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Application of compound viscosity reducer for low temperature transportation in Huabei oilfield

X L Gao[1, 6], C F Wang[1], J Z Feng[1], Q Sun[1], L Q Xue[2], W N Ma[3], H Wang[4], N Su[5], G Y Liu[1], L F Liu[1] and L B Yue[1]

[1] Huabei Petroleum Tiancheng Industrial Group Co.Ltd, Hebei, Renqiu, 062552, China
[2] The Third Exploit Factory of Huabei Oilfield Company, Hebei, Hejian, 062450, China
[3] The Fifth Exploit Factory of Huabei Oilfield Company, Hebei, Xinji, 052300, China
[4] Technical Supervision and Inspection Department of Huabei Oilfield Company, Hebei, Renqiu, 062552, China
[5] Engineering Technology Research Institute of Huabei Oilfield Company, Hebei, Renqiu, 062552, China

[6] E-mail: 270386966@qq.com

Abstract. Reducing the viscosity of heavy oil is one of the main works in oilfield development. This article chose the nonionic surfactant and anionic surfactant as the main agent, and after optimizing the proportion of combination and joining the functional additive, the compound viscosity reducer with dual function of viscosity reduction and pour point depression for low temperature transportation in pipelines is prepared. The compound viscosity reducer is non-toxic, safe and environmentally. Experiments show that when the concentration of the compound viscosity reducer is 0.05%, the freezing point of crude oil fall by more than 8 ℃, and the viscosity reduction rate is more than 75%. After field application in Huabei oilfield, the average pipeline pressure drop is 0.6-1.5 MPa(the average pressure drop rate is 53%), which plays the important role for low temperature transportation in pipelines

1. Introduction
Crude oil transportation is a complicated and high-tech work. Reducing the viscosity of crude oil in the pipeline has always been a key work in oilfield. Especially for the heavy oil, high pump pressure is required in the transported process [1, 2]. At the same time, when the oil-water mixture which is produced by the product well passes through the choke and valve, the mechanical action leads to the formation of the water in oil (W/O) emulsion, which reduces the fluidity of fluid and increases the difficulty of crude oil transportation [3, 4]. At present, the most commonly methods to reduce viscosity of the crude oil in China are physical viscosity reduction method and chemical viscosity reduction method [5]. Among them, the heating cost of physical viscosity reduction method is relatively high [6, 7]. In chemical viscosity reduction method, the water-based viscosity reducer is safe to use, but the effect is unsatisfactory.

At present, the viscosity reduction methods used in Huabei oilfield are mainly physical heat tracing. This method not only consumes a lot of energy, but also requires burning a lot of associated natural gas, which leads to the increase of greenhouse gas emissions and environmental pollution. In view of the actual situation of the present production, chemical agents are used to improve the fluidity of crude oil and to eliminate adding water or heat tracing. Under the condition of ensuring the normal gathering and transportation of crude oil, normal temperature or low temperature oil transportation can be realized to reduce the energy consumption.

2. Experiment material

2.1. Experiment instrument

Oil pour point tester(JSR0908, made by Jinshi petrochemical instrument CO.,LTD), viscometer(DVS+, made by Brookfield), electronic balance(XB620C, made by Precisa), thermostatic water bath(HH-6, made by Changzhou city Wanfeng instrument manufacturing CO.,LTD), electric agitator(MYP2011-100,made by Meiyingpu), rheometer, colorimetric tube, beaker, measuring cylinder.

2.2. Experiment reagents

Anionic surface active, onionic surfactant, cationic surfactant and betaine type surfactant, and all these surfactant are made by Lanxing chenmical auxiliarier factory. Homemade functional additives.

3. Development of compound viscosity reducer

3.1. Physical analysis of crude oil

Resins and asphaltenes are the main ingredient of oil-water interface film, which has great adhesion to crude oil and reduce the fluidity of crude oil. At the same time, the crude oil viscosity will be increased after hydrogen bonds formed between resin molecules and asphaltene molecules through association. And the higher the total content of resins and asphaltenes, the higher the viscosity. The higher the wax content, the higher the pour point. As the temperature drops, the wax gradually precipitates out and accumulates, which leads to the increasing viscosity of crude oil [8].

The crude oil in A69-45 well of A69 block is selected as the experimental crude oil for physical analysis and testing. The specific results are shown in Table 1.

