Research on energy consumption evaluation methods for production process of large transit crude oil depot in alpine region

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Abstract. According to the production process characteristics of transit crude oil depot, the evaluation model for the major energy-using equipment in crude oil depot was established. According to the law for energy conservation and transformation, the energy balance equation for crude oil depot was established. Six evaluation energy level depot indicators, including the energy efficiency, heat energy efficiency, electricity energy efficiency, power consumption for the transport of unit oil, and gas consumption for the transport of unit oil, the comprehensive energy consumption for the transport of unit oil were proposed. On the basis, the energy using status for a transit crude oil depot in the oil filed was evaluated. The result shows that, the overall energy utilization level of transit crude oil storage can be reflected by energy efficiency. The energy efficiency analysis for crude oil storage is helpful to determine the energy weaknesses and is contribute to point out the direction to improve the energy level.

Introduction

Crude oil transit unit depot is the heart of oil production. Meanwhile, it is the center unit of output and storage of crude oil. In general, the crude oil storage is abundance, the energy-using equipment and energy consumption are very large. Particularly for large oil depot alpine region. However, its dimension warm winter consumption is very impressive. How can reasonably control the oil reservoir of energy consumption and how to improve its operating efficiency is an important issue that concerned by researchers in the field of crude oil storage and transportation. In order to achieve this goal, the premise is to accurately grasp the energy levels of crude depot, and to determine their energy weakness. At present, some scholars to carry out research on energy consumption of crude oil depot, Zhou Hailian [1] use the process simulation systems theory for crude oil storage and transportation system parameter simulation, using thermodynamic analysis method based on this depot for crude energy evaluation and analysis. Yu Tao adopted [2] "three-box" model based on thermodynamics, with C++ Builder programming language developed a calculation program depot system energy analysis of the energy process depot a preliminary analysis. Liu Erheng [3] to establish a thermal storage tank, into the pot of oil brought into sensible heat, among external heat source-dimensional mathematical model of heat transfer and temperature correlation System thermal load obtained by oil minimum allowable maximum storage temperature affect the conclusions on this basis, summarized the critical process parameters to optimize storage and transportation systems Simple Graphical design methods and optimization of energy measures. In the depot steam pipe network system and the heat medium heater system as the research object, oil depot energy consumption is the objective to establish the corresponding mathematical model, through its optimization method established can obtain crude oil storehouse energy consumption lowest operating mode by Li Dehai [4]. In addition, there are some scholars try [5-7] from the heating temperature of the crude oil reservoirs, storage tanks and pipelines temperature insulation angles analyze energy consumption of crude oil depot, the operational plan for optimization studies. Although some researchers carried out the energy consumption of crude oil, most depots concerned that long-term storage of crude oil state. As the crude oil transit depot, since they tend to run in a non-steady state process receive oil. So their energy analysis will be more complex. Nevertheless,

energy analysis in alpine regions crude oil reservoir to enhance oil production efficiency, reduce energy consumption makes sense. Therefore, this paper major transit depot alpine region in this study. It is based on the energy balance and conversion model, a depot of crude oil transit energy evaluation method of forming a depot of crude energy level analysis.

Mathematical mode

Analysis of energy transfer process

For energy process, to send and receive process oil depot of the Central Plains depending on the system model can be classified into the energy transfer process, the process of energy conversion and energy utilization processes. For different energy process, according to its nature characteristics, it can be performed by specific indicators of its energy level evaluation, from the depot unit process point of view of energy use efficiency can reflects the crude oil. The major energy transit depot for equipment in the process can be summarized as follows:

