Improving the Efficiency of the Tank Farm of the Well Product Preparation System

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Abstract. The article deals with a set of issues related to the design of a reservoir park for the preparation of well products. In the calculation part, the required capacity was calculated for the selection of the main equipment of the tank farm. Also, the selection of auxiliary equipment of the fleet and the calculation of the proposed option for optimizing the operation of the fleet are carried out. The main technological operations, which are feasible with the help of the selected equipment, are considered. The technical characteristics of the equipment are given.

1. Introduction
Western Siberia is the largest oil supplier in the Russian Federation. The main part of Russian oil reserves (64%) and natural gas (91%) are concentrated in the Tyumen region. On its territory there are tank farms with a total capacity of more than 2.5 million m³.

Emissions of hydrocarbons into the atmosphere of the Tyumen region annually amount to more than 600 thousand tons. Rough calculations show that the annual loss of oil during pumping from a well to the installation of an oil refinery and oil products during delivery from the plant to the consumer, inclusive, is about 10% of the annual oil production.

Thus, the calculation of the necessary technical and economic indicators of the tank farm, ensuring its efficient operation and cost savings when making operational decisions when regulating its operation is very important.

2. Methods
The studies presented in the work are justified, since they are based on the classical provisions of theories: similarity, heat and mass transfer, diffusion, mathematical analysis. Calculation schemes, calculation methods and algorithms meet the modern requirements of production informatization.

3. Results and discussion
The breather valve is designed to reduce the loss of oil products from evaporation in the tank and to prevent its destruction. Breathing valves of tanks are selected according to the throughput and the allowable pressure drop.

Maximum gas flow through the breathing valve:

\[ Q = q_1 + q_2 + q_3 + q_4, \]  

(1)
where $q_1$ - is the largest amount of liquid entering the reservoir, $m^3/h$;
$q_2$ - increase in the volume of gas in the tank due to heating of the tank surface, $m^3/h$;
$q_3$ - is an increase in the volume of gas in the reservoir when a warmer liquid is supplied, $m^3/h$;
$q_4$ - increase in the volume of gas in the tank due to the evaporation of liquid $m^3/h$;

\[ q_2 = \beta V_g, \]  
(2)

where $\beta$ - is the coefficient of volumetric expansion of gases ($1/273 K^{-1}$);
$v_0$ - is the heating rate of the gas space (taken equal to 0.0013 $K/s$);
$V_g$ - the maximum volume of the gas space (taken equal to the geometric volume of the reservoir), $m^3$.

\[ q_3 = E D^2, \]  
(3)

where $E$ - is the experimental coefficient, depending on the temperature difference between the injected oil product and the gas space of the reservoir, is determined by [9]; for $\Delta T = 100^\circ C$ $E = 0.089$;
$D$ - tank diameter, m.

\[ q_3 = 0.089 \cdot 28,5^2 = 72.3 m^3/hour, \]

\[ q_4 = 1.3 D^2, \]  
(4)

\[ q_4 = 1.3 \cdot 28,5^2 = 270.8 m^3/hour \]

\[ Q = 1700 + 187,7 + 72.3 + 270.8 = 2230.8 m^3/hour. \]

When the reservoir is operating in vacuum, the flow rate of air entering through the valves is:

\[ Q_v^i = q_1^i + q_2^i, \]  
(5)

where $q_1^i$ - tank fluid flow, $m^3/hour$;
$q_2^i$ - decrease in gas volume due to cooling, $m^3/hour$

\[ q_2^i = \beta V_g, \]  
(6)

where $\beta^i$ - is the rate of cooling of the gas space (in case of rain and heavy rain, it is taken equal to $8 \cdot 10^{-3} K/s$).

\[ q_2^i = 8 \cdot 10^{-3} \cdot 10950 \cdot \frac{1}{273} = 1155 m^3/hour, \]

\[ Q_v^i = 100 + 35.46 = 135.46 m^3/hour. \]

According to [9], according to the calculated data, we take the most suitable breathing valve.

Let us consider the possibility of changing the operating technology of the commodity park in order to simplify the oil pumping schemes, and, consequently, the possibility of eliminating errors on the part of the operating personnel serving the park. It turns out that intra-park pumping will be carried out through different pipelines, although, in fact, they duplicate each other. It is possible to alternately pump different types of oil through the same pipeline, for this, for example, before pumping oil1 after oil2, the remaining hydrocarbons in the pipeline must be drained from the pipeline into a buried tank provided
for this and the oil and remaining vapors must be displaced with an inert gas, such as nitrogen. It is necessary to provide for two tanks, one for each type of oil and the possibility of pumping it out of the tank into the vertical steel tank.

