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POWER EFFICIENCY OF REFRIGERATING EJECTOR SYSTEMS FOR CONDENSATION OF LIQUID HYDROCARBONS OF OIL PRODUCTS

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Abstract. Feature of processing of the hydrocarbon raw material - is an imperfect technology processes. Therefore one of the priority directions of increase in efficiency of economy of energy of oil refining is the maximum use of the recuperation of warmth and optimization of the operating modes of technology installations.
In many cases along with increase in thermal efficiency of such equipment not less important problems are also solved: metal consumption reduction, increase in operate reliability and simplicity of service.
In the paper the attention is concentrated on the use of the refrigerating ejector systems in the solution of the most important problems of the industry of oil refining. The offered systems allow one to resolve effectively issues of economy of energy and rational consumption of fuel and energy resources of the enterprises of the oil-extracting industry. These solutions in the industry are the priority direction of policy of energy economy.

Keywords: *refrigerating ejector systems, liquid hydrocarbons, power efficiency, energy saving, hydrocarbon raw material.*

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1. Introduction

Annually by different estimates more than 1 million t of hydrocarbons are thrown out. Specific losses of hydrocarbon only at each operation of draining of oil make are 1, 1-1.5 kg on 1 m3 of the poured product.

The simple traditional methods of prevention of losses of oil product having the low cost (the respiratory valve, gas-leveling system) are insufficiently effective. The known basic approaches of storage of oil products by introduction of superficially are active agents. However in practice these ways have not found a broad application.

Essential source of economy of oil resources is an elimination of losses at their production, processing, transportation and storage. By estimates of specialists, only at these expenses it is possible to receive up to 20% of all economy of fuel and energy resources.

Damage caused by these losses consists not only in reduction of fuel resources and cost of the lost products, but also in negative ecological effects which are a result of environmental pollution by oil products. Therefore, fight against losses of oil products gives not only economic effect, but also is vital for ensuring conservation.

Negative influence of petrol stations on a circumambient, is higher in comparison with other storages of oil products. It is connected with the fact that, on the one hand, these stations are placed in the large cities with a high density of building and considerable concentration of transport, and on the another hand – with the fact that emissions come from them at the height only 2 -3 m above the ground.

Despite quite considerable losses of gasoline from evaporation, reservoirs of petrol stations, as a rule, have no funds for reduction of the losses, except respiratory valves. It is impossible to apply pontoons in them since with change of a fluid level in the reservoir the area of its surface also significantly changes.

In these conditions the most preferable method of reduction of emissions of vapors of gasoline in the atmosphere are the systems of the accumulating of light fractions (ALF).

Advantages of use of these installations:

- 100% decrease in technology losses of oil products from evaporation at their transportation and storage;
- Considerable reduction of emissions of harmful substances in a circumambient in commodity oil depots;
- Quality maintenance of light oil products (petrol, kerosene, diesel fuel, etc.) at their long storage and etc.

Scopes of installations on catching of LFU on the basis of the ejector heat exchanger

- petrol stations
- tankers, railway tanks
- port terminals
- commodity oil depots
- storages of oil products

In Ukraine the definitions of oil product losses is regulated according to the normative documents. According to this the general losses of oil products consisting of natural losses at storage, reception, transportation are defined. Also the general losses includes one-time losses at cruses, repairs, etc. Natural losses are defined as a difference between the general and one-time losses.

Considering feature of carrying out technical and economic calculations we consider that the comparative economic efficiency of modernization of system defining for definition efficiency assessment as from the point of view of reduction of losses, and economic efficiency of means of modernization is not effective [1, 6].

Some authors carry out technical and economic calculations at cost value of the storage of one ton of oil products, and some - at cost value of storage of oil product in 1 m^3 of operational tank volume. At the same time:

$$C_{н} = \frac{E}{Q}, \quad C_{p} = \frac{E}{V}, \tag{1}$$

where Cn and Cp is a cost value of storage of 1 t of oil product, and oil product in 1 m^3 of operational tank volume respectively; E is an operational costs in one year; Q is a turnover of the reservoir in a year.

The norm of depreciation expenses on renovation from capital investments on modernization depends on normative service life of technical improvement. Positive economic effect of application of ejector means of prevention of losses of oil product is reached only if expenses on prevention of losses of 1 t of oil product there is less its generalized cost.

Annual losses of gasoline from evaporation are equal to the sum of losses from small and big "breath", and calculate them behind the developed technique for each reservoir separately.

$$П_1 = хП_6 \qquad (2)$$

where x –is a part of losses from the reservoir;

$$К_1 = П_1 К_с + С_{м1} + 0{,}35 C_1 \qquad (3)$$

where $Cm1$– the cost of mounting of system of reduction of losses from evaporation (4-5% of the cost of system of reduction of losses), UAH; $C1$ – the cost of system of reduction of losses from evaporation, UAH; $К_1$ – the accompanying capital investments consisting of expenses on mounting, transportation of system, UAH, Ks –the specific accompanying capital investments, UAH; they are calculated that for receiving 1 t of gasoline it is necessary to spend 5 t of crude oil.

Cost value of storage of gasoline in the reservoir equipped with system of reduction of losses is calculated by a formula:

Production Sharing Agreement $$С_р^п = \frac{Е_1}{V_{rz}} \qquad (4)$$

term of payback:

$$Т_1 = \frac{К_1}{Е_6 - Е_1} \qquad (5)$$

Calculation was carried out for the installation working with tanks of the big sizes (RVS-1000, RVS-2000, RVS-3000, RVS-5000 that RVS-10000) for LLC NPIK Zirka in the city of Zaporizhia. Results of calculations are given in Tab.1,2, 3.

