The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Pressure, surely not in the oil business ?

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There are some myths growing up about oil and the energy business, on both sides of the aisle. Here, on Saturdays I am trying to give a little of the technical background so that those interested can understand more about the realities of production. The posts are a simplification of what goes on, but give enough detail that, hopefully, it is understandable (and if not then you should ask questions).

I also have said that I would explain the scientific background that justifies the depletion argument (in rebuttal to Lynch â€“ though I am not the first). That is going to take more than one post, but as it turns out I can lay some background for both, in what I want to cover today. It all comes down to something called **Differential Pressure**, but to explain that, let's remember High School.

Let's, in fact, go back to Newton's Three Laws. And for those who slept through that part of the Physics class in school (don't be too ashamed - I have seen the desk where Newton whittled his name, being similarly bored). Let's start with the first law, which is probably the most relevant.

> Every object in a state of (rest or) uniform motion tends to remain in that state of (rest or) motion unless an external force is applied to it.

Except that I want to change external force into pressure (which is force divided by area) since it is the way we normally think of it. (UPDATE - I added rest which is a special case of uniform motion since that is specific to the oil we want to talk about).

And though we had our drill, mud, derrick and casing all working away, I had stopped progress last week just before we went down to total depth (**TD**) of the well, or into the **pay**. And the reason I did has to do with this differential pressure. But first, the pressure bit.

As you go deeper into the earth, the rock at any layer is carrying the weight of all the rock vertically above it. For rough calculations we generally consider that this rock weighs 144 lb a cubic foot. So that 10 ft down the weight of the overlying column on a square foot would be 144 x 10 = 1,440 lb/sq ft. But through convention we reduce the area that we talk about to a square inch (144 sq in= 1 sq ft) so with this division the weight on a square inch would be 10 lb. A remarkable resemblance to the depth number (grin). This means that we can assume, as we go deeper into the earth, that the pressure on the rock increases by 1 lb/sq. inch (psi) for every foot we go deeper. This means that at 6,000 ft, the rock is under a pressure of 6,000 psi. (As will be, initially, any fluid in that rock).

Now water does not weigh as much as rock, but can be approximated to roughly half the weight. So that, by the same argument, under water, for every foot of depth the pressure goes up half-a-psi. So that at 6,000 ft under water the pressure is 3,000 psi (roughly twice the water pressure in the wand you use at a car wash).

Now why do we need to know this before we reach our layer of oil-bearing rock? Well first let's go and interpret that first law a little more.

If a person on either side of you pushed you with equal force at the same time, you don't move, because the two forces balance out. It is only if there is one force, or if one of the two pushes harder, that you move. In other words, where there are a number of forces acting on a body, it is the size of the **difference in pressures**, and the direction of that difference, that controls the movement.

Consider, here we are drilling merrily away (and have cased the well near the surface, and hit no more fluids on the way down)and at 6,000 ft. we penetrate the rock that is capping the well, and enter the rock with the oil in it. The oil (in the rock) is at 6,000 psi , the fluid in the well (under water) is at 3,000 psi. There is a difference of 3,000 psi. We are drilling a hole some 6-5/8th inches in diameter. That has an area of about 34.5 square inches. The total force we have suddenly applied to the bottom of the well (bit and fluid) is thus 35 x 3,000 = 100,000 lb (or 50 tons). Oops!

It's called a **blow-out**, and they still happen. The one capped in Alberta last week killed one of the crew and injured three, and left the well on fire.

This is why we approach the oil/gas producing zone of the rock with caution. And bear in mind that the driller that is controlling the progress of this well is at the surface, trying to guide the bit at the bottom of the hole, with, historically, little immediate information to help.

Based on the surveys that brought the crew to the site in the first place he knows roughly how thick the layers of rock are, and probably what rock they are, but the only real information on where the bit is in that sequence, is from the returns (cuttings) that come out of the well, and there is the lag, we mentioned before, while those chips make their way up the 6,000 ft pipe. (This is why **Measurement While Drilling** [**MWD**] has been such a relatively recent boon to the industry â€“ though not all rigs have it).

By monitoring a number of pressure gages the driller can gain a sense of what is happening at the bottom of the well. If he senses that there is going to be a problem, then he can do one of several things, based on the way the well is set up.

The first thing is to increase the density of the mud. By making the fluid in the well weigh more, the difference in the pressure across that face is reduced, and the change in conditions is easier to handle. However **weighting up the hole** has the disadvantage that it becomes much slower to drill with a heavier mud (it is a poor bottom-hole cleaner among other things). And, if done during drilling, bear in mind that once the heavier mud is added to the well it won't be fully effective until it has had time to get down to the bit and then fill back up the annulus between the drill string and the casing all the way to the surface.

So that is an expensive and slow option. Let us take the game a little more interesting and say that there is a gas pocket above the oil. Gas will enter the well at the down-hole pressure, but as the bubble rises, that pressure is reduced, and the gas expands, pushing the mud above it out ahead of itself. Another potential source for big-time trouble. And this one (which is known as **a kick** in the well) happens much faster, so there is less time to react.

How do we handle this? The answer is to invert the problem. Gas or oil flows into the well because the well is at a lower pressure than the fluid in the rock. The fluid in the well is, initially at the pressure created by the depth, and by the weight (density) of the mud in the hole. However, if we put a restriction on the flow of fluid out of the well (such as when you put your finger over the end of a garden hose so that the stream becomes smaller and shoots out further) we can increase the pressure in the well.

(For those who want to know why, if the same volume has to go through a smaller hole in the same amount of time it has to go faster. This means it has to be pushed harder. **Bernoulli** explained it, and you can read the explanation from Tufts or, if you are really mathematical, from Berkeley).

What it means is that by adjusting the flow out of the hole, the driller can adjust the internal pressure, and thus "**kill the kick**", or if gets to be too much of a problem, "**kill the well**". But it is not completely that simple. Bear in mind that there is the Kelly and all the rotation gear connected to the drill pipe at the top of the well. None of which can stand much pressure. Another piece of equipment has to be placed at the top of the well.

This is the Blow-out Preventer, which is essentially a ram that very rapidly shuts off fluid flow at the top of the well. A more modern one can be seen here. These have to be well designed, since they are generally the line of last defense against a blowout, and when they fail serious problems arise. They also form the basis for the well-known structures, often referred to as **Christmas Trees**, that sit at the top of producing wells. By themselves, however, these aren't enough, since their main function is just to slam the door shut, before all the oil gets out and we have a gusher. The more critical tools are the **chokes** on the well. There are generally several, both hydraulically operated and manual (in case the power dies) which are simply large valves that can be turned to increase or reduce the size of the flow path out of the well over to the mud pits. By adjusting these, in real time, the driller can control the well pressure, and thus the dynamics of the behavior at the bottom of the well. And after the rig leaves, an operator can adjust well pressure, and thereby the production from the well and its long-term performance.

If the operator is well trained (and you find drilling simulator equipment in Petroleum Engineering Departments so that students can understand how to do this â€" I last tried some decades ago) the well pressure will be controlled, so that any kicks can be handled, and the drill can now penetrate safely into the rock containing the oil/gas, which we call the **reservoir**, or the pay. And you think the hard part is over ?

There is still well completion, and then production (which will be where the answer to Lynch comes in), but for now â€" as usual comments, questions and criticisms are welcomed.

BTW â€" if you're impatient with the speed of these posts, there is a lecture series on all this available from Rigzone, with videos. I haven't seen it, but I noticed it while looking for sources of pictures.

Technorati Tags: peak oil, oil