The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

From the old to the newer, or a thought for Khurais and its companions

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In recent posts I have talked about the major oilfield in Saudi Arabia that is closest to exhaustion. Perhaps it is now time to move to their oilfield of the future. Khurais. As we look to where the oil is going to come from tomorrow, there have been only very few places where production levels above 1 mbd have been projected. In fact a quick skim through Chris Skrebowski's Megaproject list (pdf file) shows that production of this level is going to get rather scarce. Counting only production above quarter of a million bd, in 2006 he has Haradh coming on line at 300,000 bd (it is), and the Azeri-Chirag-Gunashli (ACG) Phase 2 coming on stream in Azerbaijan at 300,000 bd. In 2007 there will be the Abu Hadriyah, Khursaniyah. Fadhili complex in KSA at 500,000 bd; The Khursaniyah NGL's at 300,000 bd; and another 300,000 bd from the ACG project. In 2008 there will be the Hawiyah NGL's at 370,000 bd; the Shaybah phase 2 at 300,000 bd or more; and Kashagan at 450,000 bd from Kazakhstan. In 2009 there will be Khurais at 1,200,000 bd. In 2010 there will be the Al-Shaheen expansion in Qatar at 300,000 bd; the combined Kushk-Hosseineh field in Iran at 300,000 bd; the Kuwaiti expansion at 450,000 bd; and the Kashagan Phase 2 at 450,000 bd. Looking further out there is Kashagan Phase 3 (300,000 bd), and Manifa (700,000 bd in total).

In terms of major developments Khurais stands out as being considerably bigger than the rest.

The project is under the engineering and management control of FosterWheeler, although it is interesting that the contract is more related to

> Foster Wheeler's scope of work includes a grassroots central processing facility at Khurais, upgrade of support facilities at the Ju'aymah gas plant, inter-field pipelines, utilities and product handling/storage/infrastructure and support facilities. Foster Wheeler will validate the work undertaken to date and will provide overall project management and engineering services for the central processing facility, including certain procurement and construction management services.

The thing missing from that list is the drilling of oilwells. And here there will be a little bit of a problem. In discussing the oil production of the fields in Saudi Arabia, Matt Simmons noted, in "Twilight in the Desert,"a quantity that he called the Productivity Index. This is the volume of oil that would flow from different fields as a result of a pressure drop of 1 psi across the rock: well interface. In other words if you divide the amount of oil you are getting from the well by the difference between the pressure in the rock minus the fluid pressure in the rock, you get the production index. For Abqaiq it was 110 barrels per day, per psi, so that a pressure drop of 150 psi across the well boundary would produce a flow of 16,500 barrels a day, diminishing as the pressure drop declined.

It is the control of this differential pressure, and the resulting flows of oil out of the rock into the well, that allows management of the oil flow in the rock, and stops too much preferential flow through larger fractures, to the detriment of long-term oil production. The pressure differential is controlled through valves at the top of the well, throttling which increases the delivery pressure of the oil from the well, and lowers the pressure drop between the pressure of the oil in the rock, and the fluid in the well.

Flow rates for the major fields in KSA per psi are Ghawar (141 bd/psi); Safaniya (136 bd/psi); Zuluf (100 bd/psi) etc. But when we come to the more recent fields to be developed, Haradh and Khurais, the production indices per psi drops to only 31 bd/psi for Haradh. I have not been able to find the production index for Khurais, but looking at the number of wells that will be drilled, together with those already in place, that presumably have been worked over, I get the feeling that it will be around the same number. With that index and under the same pressure differential as Abqaiq, therefore, each well can be anticipated to produce only around 4,500 bd. Given the promise of a 1.2 mbd increment, this would thus require that some 300 wells will need to be drilled into the formation. However, as with the other fields in KSA the field will be produced under simultaneous water injection. Thus the field will need 4.5 million barrels of treated seawater per day to be injected. Needless to say that cannot be all poured down one well, but must be injected through special wells drilled for that purpose around the perimeter of the field. The total number of wells that must be drilled thus must, under the same conditions, exceed 300 wells. The recently awarded drilling contract calls for just 300. The drilling part of the project has been awarded to Halliburton, and some 23 drilling rigs have been assigned to the task. Providing the rigs themselves does not appear to be quite the issue that was once thought. The 100th rig was commissioned recently, although, given where that one came from, they may still have some difficulty in reaching their target of 121 rigs in the Kingdom by the end of the year.

There are, however, several ways in which production can be increased. The most likely will be that, as has been reported the wells will be extensively hydrofracked to increase the flow, and one can also assume that MRC techniques will be used in the field. The one thing that it is unlikely that they will do is to increase the pressure difference across the well wall, which can be achieved by opening the valves wider at the top of the well. The reason for this is that the greater this pressure drop (which can be thought of as sucking harder) then the greater the problem of controlling the flow to ensure that the water:oil interface (and the overlying gas:oil interface) stay relatively flat, and don't cone into the wells. The problem of coning is one that plucky underdog addressed the other day, and I quote

> OK, briefly: oil floats on water in the rock. Horizontal interface between the two phases is called the oil water contact (ignore the transition zone). Production wells are drilled down to somewhere above the contact. When production begins, the area of reduced pressure (drawdown) around the wellbore causes the contact surface to be perturbed upwards until it reaches the production well and you start producing water. This is "coning", so called after the shape of the perturbed contact. If you stop production then the pressure disturbance goes away and the cone collapses, in certain rather complex to define circumstances (has to do with "relative permeability hysteresis", which I can't describe compactly, or maybe at all).
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> Really hard to interpret diagram here http://www.glossary.oilfield.slb.com/search.cfm and search for "coning"

Coning is promoted by:
High production rates
Narrow interval between contact and bottom of well
High oil viscosity (=> high drawdown & adverse mobility ratio)
Low horizontal permeability (ditto)
High vertical permeability (gas moves faster)
High net:gross (no shale stringers to stop water moving vertically)

If you know enough about the rock and fluid properties then you can estimate the "coning critical rate", i.e. the rate at which the cone will have grown to the point where it just reaches the bottom of the producing well. You can then choose to limit your production rate to just below this level to avoid water production. It certainly extends DRY production into the future at lower flowrates, but if you are willing to cycle enough water through the reservoir then you'll eventually get all the moveable oil out anyway, up to the economic limit. And sometimes the coning critical rate is so low that you just have to shrug and accept that it will happen at any economically realistic well production rate, and manage the water on the surface.

Remember that if you are injecting water below the oil, or if an aquifer is influxing into the reservoir, then the contact will be moving upwards anyway so the coning critical rate will change with time as the contact gets nearer to the wells and eventually breaks through independent of production rate.

Coning can happen with gas as well, this time coming from above not below - think Cantarell (but unlikely there due to very high horizontal permeability).

Horizontal wells spread production out through a larger volume of reservoir (hand wave) and so reduce drawdown and the propensity for coning. Again this delays water breakthrough but once it happens, it happens. See "cresting" in the Schlumberger glossary linked above.

In other words sucking too hard can be detrimental to longer-term production. Could be an interesting field to watch being produced.

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