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Study on Waxy Crude Oil Pipeline Restart Simulation

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Abstract: - In view of the potential technical problems of heavy oil long distance transportation heating in windy city, we investigated heavy oil pipelines on the spot, and collected the pipeline operation parameters and yard equipments' basic data. Moreover, we simulated the heavy oil pipelines in the windy city by using simulation software TLNET model, and studied the characteristics of restarting the heavy oil pipelines and during temperature drop, having determined the time of safe shutdown and scheme of restarting the heavy oil pipelines, providing a reliable theory basis for the pipeline safe operation.

Keywords: - *Heavy oil; Shutdown and restart ； Shutdown time ； TLNET software*

I. INTRODUCTION

The temperature drop principle and problems of shutting down and restarting the hot oil pipeline will directly affect pipeline operation safety and its cost. On the condition of low temperature for a period of time, the pipeline will precipitate wax crystal, forming space three-dimensional network structure which will make the oil liquidity deteriorated. When the oil temperature drops below the freezing point, wax oil will occur, which will obviously increase the resistance of pipeline restart. If the shutdown time lasts too long, it will cause the accident of "condensing tube". This serious production accidents happened in oilfield gathering line and line which have both long and large diameter pipelines. As for problems of heavy oil transportation in windy city fields, this article simulates the temperature drop principle and restart pressure of heavy oil heating pipeline by using the TLNET simulation software, guiding the pipeline safety operation and management.

II. OIL COMPOSITION AND PROPERTIES

Analyzing the contrast of composition and basic physical properties (table 1) between the heavy crude oil in windy city and in nine 6 zone, the freezing point and viscosity of heavy oil in windy city was relatively high, 50 ℃ for 37012 mPa·s viscosity, and is several to 10 times higher than 96 area of crude oil in the same temperature, which clearly proves heavy oil in windy city belongs to the category of thick oil. However, the viscosity of heavy oil in windy city is extremely sensitive to temperature, when the temperature rise to 70 ℃, its viscosity decreased significantly. When the temperature reaches 80 ℃, its viscosity is under 2000 mPa·s. Therefore, when the oil temperature remains above 80 ℃, it can ensure normal transportation of the heavy oil pipelines in windy city.

Table 1 Contrast of composition and basic physical properties between the heavy crude oil in windy city and in nine 6 zone,

Crude oil production	Composition %			Properties			
	wax	Colloid	Asphaltene	Freezing point /℃	Initial boiling point /℃	Density /g·cm^{-3}	Viscosity /mPa·s
In the windy city	2~8	15~25	2~8	22~28	142~270	0.9459(50℃)	3197
Nine 6 area	2.24	-	-	-9.11	120~200	0.9405(50℃)	855

The heavy oil in windy city is of Newtonian fluid in temperature range of 50 ~ 100 ℃, but the viscosity is higher than the ordinary one. Therefore, in shutdown process, as long as we control the temperature above 70 ℃, we do not need to press the static yield value and calculate the start-up pressure again. Due to the limitation of the indoor experimental conditions, the author attempts to apply the TLNET software to the simulate this research.

(1) MODEL RESEARCH

Based on the analysis of early indoor research in the crude oil physical properties and fluidity, and field investigation, using TLNET model, according to the results of the model, making some analysis and economic comparison, through the "gray optimization evaluation method" in each of the factors in the scheme selection, we determine the technological parameters of pipeline transportation. Then according to the selected parameters,

we re-established the TLNET model, by controlling the pump start-up time and the opening valve order, we simulate the shutdown temperature drop and restart pressure.

(2) BASIC PARAMETERS

According to the requirements of the model, it is necessary to determine crude oil physical property parameters, like density, specific heat and dynamic viscosity. Typing the basic parameters such as crude oil flow G = 0.0356 m^3/s, heat pipe structure parameters, physical parameters ; At the same time we also need to input the pump characteristic curve and crude oil physical property parameters.

(3) SIMULATION OF TEMPERATURE DROP AFTER SHUTDOWN

Temperature drop of the waxy crude oil in pipes after shutdown, is a unsteady heat transfer problem with phase change, natural convection and three-dimensional moving boundary. As the extension of shutdown time, the temperature dropping process generally can be divided into three stages: natural convection heat transfer, natural convection and heat conduction common control, and heat conduction. Among them, the natural convection of waxy crude oil is a typical natural convection on moving boundary conditions, in this process, the physical parameters of oil changes with the temperature, which is difficult to handle in math. When the pipelines run stably, we simulated the temperature drop principle at various points after shutdown time of 8h, 16 h, 24 h, and 32h by using TLNET. The result is shown in figure 1. Therefore, different shutdown time corresponds to the pipe ends oil temperature respectively, 83 ℃, 77.7 ℃, 74 ℃, and 71 ℃; when shutdown time is 32h, the oil temperature is close to 70 ℃, which still belongs to Newtonian fluid, but because of the temperature dropped, the viscosity increased, whether the pipeline can meet the restart requirement, also need to be determined by the restart pressure of the pipe.

