METHODS FOR ENHANCING PRODUCTION EFFICIENCY OF GAS LIFT WELLS IN VIETSOVPETRO OIL FIELDS

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Summary

Research for solutions to improve the efficiency of oil production from wells with low production rates and/or flooding is a goal and strategy of the oil companies of Petrovietnam in general and Vietsovpetro in particular. This paper presents the effects of physical and chemical methods on the product flow of gas lift-based production wells both on laboratory and industrial scale in Bach Ho oil field. Chemical mixtures containing paraffin inhibitors and demulsifiers were pumped into the production flow of several wells using the gas lift production method in Bach Ho oil field. Initial results indicate that the output increased by about 7.1 - 80.0%, lift gas volume reduced by 5.6 - 32.7%, and paraffin deposition decreased by 12.1 - 14.1%. These results illustrate the effectiveness and feasibility of aforementioned technique. It is believed that the application of this technique over a broader range would bring increased profit for Vietsovpetro.

Key words: *Bach Ho oil field, gas lift, chemical mixture, foam.*

1. Background

Oil production by gas lift method has been implemented in the oil and gas fields of Vietsovpetro since 1997. So far, the results have confirmed the correct choice of mechanical production methods. In Bach Ho and Rong fields, oil is produced from many different areas having different geological parameters, hence requiring different optimum production methods. The production rates of the gas lift wells vary widely, ranging from 5 to 100 tons/well/day. The wells that have production rates greater than 60 tons/day are less complex than those having low production rates (less than 30 - 40 tons/day). For the latter, in the production process, paraffin/wax deposition often occurs on the wall of the pipe/tube leading to tube blockage. As a result, the oil and gas flow rate of these wells gradually reduces, leading to complete blockage and lost production. These wells are periodically shut in for removal of the paraffin deposited on the pipe walls. The frequency of the cleaning procedure is every week, and it takes from 3 to 4 hours each time. The deposited paraffin can be cleared by directly pumping steam into the tubing to melt the deposits. This technique is simple and easy to implement but it does have some disadvantages, including:

- The well needs to be shut in causing loss of production;
- Effect is seen normally with only the paraffin deposited at the wellhead;
- High temperature steam can cause problems for the flanges of the equipments located in the wellhead, probably leading to damage.

One of the possible methods that can overcome the above drawbacks of the thermal method is to pump a suitable chemical mixture into the well produced fluids. This chemical method might help not only by reducing paraffin deposition but also by decreasing the volume of gas used for gas lift.

2. Factors affecting oil production in gas lift wells

Effective working of the gas lift wells in Bach Ho oil field depends heavily on the flow capacity of the oil-gas-water mixture in the lift tubing, creating gas in the oil level and the ability to diffuse them into the fluid flow.

Oil produced in all areas of Bach Ho field has a high paraffin content (22 - 27%). Oil paraffin crystallisation temperature is in the range of 59 - 61^oC and its freezing point is 29 - 36^oC. Meanwhile, the temperature at the wellhead of nearly all the wells utilising the gas lift technique in Bach Ho field is about 25 - 40^oC. This leads to problems of paraffin deposition in the production tubing, and the low lifting of oil. With time, the deposition layer increases and eventually causes blockage. This problem is particularly serious in the case of high water content wells.

The following formula can be used to evaluate the performance of the wells:

$$\eta = \frac{1}{\frac{fC_s}{q}\frac{p_z - p_y}{h\rho g} + 1}$$

Where:

η: The effective lift coefficient;

C_s: The relative velocity of the gas phase, m/s;

q: The fluid flow, m^3/s;

f: The cross sectional area of tube, m^2;

p_z: The working gas pressure after the valve, Pa;

p_y: The wellhead pressure, Pa;

h: The length of the lift, m;

ρ: The average density of the oil and gas system, kg/m^3;

g: Gravitational acceleration, m/s^2.

Based on the above equation, it is recommended that a chemical mixture having the ability to inhibit paraffin deposition combined with surface active properties should be pumped into the product flow for improved oil production.

3. Laboratory Studies

3.1. Information of chemical additives and study methods

The chemical additives used for crude oil treatment must satisfy the "Technical requirement on pour point depressant and demulsifier for treatment of crude oil produced from Vietsovpetro oil fields". The physical and chemical properties of some chemical reagents are presented in Table 1.

The modelling processes were conducted on laboratorial equipments in the Laboratory for Oil and Gas Treatment and Transportation of Vietsovpetro Research and Engineering Institute.

