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A new anti-freezing foam scrubbing agent technology research

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Abstract: With the long delaying development and the higher pressure, the anniversary production of Yu-Lin Gas Field is reducing. Because of the lower temperature in the winter, the traditional foam scrubbing agent is not easy to foam that makes a poor drainage effect, lower developing and decreasing benefits. According to the common anti-freezer properties and parts of some development data, new anti-freezing foam scrubbing agent laboratory experimental study was put forward. Computed with the water production, when the new foam agent consumption is 200-400g/L, the roaming ration, foam stability and water carrying ability is greatly improved. When the foam agent consumption is 200g/L, the freezing point of foam scrubbing agent can reach to -10°C, and when 400g/L, it can reach to -25°C, which both satisfy the site temperature condition.

Introduction

With the gradual development of Yulin gas field and the exploitation of natural gas, the formation water was entering the bottom of the well at different degree. From the production status of Yulin gas field, one of the main reasons for gas production conditions deterioration and production decrease is the well bottom and wellbore liquids.(formation water or light oil), especially at low temperature in winter, the performance of foam drainage and gas recovery were significantly reduced. In order to improve the gas production capacity in Yulin gas field, (At low temperature in winter, the traditional foaming agent was not easy to foam, which resulted in unsatisfactory effect of the foaming agent. That made the development effect of the oil and gas field worse and lower benefits. A development of new antifreeze foaming scrubbing agent was proposed ^[1-2], based on the commonly used performance of antifreeze and some mining data of Yulin gas field.

1. Foam scrubbing principles

Surfactants have two different functional groups, one is a water soluble and polar hydrophilic group, and the other is an oil-soluble, non-polar, lipophilic group. With the constant agitation of the natural gas stream, the surfactant (foam scrubbing agent) injected into the wellbore (due to the reduction of the surface tension between the natural gas and gas field water) were easy to form a large number of stable foam^[3], which eventually resulted in the density of wellbore fluid dropping, as shown in Figure 1.

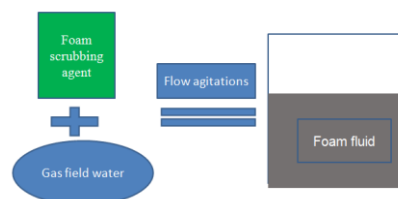


Figure1 The Schematic Diagram of Foam Forming Processing

The effect of the surface tension changes between natural gas and gas field water on gas well production can be explained by the typical equation of Critical Liquid Carrying Flow of Turner^[4]. The relationship between the critical flow rate of continuous liquid carrying and the surface tension of natural gas-gas field is shown in Figure. 2.

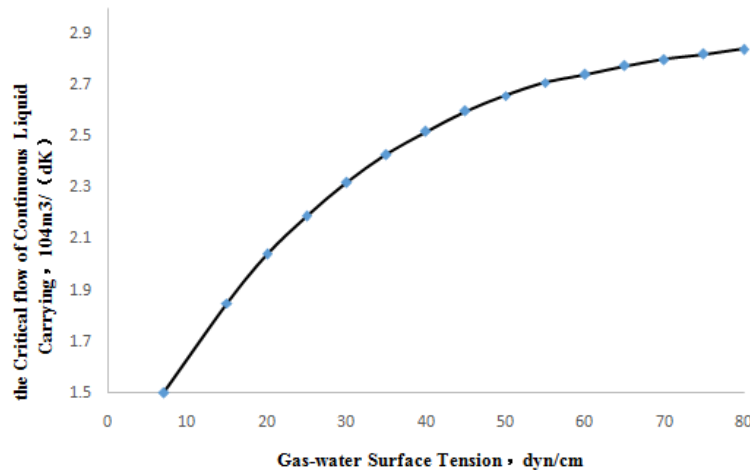


Figure 2 Relationship between the Critical flow of Continuous Liquid Carrying and Gas-water Surface Tension

It can be clearly read from Fig. 2 that (assumed that the gas production of the existing water- gas wells was constant), as the surface tension decreases, the critical flow rate of the continuous liquid-carrying gas wells also drops. In the case of low temperature in winter, the surface tension of natural gas-gas field and the pressure gradient of wellbore fluid were reduced by injecting surfactant, furthermore reduced the critical flow rate of continuous liquid carrying in water producing gas wells^[5], which could achieve the actual gas production of water producing gas wells and restore water production of gas wells

2. Anti-freezing Foam Agent research

2.1 Experimental water quality determination

Water Composition Data on Site was shown in Table 1.