Let's calculate the volume of oil that needs to be emptied into the tank. The volume of oil in the pipeline from the pumping station to the tanks will be equal to:

$$V_p = \frac{\pi D^2 l}{4},$$  \hspace{1cm} (7)

where $D$ - is the diameter of the pipeline, m; $l$ - is the length of the pipeline, m.

For example, let's count on specific data

Knowing the volume of oil, we select the capacity. Consideration should be given to the possibility of draining oil from pumps and the bypass line, in this regard, we select a capacity EP 63-3000-1, the capacity of which is 63 m$^3$, diameter 3000 mm and length 9250 mm. For pumping out of the tank into the oil tank, two GHI 50/32 pumps should be provided, one working, one standby with a capacity of 50 m$^3$/hour and a head of 32 m. This capacity will be enough to swing the tank and empty the pipeline.

Let's calculate the time for emptying the pipeline. A drain line should be provided at the lowest point of the discharge line, for example on the bypass line between the suction and discharge lines. Pipeline emptying time:

$$t = \frac{V_p}{Q_d},$$  \hspace{1cm} (8)

where $V_p$ - is the volume of liquid in the pipeline, m$^3$; $Q_d$ - liquid flow rate through the drainage pipeline, m$^3$/hour.

$$Q_d = \mu \omega \sqrt{2gH},$$  \hspace{1cm} (9)

where $\mu$ - is the flow coefficient equal to 0.71; $\omega$ - cross-sectional area of the drainage pipeline, m$^2$, equal to:

$$\omega = \frac{\pi d^2}{4},$$  \hspace{1cm} (10)

where $d$ - is the diameter of the drainage pipeline, m, we take $d = 0.057$m; $H$ - liquid head, m; let's take the height of the pipeline on the overpass, 4m.

$$\omega = \frac{3.14 \cdot 0.057^2}{4} = 0.0026,$$

$$Q_d = 0.71 \cdot 0.0026 \sqrt{2 \cdot 9.81 \cdot 4} = 0.012 m^3/s$$

find the drainage time:

$$t = \frac{V_p}{Q_d} = 4108,3s \text{ or 68.5 minutes time for emptying a section of the pipeline.}$$

Determine the nitrogen consumption for blowing the emptied section of the pipeline according to:

$$Q_n = 0.995 \cdot V \left( \frac{P_{st.a}}{z_{st}} - \frac{P_{f.a}}{z_f} \right),$$  \hspace{1cm} (11)
where $V$ - is the geometric volume of the area to be emptied, $m^3$; $P_{st,av}, P_{f,av}$ - the average absolute gas pressure before starting work and after emptying the site, $kgf / cm^2$; $z_{st}, z_{f}$ - coefficients of gas compressibility, respectively, at the beginning and end of the pipeline section.

Since the section of the pipeline, purged with nitrogen, is only 234 m long, the pressure and compressibility do not change.

The compressibility factor is:

$$z = 1 - 0.4273 \frac{P_r}{T_{3.668}} ,$$

where $P_r$ - reduced gas pressure; $T_r$ - reduced gas temperature;

$$P_r = \frac{P}{P_{cr}},$$

where $P_{cr}$ - critical gas pressure, characterizing the possibility of gas transition into liquid, $MPa$; $R_{cr} = 3.9$ $MPa$.

$$T_r = \frac{T}{T_{cr}},$$

where $T_{cr}$ - is the critical gas temperature characterizing the possibility of gas-to-liquid transition, $MPa$; $T_{cr} = -146.950C$.

When blowing the pipeline at a temperature of -380C and a pressure at the outlet of the nitrogen station equal to 6 $kg / cm^2$:

$$P_r = \frac{0.6}{3.9} = 0.154,$$

$$T_r = \frac{235}{126.05} = 1.86 ,$$

The compressibility factor is:

$$z = 1 - 0.4273 \frac{0.154}{1.86^{3.668}} = 0.993,$$

Next, we determine the nitrogen consumption for blowing the pipeline:

$$Q_r = 0.995 \cdot 49.3 \cdot \frac{6}{0.993} = 296.4 m^3$$

When optimizing this kind, we save on the one hand on the pipeline, and there is no need to build pipeline fittings, on the other hand, we bear the costs of purchasing and installing two tanks and submersible pumps.

4. Conclusion

The article managed to reflect the main methods of selection of the main and auxiliary equipment of the RP. The main advantages of the equipment used are considered, based on the optimal use, both from the point of view of financial costs, and from the point of view of the occupied space.

The option of optimizing the operation of the tank farm by reducing the number of process pipelines is considered. And as a consequence, the reduction of capital costs for the construction of the park.
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