ISSN: 2664-9640

Application of pipeline cold transport technology in unattended oilfield

Xiwei Shen, Dongliang Cao, Biao Zhao, Mingjiu Rao

The ninth oil production plant of PetroChina Changqing Oilfield Branch 750006, China

Abstract

The ultra-low permeability of the Ordos Basin reservoir and the harshness of the on-site production environment directly lead to high crude oil extraction costs and low efficiency. In order to respond to the national call for energy conservation and emission reduction, and at the same time solve the current serious production contradictions such as low oil prices and labor shortages, in accordance with the concept of "technology leading development", we will further study the cold transportation technology of oil pipelines from the aspect of oil collection technology. Based on the domestic status quo of cold transport technology, combined with the current situation of oil collection technology, this paper theoretically analyzes the support points of pipeline cold transport technology, proposes specific technical countermeasures for the problems existing at the cold transport site, and summarizes the suitable cold transport pipelines through field tests. Then, the economic benefits brought by pipeline cold transportation are analyzed, and the application prospects of pipeline cold transportation in unattended oilfield are discussed.

Keywords

Oilfield gathering and transportation Cold loss Thixotropy Unattended.

1. Current situation of domestic development

Crude oil collection process can be divided into unheated oil collection process (customary cold transmission process), well field heating oil collection process, wellhead mixing process, hot water heating collection process according to the heating method[1]. Among them, the oil pipeline unheated cold oil collection process was first applied to Yumen Oilfield, and began to test in Changqing Maling Oilfield in 1971, and then the test was successful and continued to mature, which mainly used the method of regularly throwing wax balls from the pipeline to remove the wax on the inner wall of the pipe. In addition to the general use of this process in Changqing Oilfield, domestic crude oil fields with better physical properties such as Tuha Oilfield, Tazhong 4 Oilfield, and some high-water-bearing oilfields such as Shengli Dongxin Oilfield also use this process to collect oil.

Summarizing the experience of using this process, the general conditions for cold transport process are as follows:

(1)relative densityd_4^{20}≤0.86, Dynamic viscosityη_t≤20mPa·s, condensation point≤35℃;

(2)Liquid production≥40t/d, Wellhead oil temperature 50℃;

(3)Viscosity at wellhead temperatureη_t≤100mPa·s, condensation point≤35℃;

(4)Liquid production≥5t/d, Gasoline ratio≥20m^3/t, Oil collection radius＜1km;

(5)The moisture content of crude oil has reached the phase transition point of crude oil emulsion 50%~90%;

(6)The minimum ambient temperature in the area where the oil field is located is close to or slightly lower than the condensation point of crude oil 3~5℃.

If any of the above conditions are met, the cold oil collection process can be considered[2].

2. The status quo of collection and transportation

2.1. Physical properties of crude oil parameters

The main production reservoirs are WQ Jurassic reservoir, Jiyuan G83 reservoir, Jiyuan G271 reservoir and W410 reservoir. The average density of crude oil is 0.806g/cm^3, and the average gas-oil ratio is 79.65m^3/t.The detailed physical properties parameters are as follows :

Table 2-1 Block crude oil property parameters

Block	*horizon*	*density(g/cm^3)*	*viscosity(mPa.s) 50 ℃*	*condensation point (℃) 20 ℃*	*Priming point (℃)*	*Gas-oil ratio (m^3/t)*
WQ Jurassic	Yan 9 (Yan 10)	0.773	4.31	17	61.6	43
G83 area	Chang 4+5 (Chang 6)	0.845	6.54	19	55.2	98.6
G271 area	Chang8	0.839	5.96	21	52.4	119
W410 area	Chang6	0.766	4.29	17	51.8	58

2.2. Current status of the oil collection process

There are a total of 375 oil pipelines, with an average pipe length of 1.5km, The average liquid volume is 12.4 m^3/day, Average operating back pressure of 0.92MPa.

At present, the oil collection process mainly adopts the well field vertical heating furnace, pipeline electric heating and other equipment heating and transportation, and some of it adopts the cold oil collection process, and the local pipeline supporting the pitching process. Among them, there are 68 cold pipelines, 50 electromagnetic heating pipelines, 46 coal-fired heating furnaces, 232 gas heating furnaces, and 319 supporting pitching pipelines.

The collection and transportation process has complex characteristics such as low liquid volume, multiple pipeline insertion and transportation, and poor pipeline conditions.

