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How to Deal with Producing Very Mature Field: case L Field Pertamina

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Abstract
As national oil and gas company that was founded 63 years ago, Pertamina deals with quite a lot of mature fields. L Field was first explored in 1925, which precede Pertamina. This field produces with wells that are mostly on more than 90% water cut. Dealing with this very mature filed is quite tricky. Selective work plan needs to be performed to achieve optimum results.

Three general approaches that are performed for L Field for the last three years are: decreasing water cut, balancing produced water and injection water, searching for remaining oil prospects. In order to decrease water cut, reversed coning treatment package was performed. The package consists of perforation cleaning using high pressure flush, paraffin solvent and relative permeability modifier stimulation, and reversed coning tool. Balancing injection and produced water was achieved by performing acidizing or solvent stimulation to injector wells to remove perforation plugging. RST log was utilized to search for remaining oil in a well.

Well M-36 was treated with reversed coning treatment package in 2019. This treatment was performed under performance based contract. Having performance based stipulation to handle mature field economically makes sense since production is not going to be really big. Powerwave tools was used to mechanically clean perforation. This tool increase fluid pressure that flows through its nozzles. Paraffin solvent stimulation then entered the picture to dissolve oil's paraffin content. Relative permeability modifier was then pumped to block water movement in the reservoir. Last, mechanical reversed coning tool was installed to attempt breaking existing water coning shaped. After treatment, well M-36 produced oil more than twice its pretreatment production from 5 to 12 bbls/day. Injector stimulation was performed for seven wells, which had drops in injection rate. Out of these seven wells, 63% success ratio was achieved. This treatment successfully maintain L-Field Production. RST log was performed on well L-071. From RST, remaining oil from potential layers in this well was found and perforated. Its oil production was the highest in L field in the last 5 years with 80 bopd with water cut as low as 30%.

These three general approaches are proven to be quite effective in producing very mature field such as this L Field. When water handling was done right, any excess from injection rate compared to produced water can be used to perform production optimization. While waiting for discoveries on new prospects in a mature field the approaches in this paper can be used as a template work plans.

Introduction
L Field was first explored in 1925 by Standard Oil of New Jersey (America) and Nederlanse Koloniale Petroleum Maatschapij (Netherland). The first oil producing well L-003 found in 1936. In 1941 Sago structure was developed with S-010 well initial rate 850 BOPD. L Field reached its peak production 30.000 BOPD in 1958 with average water cut around 30%. Pertamina operated L Field from 1983 and now its producing 1600 BOPD from 109 producing wells with 98.8% water cut and injecting around 150,000 BLPD produced water through 57 injector wells. L Field has reached a mature stage with 52% recovery factor. L field has sufficient wells drilled to adequately drain the productive reservoirs, no new wells are considered necessary to be drilled, as 1986 study suggested. One way to increase oil production is gross up optimization which causes the increment of water production.

With this condition, L Field facing some major problems:
- High water cut
- Water management
- Low remaining reserves

For the last three years several efforts performed to decrease water cut, balancing produced water and injection water, and look for remaining oil prospects. This paper will explain it further.

Data and Method
A. Reverse Coning Package Method
As we know reverse coning method often used to prevent water coning or thin hydrocarbon layer. In this case, we combined several techniques and performed it as one job sequence. This job sequence consists of:
1. Powerwave tools
Water was injected through powerwave tools that have a nozzle on the tip. This tool increase fluid pressure that flows through its nozzle, creating jetting effect to mechanically clean the perforated zone. The powerwave technology is based on internal differential pressure forcing the flow to oscillate from nozzle exit to the other, these burst of fluid create pulsating pressure waves within wellbore and formation fluid that break up and removing near wellbore damage. Figure 1 shows description of this tool.

