The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

How carbon dioxide improves recovery

Posted by Heading Out on February 12, 2006 - 9:51pm
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Tags: canada, carbon dioxide, china, eor, tech talk, texas [list all tags]

Following Yankee's story about carbon dioxide injection, it appears that not everyone understands one of the ways in which carbon dioxide will help enhance oil recovery (EOR). I am therefore going to just list some of the previous posts that include carbon dioxide, which was discussed here, and here, not to mention here and here.

Below the fold, however, I am going to repeat, with a little update, the post where I described what carbon dioxide injection can do to an existing oil well, and that itself followed an earlier post. These were pre-cursors to what later became the weekend techie talks, and these really relate to those, and from now on I will include this post in that listing. Since the topic largely relates to oilwell production, the listing this week will be for those sites. For those new to the site, on most weekends (though not next week) I will post a simplified explanation of one aspect of fossil energy extraction. So far we have been covering coal this year, after covering aspects of oil and gas production last year.

Carbon dioxide injection is a current DOE program for enhancing oil recovery from an older oil reservoir that has already produced the bulk of the primary oil that it will yield. Just recently Glencoe have started injection in central Alberta, and though the OGJ article on this is behind their wall, a short quote:

> Glencoe Resources Ltd., private Calgary independent, is using the gas to improve recovery of primarily light oil from multiple formations in several depleted oil fields about 100 miles north-northeast of Calgary.
>
> The company hopes to boost the recovery factor to as high as 40% from 10-20%. All of the formations are deeper than 1,300 m.
>
> Glencoe has long-term agreements to purchase CO_2 from two industrial plants. It operates about 50 miles of CO_2 pipelines and has begun injecting gas from the MEGlobal Canada Inc. plant at Prentiss. A second CO_2 separation facility being built near the NOVA Chemicals Corp. petrochemical plant is to go into service in early 2006.

The original post related to cleaning up after elephants*, and was written during the time when I frequently compared Saudi Arabia to a sandwich shop (sorry but no-one every noticed the pun!)

So you're feeling cheap and don't feel like going to the sandwich shop, huh? So lets see what's in the refrigerator. An apple, some cheese, some butter - that will do. You put them on the table and.... darn, you got a blob of butter on the apple. Rather than have it roll all over the table

making a mess, you stick it under the tap.

With the water running on cold it seems to take forever to wash the butter off the apple, but if you turn the tap to hot, the butter runs off very quickly. The same sort of thing happens when you apply hot water or steam to the oil left on the sand grains of a rock after the primary and secondary recovery of the oil is over. The oil is a lot thicker than butter and you generally have to heat the water a bit hotter (it works best above 185deg F) but you can still clean the oil from the rock that way. There is, however, a bit of a snag. (And from this point on DO NOT TRY THIS AT HOME).

Think of it as little Johnnie (helped of course by Jessica) having raided the orchard and spread butter onto all the apples, gluing them together and filling the kitchen full, right to the ceiling. How do we clean the butter off and get it back without taking all the apples out and cleaning them one by one (which is sort of what they do with the oil sand up in Canada).

We could just stand in the hall and stick heaters up against the wall of apples, hoping that the heat would melt the butter and work its way back to the ones further into the kitchen. That sort of works, but burns the local apples and doesn't reach all that far. (They have tried setting fires inside oil wells). You could fill the kitchen with hot water, but while that washes out some of the butter, a lot of the heat goes into the apples and the water is cold before it reaches the back of the room. And the water doesn't have that much pressure to push the remaining butter off the apples. (In oil wells this is the secondary recovery that might get us back another 10 - 20% of the oil, except that they use cold water and some rocks have clays that swell when wet and this stops the oil from flowing).

What we need is something that will get through the gaps between the apples and keep its heat. So how about steam? You get a steam cleaner (such as you use for carpet cleaning) and blow the steam into the apples. That works but as the butter starts to flow out it clogs the gaps and starts to re-harden except when the steam is right there. So you start to run the steam for a bit, stop and collect the butter that comes out, run the steam for a bit, etc. You can do this in an oil well and it has the exciting technical name of "Huff and Puff" (would I kid you?). (Ask Your Government). (pdf file) To make the steam more effective it is heated to between 150 and 300 deg C. Where the rock is very permeable and the steam can, in time, work its way back through the particles (apples) this can recover a lot of our butter. But you still lose a lot of heat, which is expensive to generate, just in heating the apples.

What if we could use something else that does chemically what we have done with the heat? How about a soap? Yes that might work, the only thing is that soaps cost a lot of money and there really isn't that much butter, so unless we can get our soap back we really can't afford it. And what we have to do is to put in the soap, wait for it to work, and then push some water through to move the water:soap:butter to a place that we can collect and separate them.

Hmmm, but what if we had a chemical that could mix with the butter, and make it melt, so that it ran off without heat? That might be a lot simpler. Well it turns out that carbon dioxide, that gas we all love to hate, does exactly that.

