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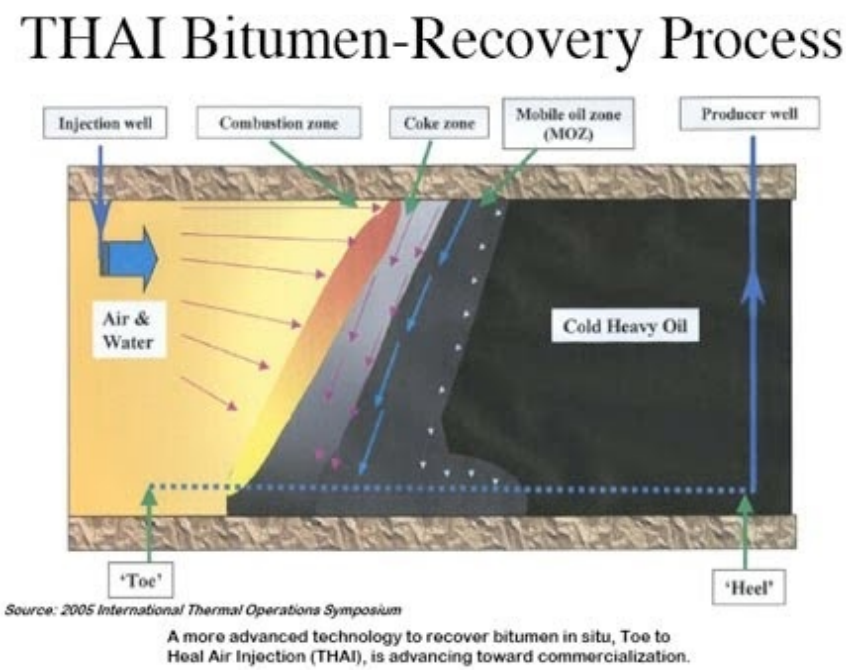
Tech Talk: The THAI process for bitumen and heavy oil

Posted by Heading Out on February 7, 2010 - 7:14am
Topic: Supply/Production
Tags: bitumen, heavy oil, tech talk, toe to heel air injection [list all tags]

For a while, when I was a student, I had an attic bedroom that was heated by a small coal fire, with a relatively short chimney up to the roof. I learned, fairly early on, that in starting the fire you needed a fairly high velocity air flow across the coals, and underlying firewood strips. And to get this I would rest a shovel over the front of the fireplace, and try and seal off the sides. I kept a small bellows beside the fire to help when this wasn't particularly successful. When you are starting a fire underground the provision of air is critical, but when you are trying to burn the residual coke that is left, after the heat has cracked the rest of the oil and caused it to flow away, keeping that air flowing at a high enough rate to sustain the high-temperature burn becomes somewhat critical to most efficient operation, particularly if the air has to get through a sand layer to reach the fire.

This is the post on THAI – Toe to Heel Air Injection for the recovery of heavy oils, which is part of the ongoing technical post (tech talk) series that I write on Sundays. It is a subject that has been described several times in the past at The Oil Drum. I first mentioned it back in 2006 when the first underground test was underway at White Sands.

I used this illustration at the time.



It is an artist's impression of a side view of the site, with the blue dotted horizontal line

representing the recovery well and air being fed in from a higher well into the formation. The test at White Sands in Alberta has been followed by a test at Lloydminster in Saskatchewan which got underway in a more conventional heavy oil last October.

The Kerrobert project followed much on the procedures from the earlier test, and the currently planned full scale production at May River (Large pdf file)

> Petrobank, which is partnered with Baytex Energy Trust on the 50/50 joint venture, recently sunk two vertical air-injection wells and two horizontal production wells into the extensive Mannville conventional oil reservoir near Kerrobert.
>
> Compressed air was added last week after a temporary steaming of the ground to mobilize the oil around the injector site. With the addition of the air, spontaneous underground combustion has begun.
>
> "I think we will see some oil as early as today," Bloomer said.

Don and Gail described the THAI process in 2007 and have given some history on its use, THAI having been patented by Petrobank who have a 12 minute video on the process and the first trial and preparation for full scale production. It is well worth watching.

Dave Murphy had an update on the EROI costs in March of last year.

