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Evaluation of Fast-SAGD Process in Naturally Fractured Heavy Oil Reservoir Using the Optimization Procedure

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Introduction and objectives

Due to the increase in oil price and its cumulative usage, enhanced oil recovery (EOR) processes have been introduced worldwide in the last two decades. The capillary and viscous forces lead to oil recovery using the primary and secondary recovery processes, and the remaining trapped part of oil is produced. Since the new technologies emerged in oil industry for viscous oil recovery, the perspective of the world's oil provision has been changed.

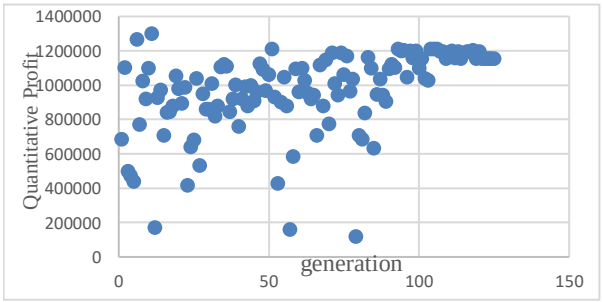
Cyclic Steam Stimulation (CSS) is a thermal recovery method which is applied for heavy oil reservoirs. Other techniques include, in-Situ Combustion (ISC), Steam Assisted Gravity Drainage (SAGD), and Continuous Steam Injection].Steam Assisted Gravity Drainage (SAGD) is one of the common thermal processes in which a pair of horizontal wells is drilled. This process was later modified to reach to higher efficiency values by introducing Fast SAGD, and NCG's SAGD processes. In Fast-SAGD process, the system is equipped with offset wells using cyclic steam stimulation to increase the rate of growing the chamber sideway. The CSS process then begins at higher pressures in respect to SAGD wells. Following this approach, the steam chamber is grown laterally. In the present study, the effect of operating parameters including CSS well elevation, CSS well injection pressure and rate, CSS well starting time, spacing of SAGD wells and SAGD wells injection rate are studied on oil recovery factor. The optimum operating conditions is obtained using the CSOR and net present value (NPV) as the goal function.

Results and Conclusion

For the first generations, the value of CSOR lays in the range of 2.5 to 4. The model is enhanced in each step and the final value of injected steam to produced oil ratio becomes one, which shows significant increase in comparison to previous studies. By assuming the value of the produced oil as four times of the injected steam, it is assumed that all the data resulted from genetic algorithm could be evaluated. To do so, the amount of produced oil is multiplied by 4. Then the amount of injected water is subtracted from it in order to evaluate the oil revenues.

Qualitative profit = 4*Produced Oil (Petroleum)-Injected Steam (Vapor)

The qualitative profit curve for the above data is as follows:



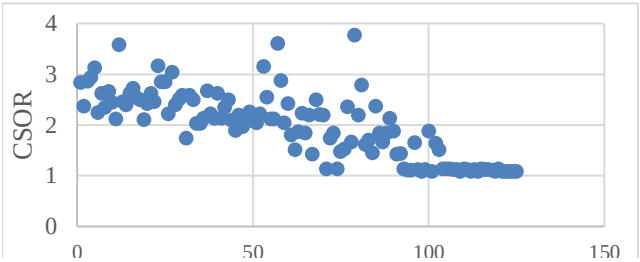
SAGD Production Well Elevation

In genetic algorithm, as generation is progressed toward future, it is more evolved; this leads to more appropriate target functions. Referring to the above figure, SAGD production wells are initially located at different heights. As the best position for SAGD production well is block number 1, after some generations, the block number 1 would allocate the SAGD production well as the most suitable position. Other parameters including CSS well elevation, CSS well injection rate, CSS well starting time, spacing of SAGD wells and SAGD wells injection rate are studied on oil recovery factor are also studied and the optimum operating conditions are obtained.

Methodology

Variables	Last Generation					
SAGD Production Well Elevation	1	1	1	1	1	1
Off set CSS Well Elevation	1	4	4	4	4	4
SAGD Injection Well Elevation	7	7	7	7	7	7
The Number of CSS Cycle	1	1	1	1	1	1
The Rest Time of CSS Well	2	4	4	4	4	4
Startup Injection Time	7	7	7	7	7	7
Injection Period	1	1	1	1	1	1
SAGD Injection Pressure	2	1	1	3	1	1
Injected rate of CSS Well	1	4	5	4	3	2
CSOR	1.132	1.0798	1.0798	1.0798	1.079	1.079

The obtained data using the genetic algorithm are stored in a text file. All of the data with respect to population are illustrated in the following figure.



variables	Last Generation					
SAGD Production Well Elevation	1	1	1	1	1	1
Off set CSS Well Elevation	1	4	4	4	4	4
SAGD Injection Well Elevation	7	7	7	7	7	7
The Number of CSS Cycle	1	1	1	1	1	1
The Rest Time of CSS Well	2	4	4	4	4	4
Startup Injection Time	7	7	7	7	7	7
Injection Period	1	1	1	1	1	1
SAGD Injection Pressure	2	1	1	3	1	1
Injected rate of CSS Well	1	4	5	4	3	2
CSOR	1.1322	1.0798	1.0798	1.0798	1.079	1.079

It is inferred from the figure that the maximum profit is obtained at end point data, in which the value of CSOR is minimized.

CSS Injection Time

Regarding the above figure, to achieve the minimum CSOR, it is essential to have the lowest injection rate in CSS deviated well. Since the values of injection flow rate and pressure are higher in comparison to SAGD, the well opening would lead to injection of more steam to the well which causes the increase of CSOR.