Figure 1 Powerwave tool

2. Paraffin Solvent
   L Field has paraffinic oil with API gravity 34 and pour point 108°F. Therefore, paraffin solvent stimulation can be utilized to chemically clean the wellbore. It dissolves oil's paraffin content and deposition near wellbore. Relative permeability modifier was then pumped to block water movement in the reservoir.
3. Reverse Coning Tool
   Mechanical reversed coning tool was installed to attempt breaking existing water coning shaped. Figure 2 shows how water coning in the reservoir is broken by installing reverse coning tool. This tool is shown in Figure 3. Reverse Coning Tool developed to extract oil in watery region by reversing the water through the bottom of the device and allowing oil flow from reservoir into the well that is shown in the following figure. With this approach, the oil recovery can be raised

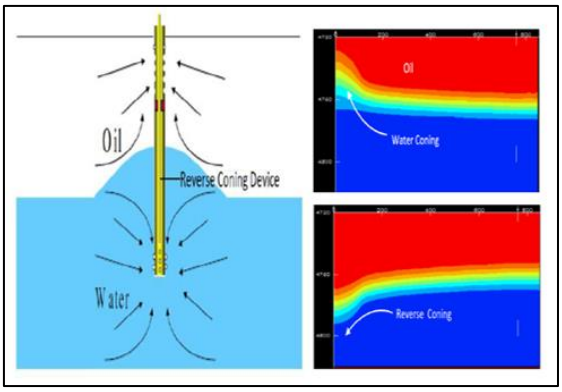

Figure 2 Reverse Coning Concept

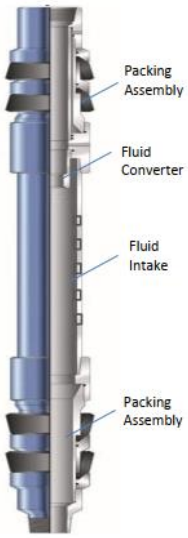

Figure 3 Reverse Coning Tool

B. Injection Well Stimulation
With 150,000 bbls of production water, L field only had 57 injector wells. Overtime, injection wells capacity started to decline due to blockage of the perforation caused by paraffin wax and scale deposition. Optimization on injector wells must be performed, while looking for new injection well candidates. Therefore, anti-paraffin agent was injected to dissolves paraffin wax, followed by acid stimulation to dissolve scale accumulation. Figure 4 and Table 1 show the form of paraffinic oil in L field and results of paraffin solvent solubility test of the oil.

Figure 4 Crude Oil from L-Field

m_{oil}	10.9018	gr
m_{screen}	2.9721	gr
m_{final}	2.987	gr
$m_{insoluble}$	0.0149	gr
$m_{soluble}$	10.8869	gr
% solubility	**99.86%**	

Table 1 L Field Crude Oil Solubility Test Result with Paraffinic Solvent

C. C/O log
C/O log is a logging tool that measures the carbon-oxygen content of a formation and its contained fluids. The C/O ratio proved to be reliable indicator of hydrocarbons in sandstone formations, independent of formation water salinity and, in most instances, independent of turbidity.

In addition to the C/O log, a continuous log similar to an ordinary neutron log can be run. Also, by selective timing within the tool, gamma ray responses indicative of silicon and calcium can be recorded to aid in interpreting the C/O log in areas of unknown lithology or mixed lithology. In a practical sense, this tool has the capability to obtain information on the hydrocarbon content and porosity of a formation, as well as to differentiate sandstone from carbonates and clean sands from limy sands. Figure 4 shows C/O example of C/O log interpretation.

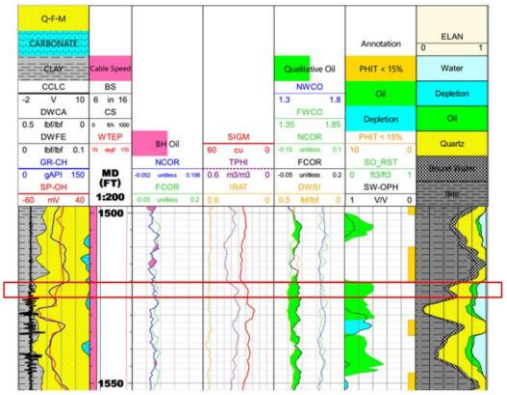

Figure 5 C/O log interpretation Example

Result and Discussion

A. Reverse Coning Package Method

M-036 well met the criteria to be applied with reverse coning package method. Its water cut rapidly increase from 94.2% to 98.8% after artificial lift optimization. Figure 6 shows this well's Chan Plot that indicated a bottom-water coning. The reverse coning package aimed to decrease water cut so that water management for this well could be easier to handle.