3.2. The effect of demulsifier on the ability to create gas bubbles in the produced fluids

Experimental study results presented in Figures 1 - 3 show that the use of a demulsifier at dosage of 200ppm increases the ability to create gas bubbles and their suspension in oil. When the water cut of the produced fluids increases, the ability to maintain the gas bubbles dispersed in the oil phase decreases. When using a chemical mixture, the surfactant disperses to the interface between oil and water phases reducing the surface tension; when the bubble is big enough it will be broken into smaller gas bubbles dispersed in the oil phase. Should the chemical mixture be "overdosed", this will facilitate a change in the emulsion type from "water in oil" to "oil in water", maintaining the level of suspension of gas bubbles in the oil. As a result, the density and viscosity of the oil-gas-water mixture in the tubing reduces, the

Table 1. *The physical and chemical properties of some chemical reagents*

Product name	Application	Composition	Physical and chemical properties
VX-7484	Paraffin inhibitor	Heavy aromatic naphtha, xylene...	Flash point: 63°C Density: 0.88 @ 15.5°C Pour point: 6°C
PAO-80033	Pour point depressant	Heavy aromatic naphtha, xylene...	Flash point: 32°C Density: 0.88 @ 50°C Pour point: 21°C
REPA-61V	Paraffin inhibitor	Heavy aromatic naphtha, xylene...	Flash point: 32°C Density: 0.9 @ 25°C Pour point: < -10°C
EC-6509A	Paraffin inhibitor	Heavy aromatic naphtha, xylene...	Flash point: 60.5 - 93.3°C Density: 0.881 at 15°C Pour point: 7°C
EC-6002A	Paraffin inhibitor	Heavy aromatic naphtha, xylene...	Flash point: > 50°C Density: 0.81 at 15°C Pour point: 6°C
DMC D-6	Demulsifier	Polymer surfactant and aromatic solvent	Flash point: > 50°C Density: 0.89 ± 0.03 at 25°C Pour point: < -20°C
DMO-86318	Demulsifier	Naphthalene, alkyl (C3-5) benzenes, alkyl benzenes (C9-10)...	Flash point: 62°C Density: 0.941 - 1.011 at 25°C Melting point: < -27°C
MA-195	Demulsifier	Mixture of non ionic derivatives in aromatic solvent	Flash point: 62°C Density: 0.950 - 0.965 at 25°C Freezing point: -25°C

lifting ability increases and eventually the fluid flow will be improved.

Research results (Figures 1 - 3) showed that DMC D-6 has better foaming ability than other tested chemicals.

3.3. The effect of chemical inhibition on paraffin deposition and kinematic viscosity of oil

As published in the results of study [1 - 3], oil produced from Bach Ho field has a high paraffin content and freezing point. When the temperature drops below the crystallisation temperature of the paraffin, crystallisation begins to occur. Meanwhile, as noted above, the wellhead temperature of nearly all the wells in Bach Ho field is much lower than the crystallisation temperature of paraffin and even lower than the freezing point of the oil. We have investigated the effects of chemical mixtures on viscosity reduction of the oil/water emulsion, thus improving the rheology of the product flow, as well as limiting paraffin deposition using the Rotovisco type RV-20 and "cold finger" equipment. The results obtained are displayed in Figure 4 and Table 2 and showed that using chemicals can significantly reduce paraffin deposition by 31 - 33%.

3.4. The ability of chemical demulsifier and paraffin inhibitor mixture to create gas bubbles in the oil water

Results of laboratory studies on the influence of the chemical mixture of demulsifier and paraffin inhibitor to form emulsion of water and oil from MSP-5 and MSP-7 of Bach Ho field are presented in Table 3.

Laboratory study results in Table 3 show that demulsifier DMC D-6 has the best result of foaming tendency and foam stability in comparison with other tested chemicals. If chemical DMC D-6 mixes with paraffin inhibitor VX-7464 with ratio 2:5, the results of foam tendency and foam stability will be better.

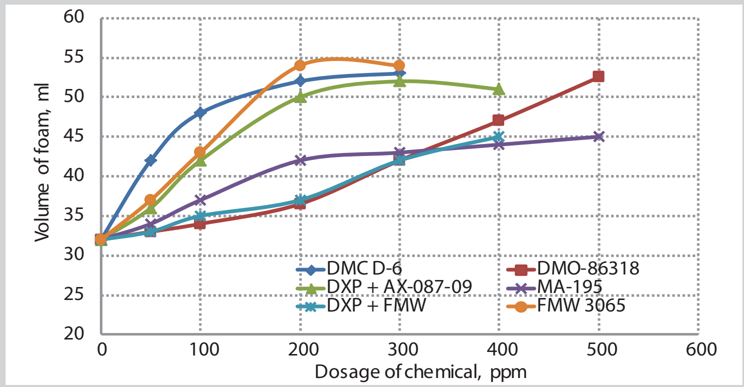

Figure 1. *The foaming ability of the oil-water emulsion from well No 507, rig platform #5 (MSP-5) (water content 15%) when using certain chemical demulsifiers*