Table 1 transit depot can process equipment energy use

Energy-consuming equipment	Crafting process	Energy process type	Input Energy	Energy output	Main index
Furnace	Crude oil heating	Energy Conversion	Fuel chemical energy	Heat	Thermal efficiency Energy efficiency
Boiler	Provide hot vapor	Energy Conversion	Fuel chemical energy	Heat	Boiler efficiency Energy efficiency
Transport-oil Pump	Crude oil booster	Energy Conversion	Electricity	Pressure energy	Pump efficiency
Heat Exchanger	Heating circulating hot oil	Energy transfer	Steam heat	Oil of thermal energy	Heat transfer efficiency
Oil Pipeline	Transportation of crude oil	Energy transfer	Crude oil heat, pressure energy	Crude oil heat, pressure energy	Transmission efficiency Utilization of geothermal energy Power utilization
Steam pipe	Transport vapor	Energy transfer	Crude oil heat, pressure energy	Crude oil heat, pressure energy	Transmission efficiency Utilization of geothermal energy Power utilization
Hot water pipes	Conveying water	Energy transfer	Hot water heat, pressure energy	Hot water heat, pressure energy	Transmission efficiency Utilization of geothermal energy Power utilization
Oil tank	Storage of crude oil	Energy using	Circulating hot oil energy	Oil of thermal energy	Heat Loss

Energy balance model

Energy balance approach is fundamental to the overall energy level of the evaluation system, focusing on the analysis system input is the output of the energy balance in the number, then grasp the system's energy situation, to understand the system of energy levels to determine energy-saving system energy saving potential and direction. According to the law of conservation of energy and conversion, the depot of crude oil transit energy balance equation is created as follows:

$$E_{Sin} + E_S = E_{Sout} + \Delta E_S \quad (1)$$

$$E_{Sin} = E_{Shin} + E_{Spin} \quad (2)$$

$$E_S = E_{Sh} + E_{Se} \quad (3)$$

$$E_{Sout} = E_{Shout} + E_{Spout} \quad (4)$$

$$\Delta E_S = \Delta E_{Sh} + \Delta E_{Sp} \quad (5)$$

Where: E_{Sin} is the total energy of the medium into the crude oil into the depot, including the media and the pressure energy into thermal energy, kJ/h; E_S is the total energy supplied to the outside world crude oil depot, including electricity and heat, kJ/h; E_{Sout} is the total energy out of media left when crude oil depot, including thermal and pressure energy, kJ/h; ΔE_S is the total energy of petroleum storage depots losses, including the loss of heat and pressure energy loss, kJ / h; E_{Shin} : When crude oil into the media depot with respect to the reference temperature into thermal energy, kJ/h; E_{Spin} : When crude oil into the media depot with respect to the reference pressure into pressure energy, kJ/h; E_{Sh} : For the supply of crude oil outside the depot heat, kJ/h; E_{Sp} : For the supply of crude oil outside the depot energy, kJ/h; E_{Shout} : Crude oil output media depot with respect to the reference temperature of thermal energy brought out, kJ/h; E_{Spout} : is the output media depot reference pressure relative to the pressure can bring out, kJ/h; ΔE_{Sh} : is the total heat loss of crude oil depot, kJ/h; ΔE_{Sp} : is the total heat loss of crude oil depot, kJ/h.

Consumption index

According to the energy balance equation, the power consumption evaluation is established:

(1) Petroleum storage depots energy efficiency

$$\eta_s = \frac{E_{Sout}}{E_{Sin} + E_S} \times 100\% = \frac{E_{Shout} + E_{Spout}}{E_{Shin} + E_{Spin} + E_{Sh} + E_{Se}} \times 100\% \quad (6)$$