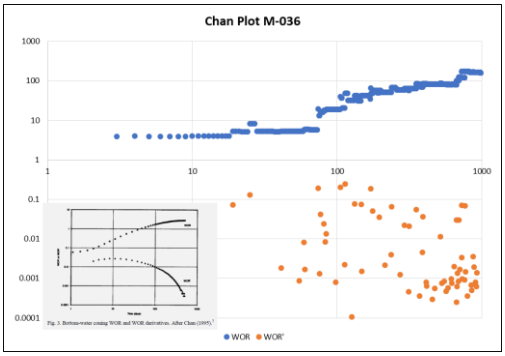

Figure 6 Chan Plot of M-036 well

M-036 was producing 5 BOPD before treatment. After Reverse Coning stimulation job in January 2020, M-036 produced averagely 12 BOPD, although no significant decrease in water cut (99.6% to 98.2%) and still producing at 6 BOPD and 99.5% water cut at the end of 2020 (Figure 7). It seems that its water cut went back to the pre-treatment condition after almost a year. It can be concluded that the treatment is effectively decrease M-036 water cut, with 1 year lifetime. Next tasks to carry are to evaluate the effectiveness of powerwave tool, paraffin stimulation, and reverse coning tool separately and the optimum period to repeat treatment process in a well.

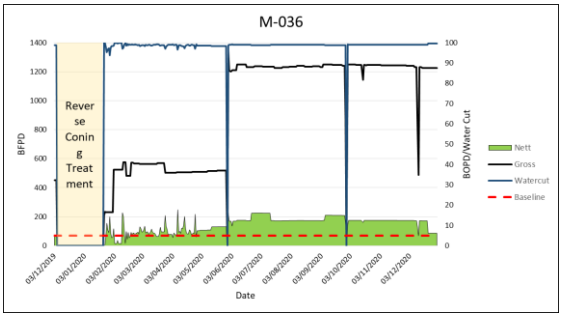

Figure 7 M-036 Production Performance

B. Injection Well Stimulation

Acid and Anti-paraffin stimulation was performed to 8 injection wells, which had drops in injection rate. The method is as follow:

a) **Pre-job injectivity rate test** with brine to identify the stimulation operating rate and pressure
b) **Inject anti-paraffin chemical** and soak for two hours.
c) **Inject acid chemical** to dissolve scale deposition near wellbore and soak for two hours.
d) **Post job injectivity rate test** to compare before-after performance.

Some wells immediately performed better while stimulation, yet a few showed improvement after soaking the chemical. Overall, 5 out of 8 injection wells showed improvement in injection rate (63% success ratio). Figure 8 to 11 show one of the successful injection well stimulation case in Well N-082 L Field.

Rate (BPM)	Pressure (psi)
0.5	290
0.75	350
1	405
1.25	445
1.5	460
1.75	490
2	505
2.25	510
2.5	515

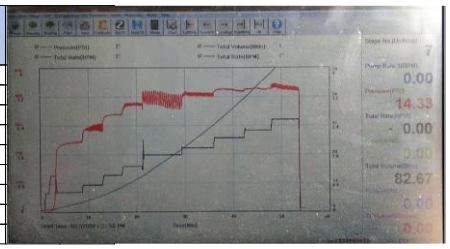

Figure 8 Anti-parafin injection of N-082 well, L Field

Rate (BPM)	Pressure (psi)
1	270
2	400
2	190
2	320

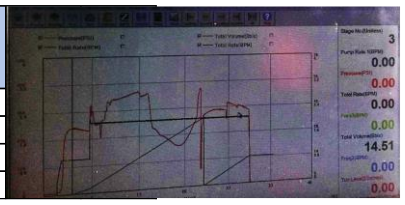

Figure 9 Anti-parafin injection of N-082 well, L Field

The graph showed pressure decline while injection of anti-parafin, indicating that chemicals reacted well and clean the wellbore.