3. Theoretical analysis of cold transport technology

Crude oil in the transportation process, the temperature and pressure in the pipeline will gradually decrease, when the temperature drops to the wax evolution point, the wax in the crude oil begins to precipitate in crystalline form, forming a crystal nucleus, in the form of solid particles in liquid crude oil, at this time crude oil shows thixotropic, pseudoplastic and other non-Newtonian fluid rheological properties. The temperature continues to decrease, the number of wax crystals increases dramatically, they gradually grow, aggregate, and form a three-dimensional spatial network structure, enveloping liquid crude oil in it, crude oil gradually solidifies and loses its fluidity, at this time crude oil has non-Newtonian fluid characteristics such as thixotropy, viscoelasticity and yield stress[3].

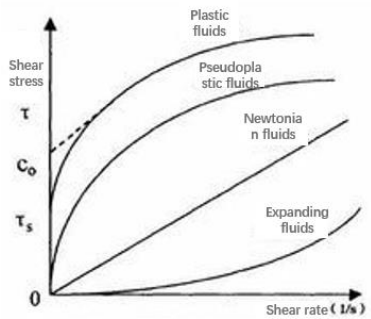

Figure 3-1 Rheological curves of four basic fluids

After the successful test of cold transport technology, the temperature of the incoming station of the oil pipeline is analyzed and studied below the freezing point, so the feasible support point of the cold transport technology lies in the rheology of crude oil.Crude oil rheology (thixotropy) changes for the implementation of non-heating cold transport technology to create a strong condition, crude oil waxing needs a process, in order to ensure that the pipeline in the low temperature conditions, can still be smooth, efficient crude oil transport to the site, as long as through the pipeline pitching, combined with hot washing, sweeping operation will be wax crystal periodic removal, to ensure that the oil flow channel smoothly can achieve pipeline unheated cold transport.

4. Cold transport technology countermeasures

Pipeline cold transmission is mainly through the oil pipeline outlet timing pitching, the site natural harvest measures to periodically remove the wax on the inner wall of the pipeline, to ensure the smoothness of the medium channel, to achieve pipeline cold transmission. The on-site operation found that the pipeline pitching could not achieve natural harvesting was mainly affected by two aspects:

First, the density of the wax ball is large, when the medium flow direction of the oil pipeline shows an upward trend and the slope is steep and long, the wax ball cannot quickly reach the receiving barrel from the well field, resulting in the wax ball accumulating in the pipeline for a long time;

Second, because the drop between the collection and transmission manifold and the receiving tube is above 2.5m, the drop is high, and the oil flow power is not enough to push the wax ball into the receiving barrel.

In view of the above two reasons, the technical countermeasures for the oil collection process have been formulated, and their effects have been tracked.

（1）Optimized wax ball design

Idea: Invent a low-density wax ball (see Figure 2), composed of two parts: a hollow steel ball and a rubber body, and adjust the density of the wax ball and the density of the extract to be comparable to the density of the extract by controlling the wall thickness of the rubber ball, so that the density is smaller than that of the ordinary solid wax ball.

Test pipeline selection: Q95-100, X294-37, P42-51, J90-06, Y13-78 and other 8 oil pipelines are selected, which have the characteristics of pipeline medium uphill, steep slope, long and long auxiliary harvesting cycle.

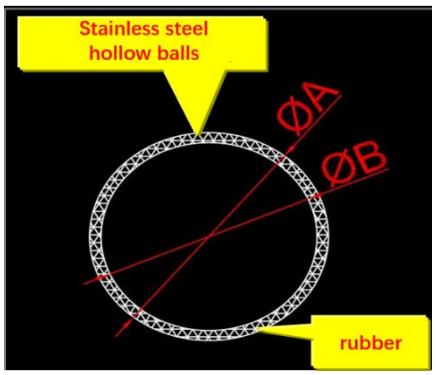

Figure 4-1 Low density clear wax balls

Test effect tracking: 5 pipelines to achieve natural harvesting, the success rate of 62.5%, and the collection cycle from 10 days↓1.5 days.

(2) Ground sink collection process optimization

Idea: Lift the ground manifold down bridge or reduce the position of the receiving barrel, this process optimization selects the lifting ground sink lower bridge, and adjusts the vertical ground sink to the ground ground manifold (see Figure 3).

Figure 4-2 Ground sink

Optimization: 10 ground manifold lower bridges were raised to the ground, and the drop between the ground manifold lower bridge and the receiving tube was reduced to 1.2m.

Test effect tracking: The optimized 10 ground manifolds involving 50 oil outlet pipelines are tracked, compared with before optimization, the natural harvest rate is 24%↑94%, and the other 3 pipelines are mainly subject to low liquid and need auxiliary harvesting.