While watching the video is the best way to understand the process, it can also be illustrated with a picture from the plan for May River and I will lift some parts of that document to describe what is planned for that site.

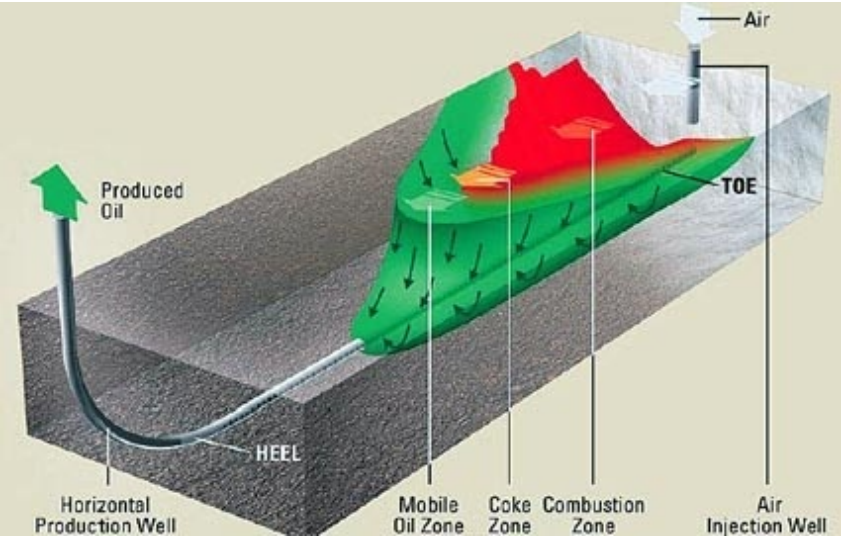
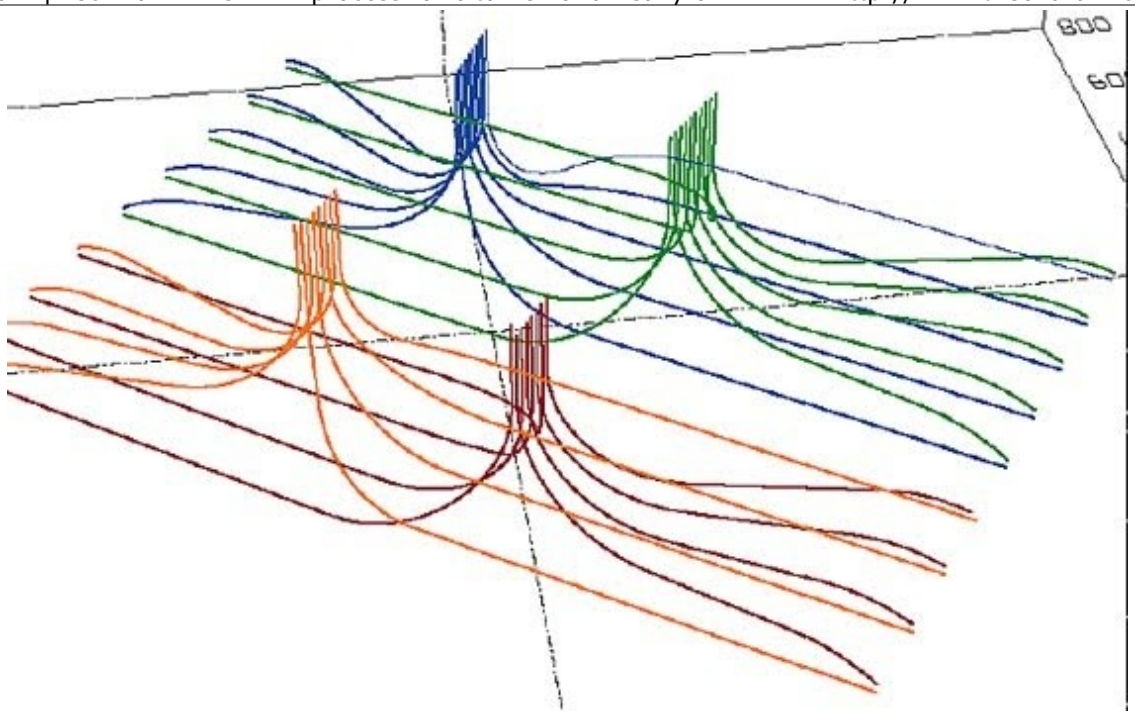


Illustration of the key parts of the process.

