THERMAL ENHANCED OIL RECOVERY (EOR) METHODS

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THERMAL ENHANCED OIL RECOVERY

Thermal recovery processes rely on the use of thermal energy in some form both to increase the reservoir temperature, thereby reducing oil viscosity and to displace oil to a producing well. These oils cannot flow unless they are heated and their viscosity is reduced enough to allow flow toward producing wells. During the process, oil undergoes physical and chemical changes because of the effects of the heat supplied. Thermal recovery is a major type of enhanced oil recovery processes and can be subdivided into various types; hot fluid injection such as **steam injection (steam flood or cyclic steam injection), hot water flooding and in-situ combustion processes.**

Steam Assisted Gravity Drainage (SAGD)

Steam assisted gravity drainage (SAGD) is a thermal recovery method that is widely used to extract heavy crude oil and bitumen from underground sands deposits, involving an advanced form of steam stimulation. This process involves forcing steam into sub-surface oil sands deposits to heat the bitumen locked in the sand, allowing it to flow well enough to be extracted. This technology is particularly relevant in Canada because it is the primary method of in situ extraction used in the oil sands. However, it has some advantages such as; more than 90% of the water used will be re-used or recycle and it creates dramatically less surface disturbance than conventional open-pit mining.

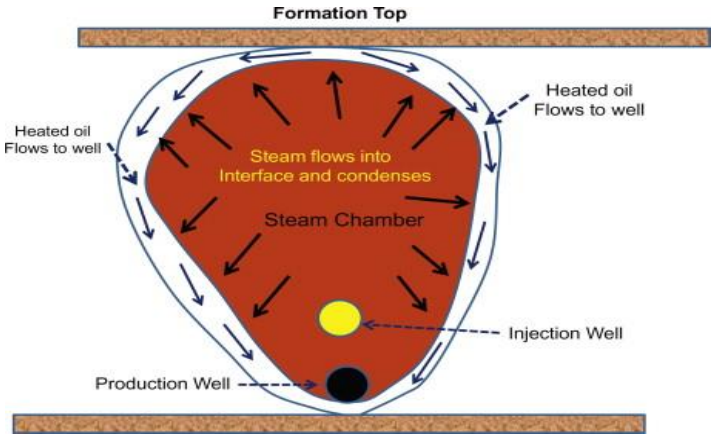

Figure 1.1: Conceptual diagram of the SAGD process.

Technique Used in the Extraction of Bitumen

In order to extract bitumen, two horizontal wells are drilled into the oil reservoir, one a few meters above the other. High-pressure steam is continuously injected into the upper well and

into the reservoir to heat the oil and reduce its viscosity, causing the heated oil and condensed steam to drain into the lower wellbore, where it flows under natural pressure or via pumps to the surface for further processing.

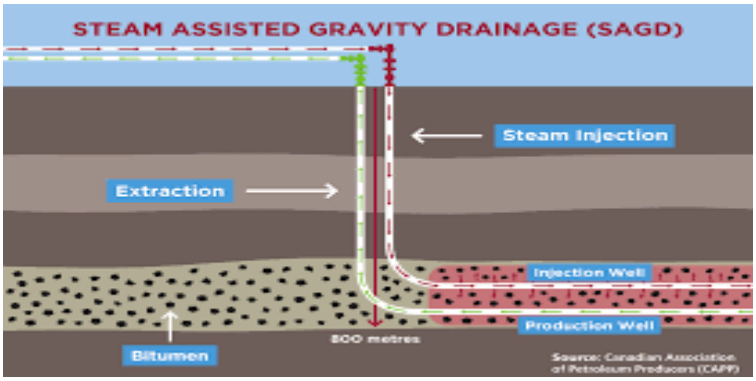

Figure 1.2: A SAGD setup to extract bitumen.

Cyclic Steam Stimulation (CSS):

This is a type of thermal recovery (steam injection), in which a well is injected with steam and then subsequently put back on production. In cyclic steam stimulation the same well is used for steam injection and oil production.