5. Cold infusion field trials

The average oil collection radius is 1.2km, the liquid volume is 12.5m^3/d, the running back pressure is 0.76MPa, and 68 normal throwing and receiving balls (including 24 with vertical heating furnace supporting pitching, 23 with electromagnetic heating equipment supporting pitching, 21 unshot without heating equipment) to carry out the oil pipeline cold transport test, and track the effect, except for X299-35, G52-107 two pipelines running abnormally, the rest of the pipelines as a whole run smoothly.

Analysis of test results

(1)The relevant parameters of 21 cold pipelines such as G41-106 and G55-100 without pitching are analyzed: for the oil collection radius ≤0.5km, the back pressure is ≤0.6MPa, the liquid volume ≥1m^3/d oil outlet pipeline can use the cold transportation and transportation process to collect oil, and there is no need to pitch during the cold transportation period;

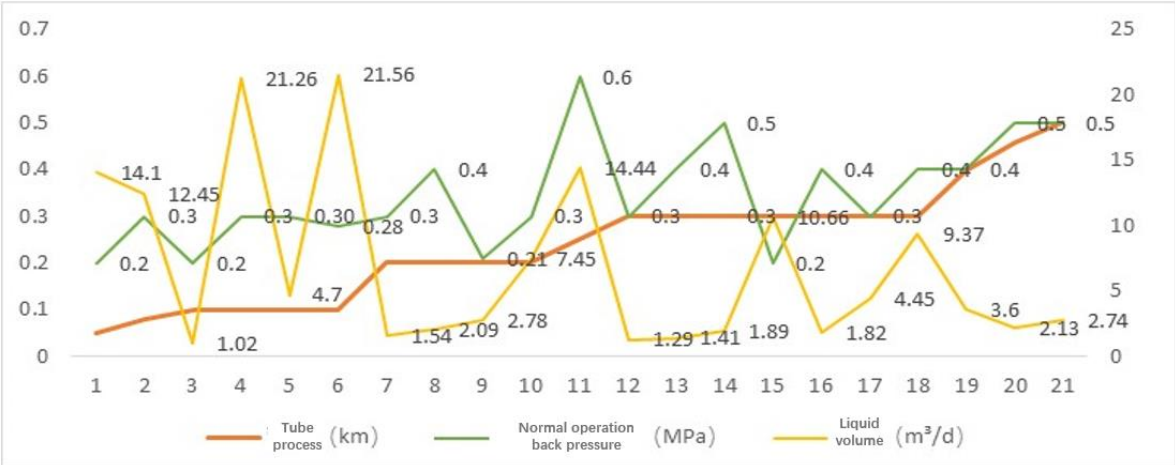

Figure 5-1 Parameter distribution diagram of cold pipeline without pitching

(2)The basic parameters of 47 pitching cold pipelines such as Q79-112 and G52-103 can be analyzed:

0.5km≤ gathering and transmission radius ≤0.9km, liquid volume ≥3.32m^3/d, operating back pressure ≤ 1.2MPa;

0.9km< collection and transmission radius≤ 1.5km, liquid volume ≥6.8m^3/d, operating back pressure ≤ 1.6MPa;

1.5km< collection and transmission radius≤2km, liquid volume ≥8.5m^3/d, operating back pressure ≤ 2MPa;

2km< the collection and transmission radius ≤ 2.5km, the liquid volume ≥ 12m^3/d, the operating back pressure ≤ 1.5MPa.

The above 4 types of oil pipelines, in the case of normal ball shooting, can use the cold oil collection process to collect oil.

(3)Analysis of abnormal causes of cold pipelines

X299-35 appeared in the pipe deformation card ball, failed to receive the ball periodically, the ball accumulated inside the pipe, resulting in the pipe due to the jam of the pipe due to the jamball.

The four incoming oil well groups at the downstream station of G52-107 have achieved cold transmission, because the overall oil temperature in the station is too low, resulting in difficulty in the operation of the station system.

6. Benefit analysis and evaluation

6.1. Reduce the labor intensity of employees and operate more safely

Compared with the uninvoluted ball-to-ball supporting heating and transportation process, the return pressure increase rate of pipeline operation is 0.08↓0.04MPa/d, the average sweeping cycle is 12↑30 days, and the winter pipeline operation workload is reduced by more than half. Due to the cessation of the use of the heating furnace, the workload of the heating furnace water replenishment is greatly reduced, and the ignition source of the well site is reduced, and the operation is safer.

6.2. Economic benefits

(1) Stop 24 vertical heating furnaces, the maximum running time of the pipeline is 234 days, and the cumulative coal consumption is 5126t (the actual 10 sets of coal, the cumulative coal saving is 2100t); 23 electromagnetic heating equipment were stopped, the longest running time

of the pipeline was 236 days, and the cumulative savings were 2.6637 million kWh. The total savings are 3.3923 million yuan.

