



*Heavy Oil Recovery by Steam Injection +
Additives through Horizontal Wells*

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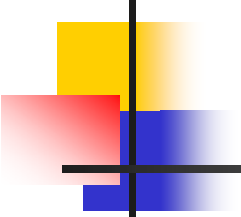
- Recovery of heavy oil through steam injection has been studied extensively.
- Such studies indicate that steam injection is very effective in heavy oil reservoirs with high permeabilities, and in thick sands.
- Several studies have also indicated that, even in low-permeability reservoirs, steam injection can be very effective, provided the reservoir is fractured.



Injection of Steam + Additives

- A few recent laboratory studies have indicated that, if steam injection is accompanied by some additives, the recovery increases dramatically over what is recovered by injection steam alone.
- The additives can be nitrogen, CO₂, air, or even light gases such as methane.
- Although injection of steam + light hydrocarbons increases the recovery considerably, the light hydrocarbons are generally lost to the formation.

- On the other hand, injection of steam + CO₂, in addition to improving recovery, has the additional advantage that CO₂ is sequestered.
- Transportation of CO₂ to the field may be difficult (and costly). Then, injection of steam + nitrogen or steam + air appears to be effective as well.

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- Although several studies have already been carried out, the reported results have been explained based on ad hoc and/or “hand-waving” arguments.
 - We are aware of no systematic study that considers all the possible additive candidates and
 - A. compares their performance with the same porous medium;
 - B. identifies the advantages and disadvantages of each;
 - C. provides thermodynamic- and flow-based rationale for the improved recovery, and
 - D. investigates how the laboratory-scale results can be upscaled to field conditions.

- In addition, no study has ever been carried out - either experimentally or by simulation - to study this process in a fractured reservoir.
- Thus, one goal of this project would be what we identified above:
systematic laboratory and simulation studies of injection of steam + additives for heavy oil recovery.



Injection of Steam + Additives through Horizontal Wells

- An important issue is the path through which steam + the additives should be injected into a reservoir.
- For heavy oil recovery, one important goal should be maximizing the effect of gravitational forces (gravity drainage), while minimizing the effect of the viscosity.
- Both goals may be realized through the use of horizontal wells.



Injection of Steam + Additives through Horizontal Wells

- A single horizontal well can often be as effective as many traditional rows of vertical injection (and producer) wells, in addition to be cheaper.
- For heavy oil, in particular, horizontal wells can be particularly effective.



Injection of Steam + Additives through Horizontal Wells

- Therefore, the overall goal of the project is a systematic study of use of injection of steam + additives through horizontal wells for heavy oil recovery.