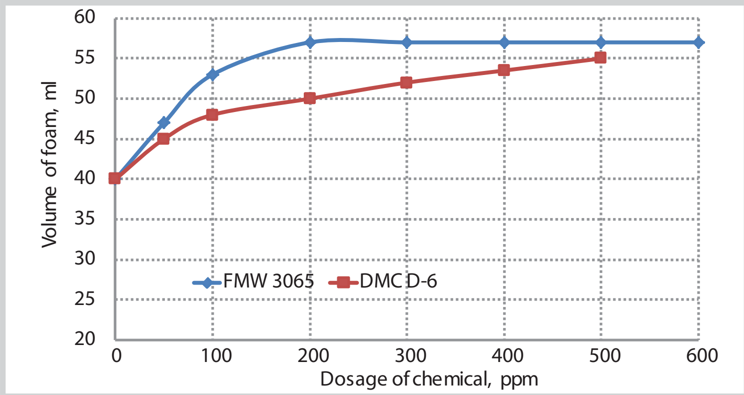

Figure 2. *The foaming ability of the oil-water emulsion from wells No 507 and 510, MSP-5 (water content 8%) when using certain chemical demulsifiers*

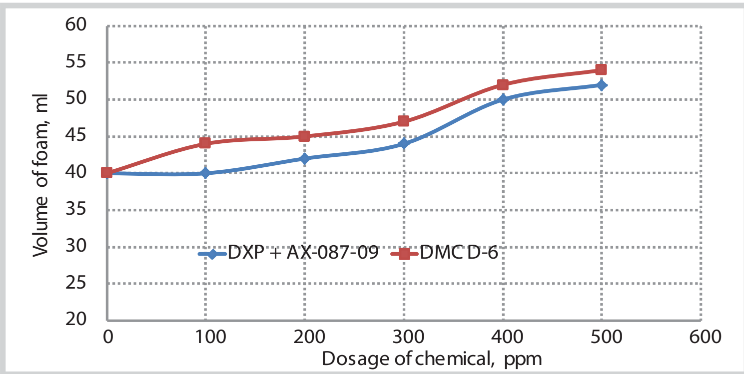

Figure 3. *The foaming ability of a mixture of oil-water emulsion from wells No 507, 509 and 108 (water content 25%), MSP-5 when using certain chemical demulsifiers*

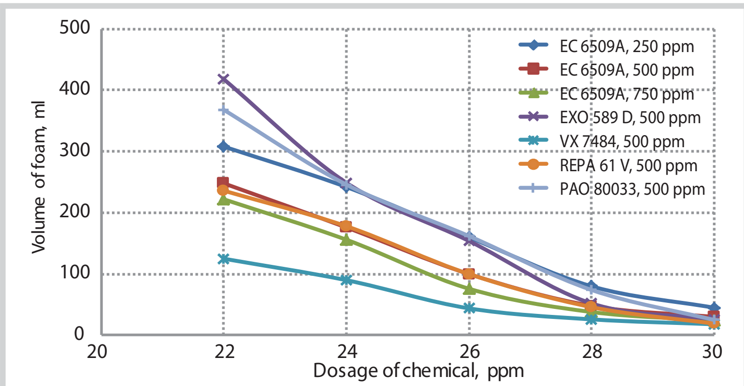

Figure 4. *The effect of the chemical on the kinematic viscosity of the oil from MSP-5*

Table 2. The effect of chemicals in reducing the freezing temperature to inhibit paraffin deposition of Bach Ho field's crude oil

No	Oil temperature (°C)	Test chemicals (g/t.)	Test time, hour	Paraffin deposition rate (g/m²/day)	Ability to inhibit deposition (%)
		Cold finger method (temperature of 22 °C)			
1	60	0	8	3538	-
2	60	500	8	2433	31.2
3	60	1000	8	2354	33.5

Table 3. Oil emulsion foaming ability of water treated with the studied chemical mixture