In this process the steam is first injected into a well for a certain amount of time to heat the oil in the surrounding reservoir to recover approximately 20% of the Original Oil in Place (OOIP), compared to steam assisted gravity drainage, which has been reported to recover over 50% of OOIP. It is quite common for wells to be produced in the cyclic steam manner for a few cycles before being put on a steam flooding regime with other wells. This method is also known as the **Huff and Puff method** or **Steam soak** and it consists of three (3) stages namely;

1. Injection
2. Soaking
3. Production.

The mechanism proceeds through cycles of steam injection, soak and oil production. First, steam is injected into a well at a temperature of 300 to 340^{0}C for a period of weeks to months. Next (soak phase), the well is allowed to sit for days to weeks to allow heat to soak into the formation. Finally, the third stage, the thinned oil (hot oil) is pumped out of the same well for a period of weeks or months. Once the production rate falls off, the well is put through another cycle of injection, soak and production.

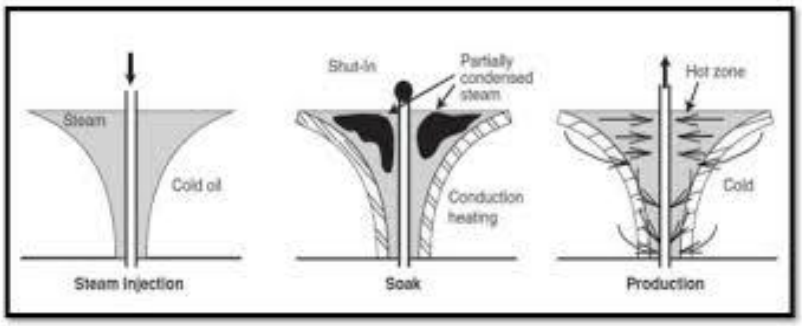

Figure 1.3: Cyclic Steam Stimulation (CSS) Process.

The CSS method has an advantage in which the recovery factors are around 20 to 25% and the major disadvantage is that the cost of injection steam is high. Cyclic steam injection is used extensively in heavy-oil reservoirs, tar sands, and in some cases to improve injectivity prior to steam flood or in-situ combustion operations.

Hot Water Flood:

Hot water flooding, also known as "**hot water injection"** is a type of thermal recovery in which hot water is injected into a reservoir through specially distributed injection wells. Hot water flooding reduces the viscosity of the crude oil, allowing it to move more easily towards production wells. It is typically less effective than a steam-injection process because water has lower heat content than steam and mostly used in certain formations such as fresh water.

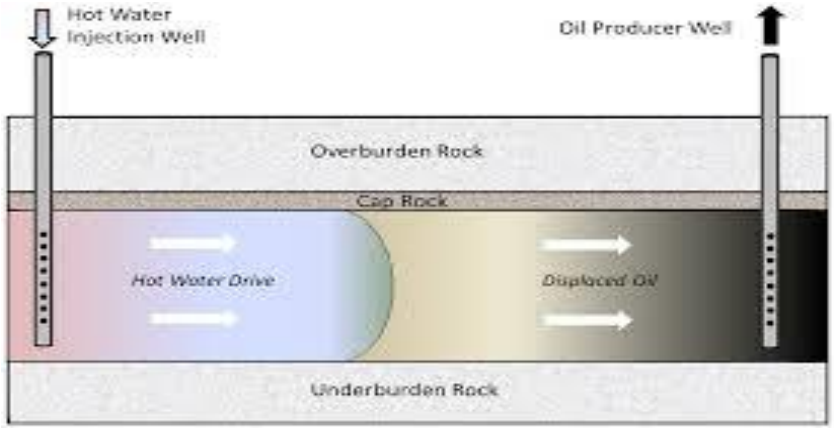

Figure 1.4: Hot water flooding process.

The hot water is injected through an injection well which is drilled parallel to the primary producing well as shown in figure 1.4. The heat from the hot water acts as a way of reducing the viscosity of crude oil, making it to flow towards the producing well with ease. Hot water flooding is generally used to extract crude oil which has an API degree of less than 20.

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