Rate (BPM)	Pressure (psi)
0.5	15
1	120
1.75	320
2	360
2.5	420
2.75	450
3	460
3.5	500

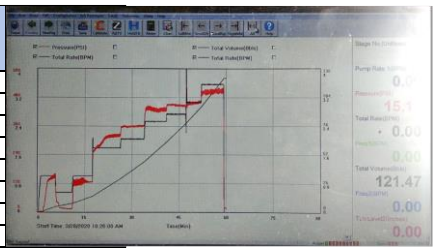

Figure 10 Post-job injectivity rate test of N-082 well, L Field

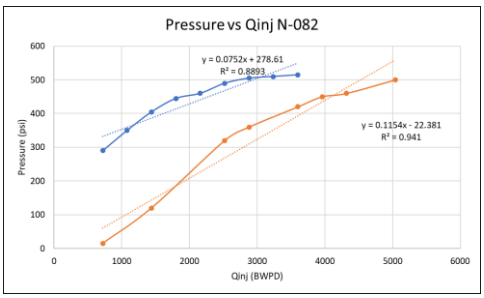

Figure 11 Pre-job and Post-job injectivity rate comparison

This shows that the injectivity rate was better after stimulation. With the same injection pressure, it could be injected with more volume after stimulation.

Injection well stimulation successfully increased injection capacity in L Field and ease the water management. Resulting space for surface facilities and artificial lift optimization.

C. C/O log

A C/O log was done on suspended well L-071 to seek hidden potential hydrocarbon resources. Figure 12 shows C/O log from Well L-071.

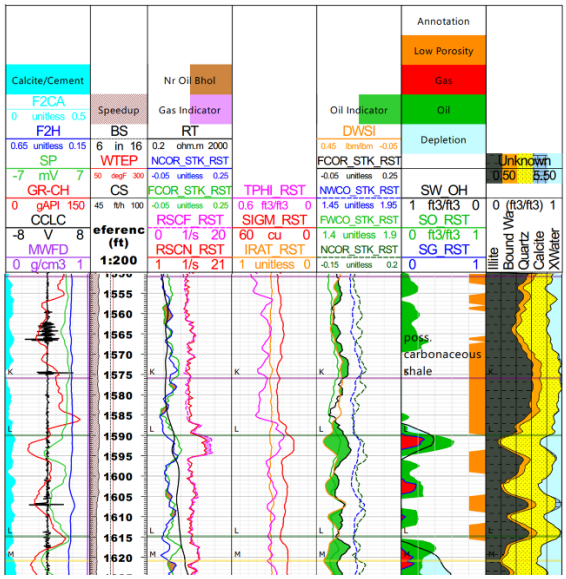

Figure 12 C/O log of L-071 well

The C/O log interpretation found an interesting zone on L layer (1590 – 1594 ftMD).

Production performance of this Well L-071 after performing well intervention based on the C/O log result is shown in Figure 13.

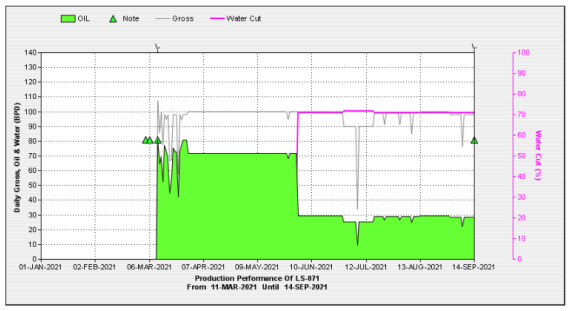

Figure 13 L-071 Production Performance

L layer of L-071 was opened with initial production = 108 BFPD, 81 BOPD, and 25% water cut. It was a huge achievement for L field and unlocked new opportunities on L layer near L-071 well to be developed.

Conclusions

These three general approaches are proven to be quite effective in producing very mature field such as L Field. When water handling was done right, any excess from injection rate compared to produced water can be used to perform production optimization. While waiting for discoveries on new prospects in a mature field the approaches in this paper can be used as a template work plans

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