Table 1. Analysis results of physical properties of crude oil in A69-45 well.

Pour point (℃)	Viscosity (mPa s, 50℃)	Wax content (%)	Resin and asphaltene content (%)
31	20.09	14.6	16.7

3.2. Viscosity-temperature curve of crude oil

Take the crude oil of A69-45 well as the sample, and use the DVS viscometer to determine the change of viscosity of crude oil with temperature under different temperature conditions(the heating rate is 1℃ /min). Then draw the corresponding viscosity-temperature curve of crude oil. The specific results are shown in Table 2.

Table 2. Test results of crude oil viscosity.

Temperature (℃)	10	15	20	25	30	35	40	45	50
Viscosity(mPa s)	8509.37	4012.65	1480.24	540.36	218.22	38.48	30.09	23.01	20.09

The viscosity-temperature curve of crude oil shows that the abnormal point of crude oil sample is 30 ℃. When the temperature is higher than 30 ℃, the viscosity of crude oil changes relatively small with temperature. And when the temperature is lower than 30 ℃, the viscosity of crude oil varies significantly with temperature.

3.3. Development of viscosity reducer

3.3.1. Screening of the main agent. At present, surfactant viscosity reduction technology has been relatively mature. The basic mechanism of viscosity reduction is mainly demulsification and adsorption. These three mechanisms often exist at the same time, but under different conditions, different types of surfactants may have different leading viscosity reduction mechanisms [9]. At the same time, the surfactant also has the characteristics of good viscosity reduction effect, low cost and strong operability [10]. Therefore, the surfactant is selected as the main agent of viscosity reducer.

5 crude oil samples of A69-45 well were took, and added different types of surfactant agents with a concentration of 0.05% respectively. Then measured the corresponding viscosity, pour point and yield value, and the test results are shown in Table 3.

Table 3. Experiment results.

	Untreated	1#	2#	3#	4#	5#
Viscosity (mPa s,50℃)	20.09	7.06	9.85	9.91	10.33	9.06
Pour point (℃)	31	29	30	27	30	29
Yield value (Pa,28℃)	324	113	160	135	198	153
Viscosity reduction rate (%)		64.9	51.0	50.7	48.6	54.9

Among them, the 1 # reagent and 2 # reagent are the different types of anionic surface active agent, 3# reagent and 4 # reagent are different nonionic surfactants, 5 # reagent is a cationic surfactant.

It can be seen from the results in Table 3 that the 1# anionic surfactant sample has the best viscosity reduction effect on crude oil with the viscosity reduction rate of 64.9%, and the 3# non-ionic surfactant sample has a significant effect on pour point depression.

3.3.2. Compounding of the main agents. Some studies have shown that different surfactants can produce synergistic effect after compound, which can improve the performance of surfactant, overcome the deficiency of single viscosity reducer, and improve the viscosity reduction effect [11].

After mixing the 1# main agent sample and 3# main agent sample in different mass proportions, test and analyze its effect on the physical properties of crude oil, so as to select the appropriate proportion.

The Table 4 shows that when the compounding proportion of 1# viscosity agent and 3# viscosity agent is 2:1, the pour point of crude oil sample drops from 31 ℃ to 23 ℃, and the viscosity reduction rate reaches 72.9%. Therefore, the compound surfactant under this proportion is used as the main agent of viscosity reducer.

Table 4. Experiment results in different proportions.

	Untreated	1:1	2:1	3:1	1:2	1:3
Viscosity (mPa s,50℃)	20.09	6.97	5.45	6.26	6.3	6.62
Pour point (℃)	31	25	23	27	23	22
Yield value (Pa,28℃)	324	139	116	150	198	174
Viscosity reduction rate (%)		65.3	72.9	68.8	68.6	67.0

3.3.3. Screening of functional additives. In order to further improve the performance of the compound viscosity reducer, different functional additives are added into the main agent system. Among them, 2# functional additive is homemade, and the 1# functional additive and 3# functional additive are similar functional additives on the market. Test and compare the effect on the physical properties of crude oil of these three additives.

Table 5. Experiment results after added different functional additives.

	Untreated	1#	2#	3#
Viscosity (mPa s,50℃)	20.09	5.25	4.55	5.3
Pour point (℃)	31	23	22	22
Viscosity reduction rate (%)		73.9	77.4	73.6

As shown in Table 5, the 2# viscosity reducer has the best viscosity reduction rate of 77.4 %, and has the obvious reduction of pour point. Finally, the 2# additive is determined as the functional additive of the viscosity reducer.