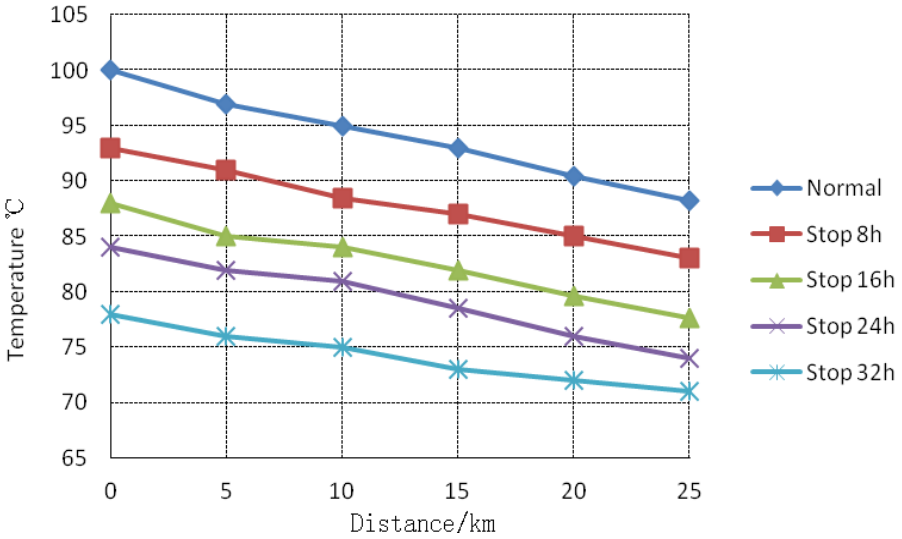

Figure 1 Temperature drop results of pipeline along distance

(4) RESTART AFTER SHUTDOWN SIMULATION

① Restart 2 pumps at the same time. Figure 2 reflects restart performance of hot oil pipeline in the windy city after 8 ~ 16 h. Thus, restart 2 pumps after shut down 16 h, the start-up pressure will reach 6.7 MPa, greater than the design pressure, so we should restart a pump first.

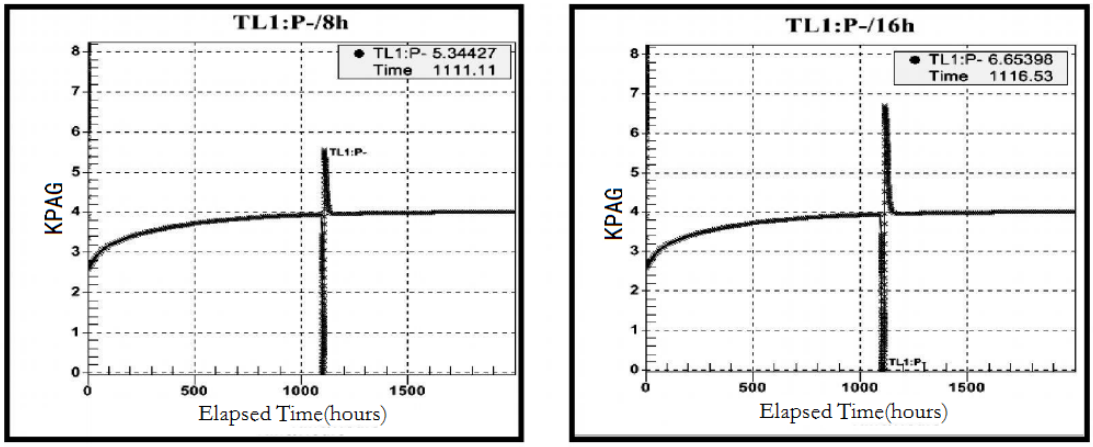

Figure 2 Performance characteristics of restarting 2 pumps at the same time

② Restart 1 pump first. Figure 3 reflects performance characteristics of restarting 1 pump respectively shut down after 24 h and 32 h. In figure 3, within 32 h, the biggest start-up pressure is 6.3 MPa, pipes can meet the requirements.