$$E_{Shin} = Q_{Sin} \rho_{Sin} c_{Sin} (t_{Sin} - t_0) \quad (7)$$

$$E_{Spin} = Q_{Sin} p_{Sin} \times 10^3 \quad (8)$$

$$E_{Shout} = Q_{Sout} \rho_{Sout} c_{Sout} (t_{Sout} - t_0) \quad (9)$$

$$E_{Spout} = Q_{Sout} p_{Sout} \times 10^3 \quad (10)$$

$$E_{Sh} = B_{Sg} Q_{net,v,ar} \quad (11)$$

$$E_{Se} = 3600 N_{Se} \quad (12)$$

Where: η_s is the depot energy utilization, %; Q_{Sin} the flow of crude oil into the media depot, m³/h; ρ_{Sin} is the density of crude oil transported into the depot, kg/m³; c_{Sin} is the specific heat of capacity crude oil transported into the depot, kJ/(kg °C); t_{Sin} is the temperature of crude oil inlet the depot, °C; p_{Sin} is the pressure of crude oil inlet the depot, MPa; Q_{Sout} is the output of crude oil outside the depot, m³/h; ρ_{Sout} is the density of crude oil outside the depot, kg/m³; c_{Sout} is the specific heat of crude oil outside the depot, kJ/(kg °C); t_{Sout} is the temperature of crude oil outside the depot, °C; p_{Sout} is the pressure of crude oil outside the depot, MPa; B_{Sg} is the gas consumption of petroleum storage depots used as fuel, m³/h; $Q_{net,v,ar}$ is the low calorific value of gas, kJ/m³; N_{Se} is the power consumption of crude oil depot, kW·h; t_0 is the reference temperature, °C.

(2) Petroleum storage depots utilization of geothermal energy

$$\eta_{Sh} = \frac{E_{Shout}}{E_{Shin} + E_{Sh}} \times 100\% \quad (13)$$

Where: η_{Sh} is the utilization of geothermal energy depot, %.

(3) Petroleum storage depots power utilization

$$\eta_{Sp} = \frac{E_{Spout}}{E_{Spin} + E_{Se}} \times 100\% \quad (14)$$

Where: η_{Sp} is the depot power utilization, %.

(4) Crude oil pool unit output power consumption postal turnover

$$M_e = \frac{N_{Se}}{W_t} \quad (15)$$

$$W_t = G_{Sout} \times 10^{-4} \quad (16)$$

Where: M_e is turnover in units of oil power consumption, kW·h/(10⁴t); W_t is the turnover for the oil, 10⁴t/h; G_{Sout} is the crude oil output capacity, t/h.

(5) units of oil consumption turnover

$$M_g = \frac{B_{sg}}{W_t} \quad (17)$$

Where: M_g is the turnover in units of oil consumption, m³/(10⁴t); B_{sg} is the gas consumption of depot, m³/h

(6) oil turn over unit comprehensive energy consumption

$$M_c = M_g \cdot p_g + M_e \cdot p_e \quad (18)$$

Where, M_g is the units of oil turnover comprehensive energy consumption, kgce/(104t); p_g is the conversion of coal to gas consumption coefficient, kgce/m³; p_e is the conversion of coal to power factor, kgce/kWh.

Calculation Example

Research Target

An oil depot belonging to a transit depot which located in northeastern China, it's average annual temperature is 2 °C and the winter minimum temperature can reach -30 °C. The depot's main production facilities include: a pumping station out of the transmission, four pumps centrifugal pump of KDY550-75 × 4, two heat pumps for heating of circulating hot oil of 300S90; a room of measurement, a boiler room, three heating furnace of ZKJ2000-Yg / 6.4-Q which is responsible for external input heating oil specifically. The depot uses packet parallel operation and eight steel floating roof tanks 2 × 10⁴m³ for a seat 2 stand 5 × 10⁴m³ storage tanks for the one, two oil storage tanks transceiver alternately. External input pipeline specifications for Φ529 × 8mm and the o length is 43000m.

Operating parameters

Field test the operating parameters of the fuel depot at different times, including the oil depot receives and outside the transmission of temperature, pressure and tank operating parameters, the ambient temperature during the test was -18.9°C, resulting specific operating parameters in the following table:

Table. 2 Crude depot operating parameters

Business units	Time	Temperature	Moisture content	Density	Pressure	Transmission capacity m ³
		℃	%	kg/m ³	MPa	
Source oil 1	16 日 8:00-16:00	59	0.26	871	0.1	4330
	16 日 16:00-24:00	59	0.26	870	0.1	4250
	17 日 0:00- 8:00	59	0.26	870.2	0.15	4214
Source oil 2	16 日 8:00-16:00	47	0.28	865.3	0.1	4443
	16:00-24:00	47	0.27	866.8	0.1	4446
	17 日 0:00- 8:00	47	0.27	866.8	0.15	4373
External input1	16 日 8:00-16:00	47.5	0.24	867.6	2.33	7484.15
	16:00-24:00	47.25	0.27	868.2	2.31	7527.06
	17 日 0:00- 8:00	48.25	0.26	868.2	2.29	7563.49
External input2	16 日 8:00-16:00	48	1.55	867.6	1.55	841.38
	16:00-24:00	48	1.55	868.2	1.55	818.37
	17 日 0:00- 8:00	48	1.55	868.2	1.55	829.37

Table. 3 tanks operating parameters

Tank labels	Time	Level m	Inventories t	Outlet temperature ℃
5# (2×10 ⁴ m ³)	16 日 8:00	10.27	11217	38.48
	17 日 8:00	9.75	10646	38.30
6# (2×10 ⁴ m ³)	16 日 8:00	10.39	11349	44.20
	17 日 8:00	9.87	10778	43.09
7# (2×10 ⁴ m ³)	16 日 8:00	10.27	11217	45.73
	17 日 8:00	9.75	10646	45.70
8# (2×10 ⁴ m ³)	16 日 8:00	10.49	11349	46.01
	17 日 8:00	9.87	10778	46.06
9# (5×10 ⁴ m ³)	16 日 8:00	10.87	25019	38.34
	17 日 8:00	11.25	25928	50.99
10# (5×10 ⁴ m ³)	16 日 8:00	10.87	24971	39.27
	17 日 8:00	11.23	25881	52.56

Energy Consumption Calculation results

According to petroleum storage depots run data collected in the field, the establishment of model (1) - (18) is calculated to obtain the oil depot in continuous operation for 24 hours with the energy situation, and concrete results in table 4.

From the above results, for the study of petroleum storage depots, within 24 hours of running time, total energy efficiency of petroleum storage depots was 69.8%, with a higher energy efficiency. The utilization of geothermal energy is 70% and higher than power utilization is 60.6%. It indicates that the depot energy utilization efficiency is the higher, the heat loss is the less, and then it reflects higher operating efficiency furnace oil tanks, boilers and other equipment, tank insulation is good. Power utilization is relatively low, indicating that the low efficiency of the pump oil depots, to be further strengthened to improve pump efficiency will improve depot of crude power utilization and

overall energy efficiency of the main aspects.

Table. 4 petroleum storage depots energy evaluation results

project	Evaluation results
Power of depot (kw.h)	24843
Fuel gas consumption (m ³)	28856.4
Energy efficiency (%)	69.80
Utilization of geothermal energy (%)	70.00
Power utilization (%)	60.60
Unit turnover postal transmission power consumption (kw·h/10 ⁴ t)	11419.21
Unit turnover oil consumption (m ³ /10 ⁴ t)	13263.99
Unit oil turnover comprehensive energy consumption (kgce/10 ⁴ t)	25456.40

Conclusion

According to the production process characteristics of crude oil transit depot, the transit crude oil process model to determine the major energy-using equipment of crude depot was established. The energy transfer process of depot was divided into energy transfer, energy conversion and energy utilization process. The energy utilization processes of different energy-using equipment were analyzed. According to the law of conservation and transformation of energy, a depot of crude oil transit energy balance equation is established. And we proposed six evaluation energy level depot indicators, including crude oil storehouse of energy efficiency, heat energy efficiency, electricity energy efficiency, power consumption unit oil turnover, turnover unit oil and gas consumption oil turnover unit comprehensive energy consumption of crude oil. Based on energy balance model and petroleum storage depots evaluation energy level established for the energy status of a petroleum storage depots were evaluated. The results shows that energy efficiency can reflect the overall energy utilization level of crude oil depot, oil depots pump efficiency is low resulting in low energy utilization the main reason is the weak link in energy depot.

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