3.4. Concentration optimization of the compound viscosity reducer

Add the compound viscosity reducers with the concentration of 0.01%, 0.03%, 0.05%, 0.07%, 0.1%, 0.15% to the crude oil and test the effect of viscosity reducers on crude oil viscosity respectively.

Table 6. Experiment results of different concentration compound viscosity reducer.

Concentration (%)	Untreated	0.01	0.03	0.05	0.07	0.10	0.15
Viscosity (mPa s,50℃)	20.09	12.52	7.42	4.35	4.28	4.26	4.24
Pour point (℃)	31	29	24	22	21.8	21.5	21.2
Viscosity reduction rate (%)		37.7	63.1	78.3	78.7	78.8	78.9

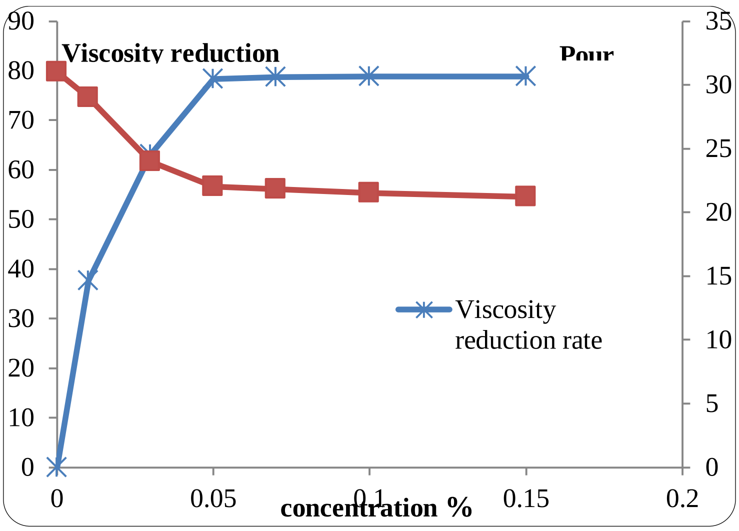

Figure 1. Relationship between viscosity reducer concentration and viscosity reduction and pour point depression effect.

The experiment results show as the Table 6 and the Figure1 .When the concentration of compound viscosity reducer is lower than 0.05%, the viscosity reduction effect becomes better with the increase of concentration. And when the concentration exceeds 0.05%, the viscosity reduction effect changes little with the increase of concentration. When the concentration exceeds 0.04%, the pour point depression effect changes little with the increase of concentration. Therefore, it is best to control the concentration of compound viscosity reducer about 0.05%.

3.5. Performance evaluation of compound viscosity reducer

In order to evaluate the viscosity reduction effect of compound viscosity reducer on crude oil in different oil reservoirs, the viscosity reduction and pour point depression experiments are carried out on crude oil samples from B19-2 well of B19 block, J12-11 wells of J12 block, B51-116well of B51 block, and B48-90 well of B48 block. The viscosity reducer concentration is 0.05%, and the experiment results are shown in the Table 7.

Table 7. The viscosity reduction effect of compound viscosity reducer on crude oil in different oil reservoirs.

Wells	Crude oil properties before treatment		Crude oil properties after treatment		
	Viscosity (mPa s)	Pour point (℃)	Viscosity (mPa s)	Viscosity reduction rate (%)	Pour point (℃)
B19-2	56.6	30	13.4	76.3	22
J12-11	220	32	20	90.9	24
B51-116	580	35	25	95.7	26
B48-90	804	38	32	96.0	29

As shown in Table 7, when the concentration of viscosity reducer is 0.05%, the viscosity reduction rate are all over 75%, and the viscosity reduction effect is significant. At the same time, it has obvious effect on the pour point depression with the pour point reducing all over 8 ℃. Therefore, the compound viscosity reducer has strong applicability to the crude oil of different blocks in Huabei oilfield, and has the feasibility of field application.

4. Field application

Since September 2017, field application has been carried out in more than 10 wells, track and monitor the backpressure of the gathering pipeline after one week of adding the compound viscosity reducer. Figure 2 and Figure 3 show the pressure change before and after the addition of the compound viscosity reducer to some gathering pipelines.