The horizontal wells are drilled (a suite of eighteen wells, each with a 2,000 ft horizontal section, spaced 410 ft apart) some 7 ft above the bottom of the formation (or the water table if that becomes an issue). Above these the air injection wells are drilled directionally and offset from the toe of the well. (By using directional drilling air injection can be better controlled than with the original vertical wells).



Layout of the air injection (upper) and production wells.

Once the wells are in position steam will be injected and circulated for a period of 3 months to bring the sand and bitumen up to around 100 deg C, then air will be injected to start combustion. The part of the bitumen that burns as the process develops is the residual asphaltene that is left after the lighter fractions are either evaporated, flow away at reduced viscocity or are cracked by the high temperature (> 400 deg C). The residual material, apparently about 10% of the OOIP, provides the fuel, driving some 90% of the fuel into the production well.

To sustain production after ignition and flame front stabilization has occurred, the wells will carry some 4.4 million cf/day into the formation, and about the same amount of a mix of carbon monoxide, carbon dioxide, and hydrocarbon gas will be released. As the video notes that gas will be used on site to generate electricity to run the air compressors, and to provide site power. Based on the earlier tests the site is anticipated to generate some 10,000 bd of cracked bitumen, and about twice that in water production. The flame front will move forward at between 5 and 10 inches a day. The oil is projected to be a significant upgrade of the original bitumen. The water has the potential for being sold to other operators in the area for use in SAGD production.

Parameter	Athabasca Bitumen	THAI™ Oil
Viscosity at 20°C (cp)	555,000	1,550
Sulphur Content (weight %)	3.2	2.6
API Gravity (degree)	7.9	12.3
SARA Analysis at 11° API (weight %)		
– Volatile Organics at 20°C	21.1	25.6
– Saturates	12.7	23.5
– Aromatics	30.3	22.6
– Resins	19.0	17.2
– Asphaltenes	16.9	11.1

Comparison of bitumen with THAI produced oil.

The energy efficiency of the site is anticipated to be 85.7%. It should be noted that the document I have taken this information from also contains a conservation and reclamation plan. (But at 653

pages long for the whole document I have only noted key passages for the theme of the post).

In response to my SAGD post both Rockman and RockyMtnGuy commented about using underground combustion to help with getting the bitumen from the oil sand.

One of the things that they were concerned about, as was I, is the control of the flame front which becomes more difficult as the height of the production zone is around 70 ft. However at May River they plan on burning from the outside in, so this may control the extent to which the fire overburns. In addition, as I noted at the beginning of the post, it is rather difficult sometimes to sustain the right temperatures without a high flow of air, and that may provide a further control.

The conditions are somewhat different at Kerrobert where the oil is less viscous and the formation is around 100 ft thick. This has caused some problems since the well flows exceeded what had been anticipated:

> the original plan was to use temporary hydraulic pumps on each well to create a drawdown pressure across the horizontal well and, as combustion gas production increased, pumping would cease and wells would flow by produced gas lift.
>
> Initial fluid production volumes were tested at 180 to 300 barrels per day per well, with oil cuts ranging from zero to 40%. However, during the transition phase to gas lift it was learned that liquid inflow to the production wells exceeded the pump's capacity, which limited the ability to draw down the wells and caused frequent pump failures. On Dec. 21, the pump in KP1 was re-configured to improve its pumping capacity. Now KP2 is being re-configured and is expected to be producing at similar rates to KP1 within the next few days.
>
> Since the re-configuration, fluid production rates from KP1 have ranged between 250 and 420 bbls per day with oil cuts averaging 36% and reaching as high as 65%. Also, the air injection rate was increased to 50,000 cubic metres per day and the produced gas rate has increased to 8,000 cubic metres per day.

Looks as though things are going quite well.

Oh, and the disadvantage of having a small coal fire in a garret flat is that during the night it went out, and in the morning I would occasionally wake up with snow in the grate.