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A Prospective Method to Increase Oil Recovery in Waxy-Shallow Reservoir

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Abstract. Waxy oil has been the main characteristics of The X field. Initial screening criteria studies indicated that cyclic steam stimulation (CSS) would be the optimum option because favorable reservoir condition. Based on this method we would like to know how much oil gain and the effect of steam for the stimulated and surrounding well. The injection of steam was done for 7 days followed by 14 days of soaking period. 39,000 liter of Marine fuel oil was used to generate steam for stimulation with an average produce steam quality about 80%. Average of 255 MMBTU of steam was injected each day with total steam injected was about 1.7 BBTU. The oil production was increased four times from 5 bopd into 21 bopd. Proper well candidate and high permeability are some reason for this method successfully increase oil production. Additional heat from steam reduced the damage near wellbore due to wax deposition. This is verifying by increasing productivity index from 3 bbl/psi to 4 bbl/psi. From results and observation data, this method can be a platform for typical shallow depth reservoir with high paraffinic content especially other reservoir in Sihapas formation.

1. Introduction

Production of oil reservoir with wax problem is challenging due to the characteristic of wax which made the oil not flowing when the temperature below the pour point. To fix this problem, several mitigation and removal techniques have been applied for numerous field with typical wax problems [1]. The common removal techniques are Fused Chemical Reaction, Mechanical Removal, Wax Removing Chemicals which are solvents type and dispersants, Magnetic Fluid Conditioning (MFC) technology, Use of Microbial Products such as marine micro-organisms, and Heat Application [1].

Heat application is one of popular method for fixing the wax problem. Several methods such as hot water injection, electromagnetically near-wellbore heating, and injecting steam, either by cyclic method or continuous, could be utilized to clean the wax in the near-wellbore. Steamflooding is the oldest commercial Enhanced Oil Recovery. It also contribute the most for the world's enhanced oil production [2]. One of its method, cyclic or commonly called as "huff 'n' puff", is widely used in oil recovery. Cyclic Steam Injection gives quick response but its result may not as higher as the other thermal method [3].

Cyclic steam stimulation projects start from decade ago in several different condition of reservoir such as tar sand [4], tight clay-rich reservoir [5], heavy oil [6], and also light oil [7]. In most cases, steam application often use for heavy oil, but some reports suggest that it could be used as an alternative for light oil reservoirs [8–10]. Laboratory and field trial of steam injection also have been reported from



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same formation, Sihapas formation [7,10,11]. Laboratory test show that 16% of the oil produced by the mechanism of vaporization at temperature of 400 °F [11].

This paper attempted to observe the application of cyclic steam stimulation (CSS) into reservoir with wax problem. Several thermal methods have been applied into reservoir with the same problem, such as Hot Water Injection in Mangala Field [12], In-Situ Heat Generation (Heat Stimulation) [13], and Steam Injection [14,15] but the CSS method has not been applied into this kind of reservoir. Numerous reports suggesting the use of heat for handling the wax problem have been taken into account [13,16,17]. The field reports showed that heat utilization will bring good result regarding both oil recovery and wax deposition. Initial hypotheses based on other fields with other thermal methods suggest the application of cyclic steam stimulation is worth to try.

2. Methodology

A number of screening criteria for the steam application into reservoir is needed to be taken into consideration such as formation thickness, reservoir depth, oil saturations, permeability of rock, and oil viscosity for the success of this project [2,18]. Table 1 shows the screening criteria for steam utilization and its comparison with the field trial project.

Table 1. Comparison between technical screening for steam injection and field properties.

Screening Criteria		X Field Properties
Crude Oil		
API Gravity, °API	8 to 25 ↗	31.9
Viscosity, cp	<100,000	14
Pour Point, °F	-	105-110
Reservoir		
Net Thickness, ft	>20	30
Depth, ft	<5,000	1100
Permeability, md	>200	500
Oil Saturation, %PV	>40%	77%
Temperature, °F	Not Critical	136 °F

In this trial, 0.05 BBTU/ft pay thickness is used to calculate total steam needed for one cycle. Steam quality range between 70-80%. Recent report suggests that steam quality above 50% is mandatory for the project to be successful [14]. Therefore, 1.5 BBTU of steam was planned to be injected into reservoir for around 7-8 days. Unfortunately, there was lacked of proper equipment to measure rate injection of steam. Hence, we estimate the total steam injected each day by using average injection pressure data. Complete calculation and data during injection is showed by table 2.

Table 2. Steam properties during injection.

Day	Steam Quality, %	Avg. Inj Pressure, psig	Avg. Inj Temp, °F	Water Injected, BCWEPD	Total heat Generated, MMBTU	Cum. Heat Generated, MMBTU	Running time, hours	Est. Steam injected, MMBTU
0	71	171	476	250	71.43	71.43	12	-
1	75	290	539	500	142.86	214.29	13	-
2	77	360	553	814	232.57	446.86	23	25.80
3	77	425	575	530	151.43	598.29	16	56.83
4	77	490	588	427	122.00	720.29	13	77.77
5	77	560	621	848	242.29	962.57	24	206.40
6	77	600	624	848	242.29	1204.86	24	242.29
7	77	600	623	848	242.29	1447.14	24	242.29
8	77	600	624	885	252.86	1700.00	25	252.39
Total				5950	1700		7 days 6 hours	1103.77

3. Results and discussion

Out of 1.5 BBTU, around 1.1 BBTU was successfully injected. It was less than the initial volume targeted to be applied into reservoir. Effect of steam can be observed from the incline in oil production. Due to the heat from steam, oil will be less viscous, therefore the mobility of oil will increase. The effect of steam into oil production rate is four times bigger from before steam was injected. It also reduced the production of water. The water cut went down from 99% into 95%. Figure 1 and 2 shows the significant change of oil and water production after the cyclic steam stimulation (CSS).

