Part 10: Meandering Through the Oil Industry - EXTRACTION

This technical article is in a series characterizing the process that the oil industry follows to bring us one of our favorite commodities, the gasoline that powers our Classics. To get to the point where we can make gasoline, we must get the oil out of the ground.

By Brian Rohrback

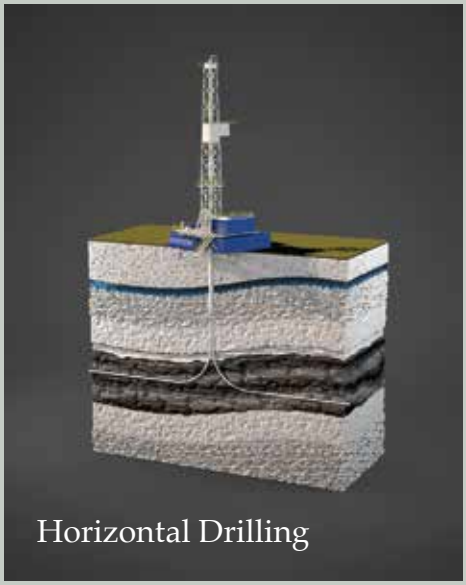
Extraction! - sounds like the title of an action movie!

And there is a lot of complicated action tied to producing the oil from its settling spot in underground reservoirs. To get at the black gold, we drill boreholes into the ground above (or to the side) of these accumulations and, to start, just let the difference in pressure drive the oil and associated gases to the surface. Just handling this initial flow is complicated but, no worries, it gets even more complicated after that.

The first documented oil well was in China around 350 AD and amazingly was drilled to a depth of about a tenth of a mile: not bad for pounding on the ground with bamboo poles. We had to wait a while before Classic Cars came on the scene, so the oil was used primarily as a heat source to evaporate brine into table salt. In ancient Japan, they referred to crude oil as burning water and they were sophisticated enough to do some distilling and using a kerosene fraction for lighting and heat.

Today, of course, we know how to drill to great depths. The current world record for the deepest boring is an ExxonMobil well (Z-44) in Russia which finished up at the 7.7-mile mark. We can also drill very precisely allowing the borehole to follow horizontal strata, thereby increasing the surface area to aid drainage. So, the hole we drill does not need to be straight up and down; directional drilling can even go up and then down like a roller coaster.

The drilling process is a combination of technology and heuristics and is accomplished by using a drill bit at the end of a drill string (the pipe that connects the bit to the surface, really just a long pipe. We turn the bit by forcing a fluid (imaginatively named the drilling mud) through the pipe as propulsion for the bit's rotation. The mud then carries bits of rock to the surface around the outside of the pipe. This mud is a carefully designed mixture of clay and another fluid, either water or something akin to diesel fuel. The rock bits are separated from the mud and the latter is recycled down the well to bore some more (kind of like the author of this piece). The rock pieces brought up from the well are often evaluated at the surface by a geologist or a "mud man".



Horizontal Drilling

When drilling is complete, we coat the sides of the hole with cement casing to avoid leakage into the environment. Then in celebration of a completed well, we cap the top of the casing with a "Christmas Tree" to manage the flow and the production pressure.

Oil is produced from a well in three stages. What dictates the total

"Mud Man"

"Christmas Tree"

Drill Bit

recovery is the porosity (oil capacity per volume of reservoir rock) and permeability (how easily fluids flow through the reservoir strata).

Primary Oil Production -

The first is called primary oil recovery and occurs when the pressure in the reservoir drives the oil up the well bore on its own. Think of the movies when the rough-hewn oilmen dance around while it is raining oil all over the place, or Jed Clampett shooting for some food, when up through the ground come a bubbling crude. Well, this first stage does involve some effort in that we do augment the flow by then using artificial lift using a Pump Jack as in the photograph below (well, similar but not exactly the same). In the primary production stage, we usually get only about 10% of the oil that is trapped in the reservoir.

Pump Jack aka "Drinking Bird"

Secondary Oil Production -

The next step is to enhance the flow by either pumping water down a neighboring well in an attempt to wash-out the oil and move it toward the production zone or by reinjecting the co-produced natural gas or use carbon dioxide or air to reduce the oil thickness and cause it to flow. We can usually enhance the recovery by another 30% of the total underground resource with secondary techniques. Note we are still, after this second stage, leaving more than half of the oil behind. If there are a lot of tectonic faults chopping up the area (as is the case in the Los Angeles Basin) the recovery rate is far less.

Tertiary Oil Recovery

When the well stars to peter out in secondary recovery, an economic assessment is done to see whether a more expensive recovery is warranted. The decision to continue is tied to the price of oil. Tertiary is just an extreme version of secondary recovery where the torturers inject steam (it costs more to heat the water) or even start a little fire in place; both heat the oil and make it flow better. We also wash with soap (to sound more technical, we call these agents surfactants), even send down live bacteria to affect compositional change to a less-viscous composition. All is in the name of increasing fluid flow. After all this, we still tend to leave more than 50% of the oil in place as not recoverable.