Table 1. Expenses on installation design

	Type of activity	**The cost of the performed work (USD, $)**
	Calculation and selection of the equipment	4,000
	Expert opinion	500
	Execution of the working draft	6,500
	Drawing up estimate documentation	2,000
Total:		13,000

Table 2. Expenses on the installation equipment

№	The equipment from the project	Cost (USD, $)
1	The fan in protective execution	22,000
2	Ejector heat exchanger assembled	3,000
3	Vessel for nitrogen supply	5,000
4	Pipelines assembled	2,000
5	Shutoff valves and devices of automatic equipment, and protection	7,000
Total:		39,000

Table 3. Operational costs during the installation work

	Operational costs	Cost (USD, $ a year)
	Installation service (in combination)	3,000*12 = 36,000
	Cost of liquid nitrogen	800gr. on 1l.oil 800*12=9,600 9,600*12=115,200 (UAH)
	Electric power expense	75kvt*12=900 900*1.5=1,350
Total:		152,550

Results of the experiments have confirmed the relevance of use of the nitrogen for cooling of a flow of mix of air with hydrocarbons in the heat exchanger the ejector, for condensation of hydrocarbons of different brands of petrol, bioethanol and diesel fuel, and then their divisions.

Application of installation with the ejector heat exchanger for condensation of the easily boiling hydrocarbons on oil depot will allow protecting a circumambient from hit of vapors of hydrocarbons in it.

The drawn conclusions concerning efficiency of use of the ULF ejector system are valid in the case to it is connected one of big reservoirs with gasoline. When the number of the connected reservoirs large than 5, the ULF ejector system can become out of competition.

2. Justification of what efficiency of the developed ULF system

Let's define what number of emissions is formed when functioning the tank farm consisting of 8 reservoirs and annual turnover of oil, equal 30.000 tone.

For calculation the following designations and assumptions are accepted:

Tank volume – $20000\ m^3$.

I_n – the amount of liquid in the reservoirs within a year, $ton/year$.

M - maximum emissions of pollutants in the atmosphere, $ton/year$;

G - annual emissions of pollutants in the atmosphere, $ton/year$;

$t_{нк}$- liquid boiling temperature;

T_{max} , T_{min} - maximum and minimum temperature of the pumping liquid in the reservoir, respectively;

R_{zh} – density of liquid, t/m^3;

N_p– the number of reservoirs;

P_{38}- pressure of saturated steam of gasolines and oil at $T = 38^oC$;

K_t^{max}, K_t^{min} - the coefficients that are equal to 0,78 and 0,42, respectively;
K_p^{cp} – the coefficient that is equal to 0.62;
K_{OB} – turnover coefficient;

Q_{Ch}^{MAX}-the maximum volume of the air-steam mixture which is forced out from reservoirs during its downloading, $m^3/_{hour}$;
K_{In} - the coefficient; is equal to 1.

Table 4. Data of a product

Product	P_{38}	$T^o C,$	*ºC*		$V,$ $m^3/_{hour}$	I_n , $ton/year$	$R_{zh},$ t/m^3
			T_{min}	T_{max}			
Oil	420	42	10	32	56	300000	0,74

Gross emissions of vapors of oil are calculated according to a formula (6) and (7) [4]:

- maximum emissions ($M, / c$):

$$= \frac{0{,}163 \times P_{38} \times m \times K_t^{max} \times K_p^{max} \times K_B \times V_ч^{max}}{4} \quad (6)$$

-annual emissions (G, $ton/year$):

$$G = 0{,}294 \times P_{38} \times m \times K_t^{max} \times K_B + K_t^{min} \times K_p^{cp} \times K_{OB} \times B \frac{ton}{year} \quad (7)$$

The maximum emissions and annual emissions will make:

$M = 0{,}163 \times 420 \times 63{,}7 \times 0{,}78 \times 0{,}62 \times 1{,}0 \times 56/104 = 11{,}8100$ g/page
$G = 0{,}294 \times 420 \times 63{,}7 \times (0{,}78 \times 1{,}0 + 0{,}42) \times 0{,}62 \times 1{,}35 \times 300000/107 = 324{,}6692/\text{year}$.

Thus, when the considered tank farm consists of 8 reservoirs and annual turnover of oil is equal to 300000 tons, then 325, 000 tons of the pollutants are formed released into the atmosphere.

3. Conclusion

Often the existing processing equipment on installations of oil refinery does not provide necessary operation factors even after optimization, and economically reasonable is implementation of the highly effective resource-saving equipment.

In many cases along with increase in power efficiency of such equipment also other not less important problems are solved: decrease in metal consumption, increase in operate reliability and maintainability.

Summing up the results It should be noted that cost on design and acquisition of the equipment, and also its mounting has made $(USD) 53,000. Annual operational costs have made $(USD) 152,550. Based on the carried-out calculations it is possible to claim that installation pays off less than in a year.

Implementation of the developed system of protection of the atmosphere based on catching of light fractions of hydrocarbons of oil will allow to reduce losses of light fractions of oil to 98%. It is 20 times less than annual emission of pollutants in the atmosphere from the reservoirs functioning without systems of catching.

Advantages of the provided scheme is lack of the separate pump that allows to reduce capital investments in system of catching of light fractions at a stage of its implementation, and also at its operation due to power saving; minimization service and increase reliability of means of reduction of losses.

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