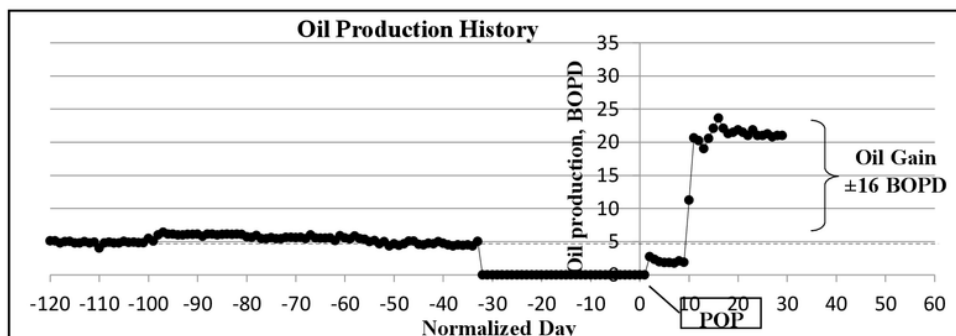


Figure 1. Oil production history.

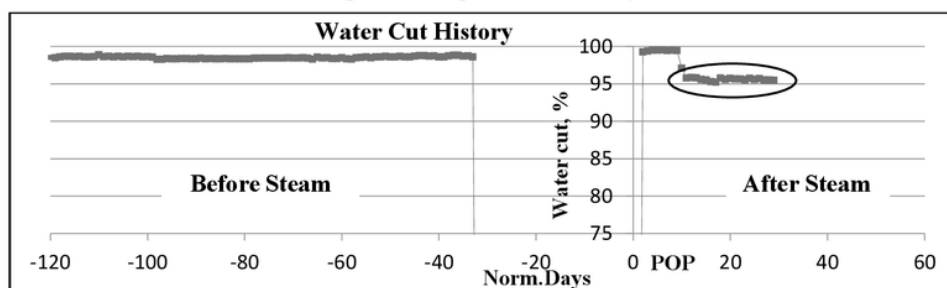


Figure 2. Water cut history.

In the other hand, steam also accountable for the melting of wax deposition near the wellbore. Wax deposited near the wellbore would restrict the flow of oil. With less restriction, it will enhance the ability of reservoir to flow the oil. It could be seen from the increasing of productivity index from 3.09 bbl/psi into 3.97 bbl/psi.

The temperature near wellbore significantly higher during steam injection. However, during soaking period, temperature drop very fast. The dropping temperature due to heat loss could have considerable impact into oil production, as the oil production much likely stay higher when the temperature was maintained high. The heat loss from steam to formation could happen due to time and wellbore heat capacity [19]. Nian et al. pointed that during the early stage of steam utilization, the wellbore heat capacity impact on heat loss is larger [19]. Increasing the injection rate and steam quality can improve the wellbore heat efficiency [20]. Therefore, further test must include the sensitivity of injection rate and steam quality. Optimum condition of those factors will be needed in order to reach the optimum injection criteria for this field. Optimum soaking time will be needed in order to maximize the oil production, thus the wax will not be formed in the near wellbore. The total of injection volume is also play a part in the rapid temperature drop. Only around 70% volume of steam was successfully injected into reservoir. Figure 3 shows the temperature near wellbore after steam injection.

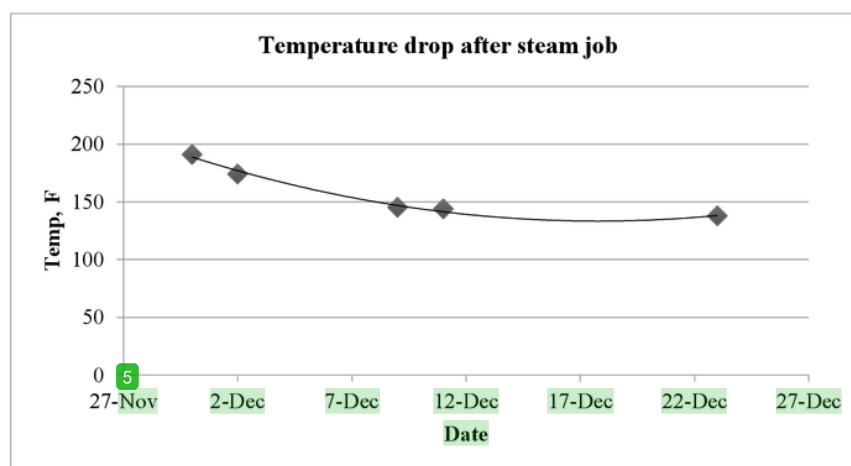


Figure 3. Temperature profile in near wellbore after steam injection.

4. Conclusion

Cyclic steam stimulation proved to be a prospect for rejuvenating oil production from waxy reservoir. The effect of steam not only boosting the oil production, but it also reduced the water production. The wax deposition in near wellbore were flushed out due to the high temperature during steam injection. Positive change from productivity index show that the oil moves freely due to the disappearance of wax. More analysis will be required should the project continue. The soaking period will be the main concern as the optimum time will give considerable effect into the production of oil.

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