Mixtures of chemicals	Volume of foam created (ml)	Time to foam dissolved (s)
Mixture of oil in wells No 507 and 104, MSP-5, 8% water content		
No chemicals	38.3	34.7
DMC D-6 200ppm	46.7	49.0
DMC D-6 200ppm + VX-7484 500ppm	50.0	43.0
DMC D-6 200ppm + EXO 589D 500ppm	53.3	49.7
DMC D-6 200ppm + RE 5942 PAO 500ppm	48.3	47.7
DMC D-6 200ppm + RE 5943 PAO 500ppm	46.7	50.0
Mixture of oil in wells No 702 and 705, MSP-7, 11% water content		
No chemicals	61.7	71.3
DMC D-6 200ppm	73.3	78.7
REPA 61V 200ppm	70.0	72.7
DMC D-6 200ppm + VX-7484 500ppm	81.7	70.3
DMC D-6 200ppm + EC 6002 A 500ppm	60.0	68.3
DMC D-6 200ppm + RE 5942 PAO 500ppm	65.0	68.0
DMC D-6 200ppm + RE 5943 PAO 500ppm	65.0	67.7
Mixture of oil in wells No 507, 108, 705, 707 and 710, MSP-5 and MSP-7, 16% water content		
No chemicals	63.3	84.7
DMC D-6 200ppm	68.3	90.0
DMC D-6 200ppm + VX-7484 500ppm	70.0	82.3
DMC D-6 200ppm + EXO 589D 500ppm	56.7	72.0
DMC D-6 200ppm + EC 6509A 500ppm	60.0	39.0
DMC D-6 200ppm + RE 5942 PAO 500ppm	63.3	84.3
DMC D-6 200ppm + RE 5943 PAO 500ppm	61.7	86.0
DMC D-6 200ppm + EC 6002A 500ppm	70.0	96.7

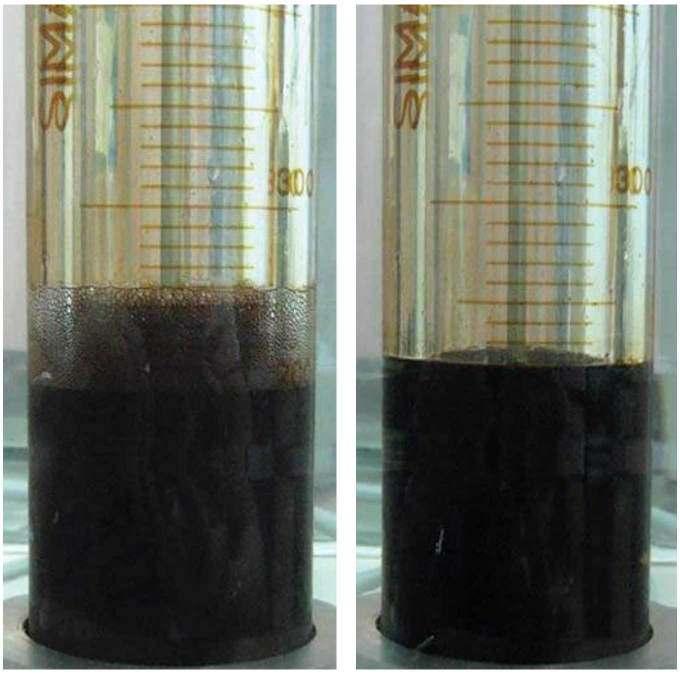

Figure 5. The formations of foam without and with chemical

4. Industrial tests on the gas lift wells of Bach Ho field

To test the results of the laboratory studies, Vietsovpetro conducted field tests in wells 104 and 510 on the MSP-5 platform and wells 75, 145, 702, 704 and 715 on the MSP-7 platform. Test results are presented in Table 4.

The results show that although there was very low oil temperature at the wellhead (about 26 - 32°C), after chemical injection, the speed of paraffin deposition was decreased by 12.1 - 14.1% (determined by mechanical methods), and the cost of lift gas consumption reduced by 21 - 32%. The average production of wells 104 and 510 increased by 7.5 tons/day and 14.5 tons/day, respectively. It means after chemical treatment, oil production in gas lift well of MSP-5 will increase to 59% for well 104, 52% for well 510 and about 7.1 - 80.0% for tested wells of MSP-7.

Table 4. Industrial tests on gas lift wells of Bach Ho field

Gas lift well	Working gas costs (m^3/m^3)		Costs of chemical products (kg/day)	Reduced paraffin deposition (%)	Fluid flow (ton/day)	
	Before chemical treatment	After chemical treatment			Before chemical treatment	After chemical treatment
Field tests on MSP-5						
104	450	303	12 - 24	12.1	12.6	20.1
510	168	133	28 - 54	14.1	28.1	42.6
Field tests on MSP-7						
75	144	136	16	-	49	54
145	228	143	30	-	10 - 13	15
702	57	53	45	-	126	135
704	381	265	8.0	-	15	21.4
715	326	246	15	-	15.0	27

5. Conclusions

- The use of pour point depressant for oil-gas-water treatment of gas lift wells will effectively reduce fluid viscosity, paraffin deposition rate in the tube and pressure to lifting well production. In this result the production flow rate of gaslift wells will be increased;
- Using chemical demulsifier for oil-gas-water treatment of gas lift wells will reduce lift gas cost, maintain the bubble formation ability and increase the lift coefficient;
- To improve the flow rate of gas lift wells, a mixture of depressant VX-7484 and demulsifier DMC D-6 (ratio 5:2) with a dosage of 700 - 1,000ppm should be injected into gas lift gas flow.

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