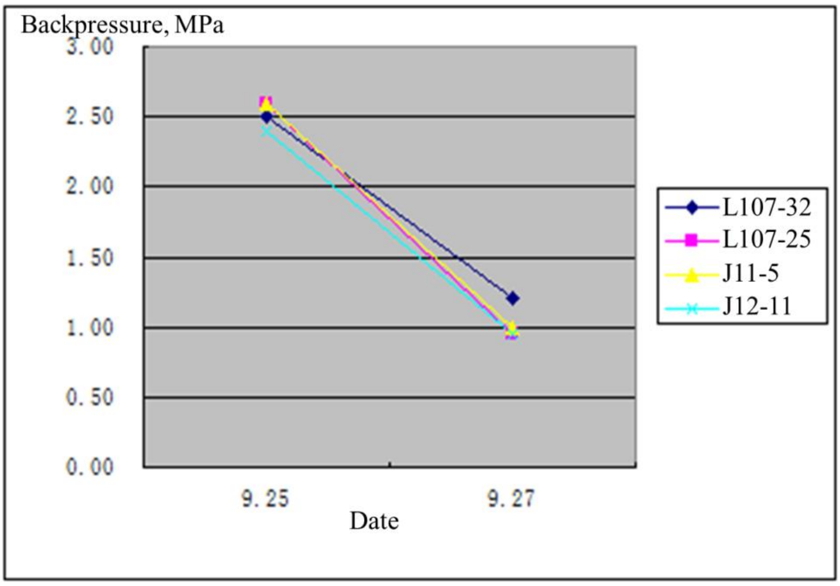

Figure 2. Pressure changes of HJ field with concentration of 0.05%.

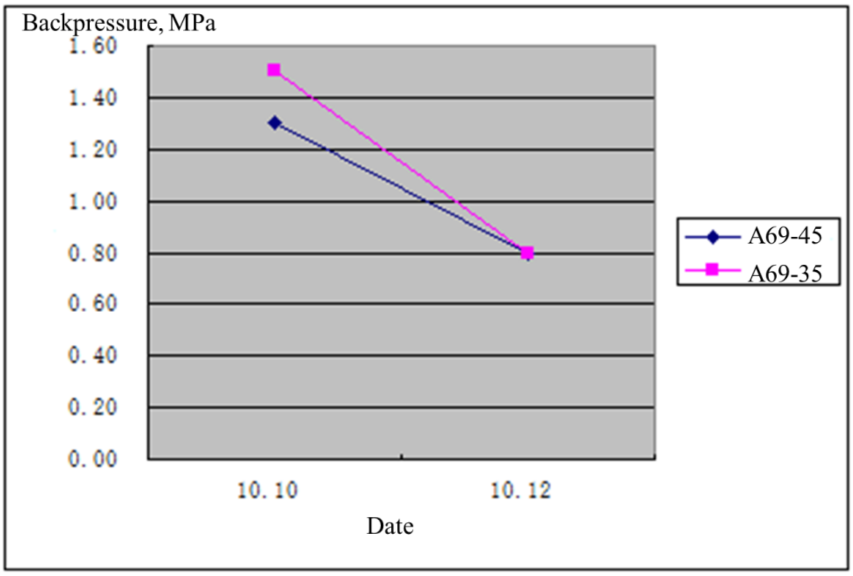

Figure 3. Pressure changes of LF field with concentration of 0.05%.

The field application shows that the compound viscosity reducer has good adaptability and can realize the purpose in low temperature transportation without adding water and heat tracing. The average backpressure drop of the transport pipeline in HJ field is 1.5 MPa, and that in LF field is 0.6 MPa.

5. Conclusions

Use nonionic surfactant and anionic surfactant as the main agent, and add the functional additive, which makes the low temperature conveying compound viscosity reducer has good effect in viscosity reduce and pour point depression. Compared with conventional oil-based viscosity reducer and water-based viscosity reducer, this viscosity reducer has better viscosity reduction effect on heavy oil. It also has the characteristics of low safety risk and safe field implementation.

The optimum concentration of viscosity reducer is 0.05%. After adding the compound viscosity reducer, the pour point drop more than 8 ℃, and the viscosity reduction rate is higher than 75%. The crude oil fluidity in low temperature has been significantly improved.

According to the field application results, the average wellhead backpressure drop is 0.6-1.5 MPa. The field application has good effect, It has good spreading value in Huabei oilfield.

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