(But now we have to talk just about oil). When carbon dioxide is mixed with oil, then it is absorbed into the oil and the resulting liquid has a larger volume, which means that it is thinner. (You could think of this as being the same sort of change as when you add a teaspoon of hot water to honey). The carbon dioxide also makes this thinner oil less sticky, so that it comes away from the rock more easily. Thus the oil will come away from the sand more easily, and will flow more readily to the well, being thinner. And tests, at the UT Austin , show that CO2 will move right through a

rock of the right sort, reaching all the oil that might be there, and coughing up a lot more of it. But that also the rock would retain the CO2, if sequestration was desired.(Note that this does work when the process takes place under water).

We can do the same sort of Huff and Puff approach that is used for steam injection, except using liquid CO2 and, in the right rocks we can get much more of the oil out. Or we can drill one well and pump in the carbon dioxide, and collect the oil and gas from the next well over. But there is an additional advantage. When we get through with pumping out the oil, we just pump all the carbon dioxide back into the rock and it stays there. So not only have we got the oil out, we have replaced it with the gas that is causing global warming, and once put into the rock it will stay there, in just the same way as the oil did.

This technique is being used in Liaohe, the third largest oilfield, in China, which is now declining in production. By pumping in flue gas from a nearby power plant and combining it with steam the recovery of oil from the reservoir was increased from the 20 -30% achieved with steam, to around 50 - 60%. Since the gas was not otherwise treated it only contained about 10 - 14% CO2, the rest of the gas being largely nitrogen. What the experiments showed is that we can use the gases from power stations, without separating the components out, which would otherwise be a lot more expensive. What is also interesting is that the Chinese gases did not appear to have been liquefied, and that there might have been some production gain (up to perhaps 40% of the oil recovered) by combining the flue gas with steam.

But the benefits extend beyond that. An experiment that the Globe and Mail referred to has been going on in the Weyburn oil field in Saskatchewan for the last five years. CO2 from a synthetic fuel plant in North Dakota is piped to the oilfield and injected. While the reservoir holds the gas, the mix with the oil, means that the oil flows out of the well more easily.

> Carbon-dioxide injection will allow EnCana to extract another 140 million barrels of oil from its 51-year-old Weyburn field, an enormous volume at a time when the average new well drilled in Western Canada yields a mere 50,000 barrels.

The technique has promise in a number of sites where the rock layer does not otherwise allow much oil to be recovered. The potential gain for Canada can be quite large.

> Now, better technology and high crude prices are about to shift an enormous amount of oil into the grasp of the industry. As many as five billion barrels could be added, according to Mr. Issacs. That would more than double Canada's conventional oil reserves.

There is now an updated page for the Weyburn site

A significant gain can also be achieved in the United States where the process has seen some limited use since it was first tried in Scurry County Texas in 1972. It is being used particularly in the Rockies and West Texas where it is currently producing over 190,000 bd of oil .

The benefits from this are two-fold, since the gas can be stripped from the oil and reinjected, thereby trapping it back underground rather than releasing it to the air. The only downside to that is that, to be economic and useful, a power plant already in existence should really be used for the gas, and it needs to be relatively near the oil to be economic.

The OGJ had an article on this last April. The article is now archived, and thus requires a password to access, but begins:

> The latest technology for enhanced oil recovery by injection of carbon dioxide holds the potential to recover 43 billion bbl of oil "stranded" in six mature US producing regions, says a study conducted for the Department of Energy.
>
> DOE's Office of Fossil Energy calls the volume, estimated in the study by Advanced Resources International, "technically recoverable potential."
>
> It identifies as "state-of-the-art CO2 EOR technologies" horizontal wells, 4D seismic to track injectant flow, automated field monitoring systems, and injecting larger volumes of CO2 than were used in earlier EOR projects.he study says state-of-the-art CO2 injection might recover 5.2 billion bbl of 22 billion bbl of oil unrecoverable by conventional production methods in California. The stranded oil is in 88 large reservoirs amenable to CO2 injection.

The technology does require that the gas be liquified (which requires a pressure of about 1,000 psi) so that it can better mix with the oil, and make it easier to extract. It even gets the CEO of Shell excited.

Which leaves us with that apple, and the butter. Why don't you spread the butter on two slices of bread, slice the apple on top of one of them. Sprinkle blue cheese crumbs on the top of the apple, put the second slice of bread on top and have lunch - you deserve it, and (like me) you don't have to go the sandwich shop today.

(Technophiles can read a less dramatic version of the above here.).
*From a play here.

This is part of an ongoing weekend series on technical aspects of oilwell (and natural gas) drilling. Previous posts can be found at::
the drill

using mud

the derrick

the casing

pressure control

completing the well

flow to the well

working with carbonates

spacing your well

directional drilling 1

directional drilling 2

types of offshore drilling rigs

coalbed methane

workover rigs

Hydrofracing a well

well logging

seismic surveying

gravimetric surveying

As ever, if this is not clear, or if there is disagreement then please feel free to post, and I will try and respond.