Table 1 Water Composition Data on Site

Well NO.	ρ (g/ml)	Na ⁺ K ⁺ (mg/L)	Ca ²⁺ (mg/L)	Cl ⁻ (mg/L)	HCO ₃ ⁻ (mg/L)	SO ₄ ²⁻ (mg/L)	Fe ²⁺ (mg/L)	Fe ³⁺ (mg/L)	total salinity (g/L)	Water type
1	1.02	4289.73	707.01	13027.88	488.61	121.04	126.67	112.59	20.53	CaCl ₂
2	0.992	3214.02	1818.03	7816.73	453.84	1452.43	288.52	14.07	15.09	CaCl ₂
3	0.994	6775.8	4728.24	20542.21	383.69	241.11	294.39	119.16	33.40	CaCl ₂
4	1.025	12923.7	12928.2	47247.76	628.3	363.11	112.59	56.3	75.84	CaCl ₂
5	0.992	3214.02	1818.03	7816.73	453.84	1452.43	288.52	14.07	15.09	CaCl ₂
6	0.866	56.12	1666.53	3647.81	174.46	121.04	0	0	5.94	CaCl ₂
7	1.061	27863.81	1479.75	45684.42	715.53	2178.64	239.26	35.19	78.66	CaCl ₂
8	1.045	4714.54	13534.21	31440.61	1290.76	242.07	260.37	197.04	51.62	CaCl ₂
9	0.811	133.4	10.02	130.46	174.46	12.49	0	0	0.47	NaHCO ₃
10	0.918	212.29	20.04	164.84	279.38	84.53	56.07	21.03	0.77	NaHCO ₃
11	0.95	3199.53	1760.71	8354.86	541.07	0	0	147.19	14.07	CaCl ₂

It can be read from Table 1 that the rang of salinity of water quality on site is 0.47-75.84g/L, water

types were CaCl_2 and NaHCO_3 . According to the water compositing data on site, CaCl_2 and NaCl were used to respectively formulate the mineral water and simulation evaluation with the concentration of 5g/L and 50g/L.

2.2 Antifreeze performance evaluation of foaming agent itself

The freezing point of Two foam scrubbing agents were shown in Table 2.

Table 2 The Freezing Point of Anti-freezing Foam Agent

Anti-freezing Foam Agent	The freezing point, °C
LDYT- I	<-40
LDYT- II	<-40

It can be read from Table 2 that the two foaming agents themselves have a freezing point below -40°C and can be kept in a liquid state at an ambient temperature of -25°C in the field.

2.3 Evaluation of anti-freeze and foam

The freezing point of the foam scrubbing of water sample was shown in Table 3 and Table 4.

Table 3 Property Evaluation of LDYT- I

Antifreeze foaming agent	Water sample g/L	usage g/L	Foaming force mm	Foam stability mm	Liquid carrying capacity mL/15min	Discharge the foaming agent solution °C
LDYT- I	5	400	155	95	177	<-25
LDYT- I	50		155	133	175	<-25

Table 4 Property Evaluation of LDYT- II

Antifreeze foaming agent	Water sample g/L	usage g/L	Foaming force mm	Foam stability mm	Liquid carrying capacity mL/15min	Discharge the foaming agent solution °C
LDYT- II	5	200	200	110	189	-10
LDYT- II	50		175	165	181	-13
LDYT- II	5	400	210	108	194	<-25
LDYT- II	50		165	135	176	<-25

It could be seen from Table 3 and Table 4 that the amount of the two foaming agents (t was calculated according to the amount of water produced) was at 200-400g/L, the foaming power, foam stability and liquid carrying property were well done. When the foaming agent amount was at 200g/L, the foaming agent solution had a freezing point of -10°C . At 400 g/L, the foaming agent solution had a freezing point below -25°C , which can meet the temperature conditions on site. At the same time, with the usage reduced, the content of antifreeze components in the foaming agent was lowered, but the freezing point and the adapted ambient temperature conditions were increased [6-8].

In order to meet the temperature of -20 to -25°C in winter and ensure that the formation water returning from the gas well will not solidify, the active ingredient of the foaming agent in the antifreeze foaming agent formula would be lower. At the amount of 200-400g/L, the effective concentration of the corresponding foaming component was 5-10 g/L, the effective content of the foaming component of LDYT-II was twice that of LDYT-I.

2.4 Oil resistance evaluation

According to the on-site condensate content of 20-30%, the performance of the 20%, 30%, 40% of oil-containing conditions were evaluated, as shown in Table 5.

Table 5 Oil Resistance Property Evaluation of LDYT- I

Antifreeze foaming agent	Water sample g/L	Usage g/L	Oil Condensate %	Liquid carrying capacity mL/15min
LDYT- I	5	400	20	158
LDYT- I	50			147
LDYT- I	5	400	30	133
LDYT- I	50			116
LDYT- I	5	400	40	94.8
LDYT- I	50			69

It could be seen from Table5 that LDYT-I had a good liquid carrying capacity at 20% and 30% oil content, which could meet the needs of the bubble foam . When the oil content was 40%, the liquid carrying amount was low, the applicable oil range of the oil-resistant foaming agent is <30%. Since the effective content of the foaming component of LDYT-II was twice that of LDYT-I, LDYT-II was also suitable for the bubble foam of gas wells with oil range <30%.

3. Conclusions

Under the low temperature conditions in winter, the traditional foaming agent is not easy to foam, resulting in unsatisfactory effect of the foaming agent. According to the performance of common antifreeze and some mining data of Yulin gas field, it did not affect the foaming and foaming ability of the foaming agent. For high condensate, high methanol, high salinity effluent gas wells, the evaluation analysis on indoor and field data and water samples of new antifreeze foaming agent LDYT-I and LDYT-II in Well 49-4 is proposed. LDYT-I has a good liquid carrying capacity at 20% and 30% oil content, which can meet the needs of the bubble foaming When the oil content is 40%, the liquid carrying capacity is lower which explains the oil-resistant foaming agent oil range (<30%)is suitable. Since the effective content of the foaming component of LDYT-II is twice that of LDYT-I, LDYT-II is also suitable for the bubble foaming of gas wells with oil range <30%.

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