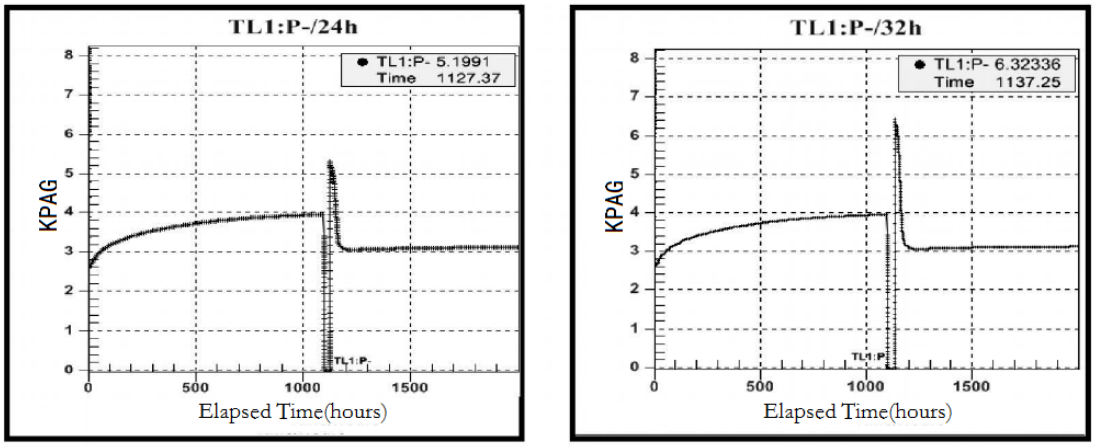

Figure 3 Performance characteristics of restarting 1 pump

③ Restart 1 pump first, then 2 pumps after. Figure 4 reflects pipeline performance characteristics of restart 1 pump first then 2 pumps when elapsed time at 32 h. According to the pump pressure characteristics. Restart 1 pump first, after 32h , then 2 pumps, the pressure is close to 7 Mpa, greater than designed pressure (FIG. 4 a); Restart 1 pump first, after 48h , then 2 pumps, pump pressure is 6.2 MPa, pipeline can be restarted safety.

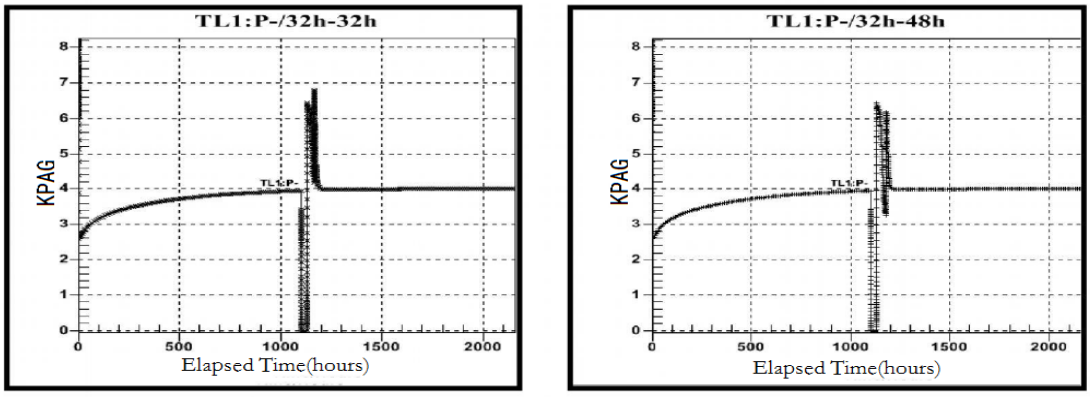

Figure 4 Pipeline performance characteristics of restart 1 pump first then 2 pumps

III. CONCLUSIONS AND RECOMMENDATIONS

(1) According to viscosity-temperature characteristics of heavy oil in the windy city by shutdown and restart simulation , when the hot oil pipeline shutdown time, are respectively, 8, 16, 24, 32 h, oil temperature at the pipe ends in turn, reduced to 84, 79.4, 74, 79.4 ℃.

(2) when shutdown time of heavy oil pipeline in the wind city is more than 16 h, if restart 2 pumps at the same time, the pipeline pressure is difficult to meet the requirements; When shutdown time is within 32 h, restart 1 pump only, or restart 1 pump first, after 48 h restart the other, the pipeline can be restart safely.

(3) Above restarting the calculation results by SPS software simulation of the hot oil pipeline, are needed to verify through indoor physical tests, and then provide the reliable theory basis for the pipeline safe operation.

(4) This paper only takes the pump shutdown and restart condition into consideration, further research in restarting pressure and displacement should also be carried out under different working conditions.

(5) Using above method to determine the safety shutdown time of the hot oil pipeline, can fully consider safety characteristic of the pipeline to restart, can take effective use of the limit bearing capacity of the pipe, and can provide basis for pipeline economic operation safety. When the pipeline safety shutdown time is determined, we can guide the pipeline operation and handle with the accident, in the longest safe shutdown time, and arrange reasonable emergency plan.

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