Table 6-1 Winter cold transmission equipment brings direct economic efficiency

serial number	*Deactivate the device*	*Quantity (sets)*	*Maximum downtime (days)*	*Save electricity (kW·h)*	*Coal Saving(t)*	*Cost savings (10^4RMB)*
1	Electromagnetic heating	23	236	266.37	0	159.82
2	Coal-fired heating furnaces	10	234	0	5126	179.41
3	Total (10^4RMB)					339.23

(2) In the winter, the winter cold transmission continued to be carried out, and according to the principle of "the new process well group prohibits the installation of heating equipment, and the original old process well group reduces the use of heating equipment", the rich heating furnace is optimized and adjusted to the need for well site, saving 4.48 million yuan in production costs compared with the past. At the same time, the post-maintenance cost is reduced by 1.198 million yuan / year.

Table 6-2 Statistics on the economic benefits of cold transport reducing the use of heating furnaces

serial number	*project*	*quantity*	*unit*	*Unit price (10^4RMB)*	*Expenses (10^4RMB)*	*remark*
l	Adjust the furnace	24	set	8	192	
2	The furnace is not matched	32	set	8	256	
3	Total (10^4RMB)				448	
4	Annual maintenance of the furnace	56	set	2.14	119.84	Coil replacement: 40,000 yuan 8.5 years 1 unit; Heating furnace replacement: 1 unit for 70,000 years; Furnace replacement: 0.25 million / 2 years / unit;

(3) Due to the smooth development of pitching and receiving, compared with last year, the frequency of hot washing lines in 47 well groups decreased by 1.5 times, and the cost savings in winter (October to May of the following year) were 1.692 million yuan (0.3 million yuan / time).

(4) After the cold transmission of the well site, the heating equipment is cancelled, and the danger level of the well site is greatly reduced, which creates the basic conditions for the well field to be unattended. After the well yard is unattended, the cost of edible water distribution and heating for the staff of the well site is reduced.

ISSN: 2664-9640

7. Conclusions and Outlook

(1)The rheology of crude oil is the basic guarantee of pipeline cold transportation, and the application of low-density wax balls and the optimization of the harvesting process measures can improve the natural harvest rate of pipelines and provide technical support for cold transportation. In addition, lowering the position of the receiver can be used as the next test measure to improve the collection rate.

(2)For the pipe range ≤ 0.5km, the back pressure ≤ 0.6MPa, the liquid volume ≥1m^3/d oil pipeline can use the cold transmission and transportation process to collect oil, and there is no need to pitch during the cold transportation; When the collection and transmission radius of 0.5km ≤ 0.9km, the liquid volume ≥ 3.32m^3/d, the operating back pressure ≤ 1.2MPa, the 0.9km < collection and transmission radius ≤ 1.5km, the liquid volume ≥ 6.8m^3/d, the operating back pressure ≤ 1.6MPa; 1.5km< collection and transmission radius of ≤2km, liquid volume ≥ 8.5m^3/d, running back pressure ≤ 2MPa; 2km < collection and transportation radius of≤ 2.5km, liquid volume ≥ 12m^3/d, running back pressure ≤ 1.5MPa oil collection, in the case of normal delivery of the ball, the cold oil collection process can be used to collect oil.

(3)Although the pipeline adopts the cold transmission mode of operation, because the throwing and receiving ball is carried out normally to ensure the normal operation of the oil flow channel, it will not reduce the hot washing and sweeping cycle of the pipeline. On the contrary, the cold transmission operation mode ensures the smooth operation of the pipeline back pressure, improves the pipeline hot washing and sweeping cycle, and reduces the frequency of operation.

(4)The comprehensive promotion of pipeline cold transport technology is not only conducive to the cost reduction and efficiency increase measures of oilfield development, but also meets the requirements of safety and environmental protection, provides technical support for the unattended well site, and does a good job in the promotion of cold transport technology is related to the long-term efficiency production of oilfields.

References

[1] Yang Xiaoyu. Oil pipeline design and management [M]. East Camp: China University of Petroleum Press,2006:52-56.

[2] Surface process technology of low permeability oilfield in Ordos Basin. Petroleum Industry Press,2015.4 : 50-55.

[3] Li Lu, Li Yiming. Paraffin deposition and its control in crude oil production [J]. Oil and gas field surface engineering,2001,20(3):82-83.

About the Author : Shen Xiwei, male, Born in August 1983, Master of Engineering in Oil and Gas Field Development, China University of Petroleum (East China)., Intermediate Engineer, At present, he is mainly engaged in ground process research.Contact number : 13619508886.