilling commences. When the directional driller starts the drilling process, periodic surveys are taken with a downhole camera instrument ("single shot camera") to provide survey data (inclination and azimuth) of the well bore.

These pictures are typically taken at intervals between 30-500 feet, with 90 feet common during active changes of angle or direction, and distances of 200-300 feet being typical while "drilling ahead" (not making active changes to angle and direction)

During critical angle and direction changes, especially while using a downhole motor, a MWD (Measurement While Drilling) tool will be added to the drill string to provide continuously updated measurements that may be used for (near) real-time adjustments.

These data indicate if the well is following the planned path and whether the orientation of the drilling assembly is causing the well to deviate as planned. Corrections are regularly made by techniques as simple as adjusting rotation speed or the drill string weight (weight on bottom) and stiffness, as well as more complicated and time consuming methods, such as introducing a downhole motor.

Such pictures, or surveys, are plotted and maintained as an engineering and legal record describing the path of the well bore. The survey pictures taken while drilling are typically confirmed by a later survey in full of the borehole, typically using a "multi-shot camera" device.

The multi-shot camera advances the film at time intervals so that by sealing the camera instrument into a tubular housing and dropping the assembly into the drilling string (down to just above the drilling bit), and then withdrawing the drill string at time intervals, the well may be fully surveyed at regular intervals (approximately every 90 feet being common, the typical length of 2 or 3 joints of drill pipe, known as a stand, since most drilling rigs "stand back" the pipe withdrawn from the hole at such increments, known as "stands".)

With modern technology great feats can be achieved. Whereas 20 years ago wells drilled at 60 degrees through the reservoir were achieved, horizontal drilling is now normal.

Drilling far from the surface location still requires careful planning and design. The current record holders manage wells over 10 km (6 miles) away from the surface location at a depth of only 1600–2600 m (5,200–8,500 ft). These are wells drilled from a land location to underneath the sea (Wytch Farm (BP), south coast of England, ARA (Total), south coast of Argentina (TFE) Dieksand (RWE), north coast of Germany, and most recently Chayvo (ExxonMobil), east coast of Sakhalin Island, Russia.

In 1990 Iraq accused Kuwait of stealing Iraq's oil through slant drilling. Such claims are doubted to have been serious enough to justify war or the occupation of Kuwait, since the limits of directional drilling (at the time) made it unlikely that any such well could have been drilled much more than a mile from the surface location. Even doing so would have involved drilling sites close to the border and the use of sophisticated and easily identifiable equipment and personnel for extreme distances.

[edit] See also

- Geosteering
- Mud logging
- MWD (Measurement While Drilling)
- LWD (Logging While Drilling)