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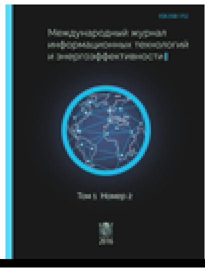

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ПРАКТИЧЕСКОЕ ПРИМЕНЕНИЕ УСТАНОВКИ РЕКУПЕРАЦИИ ПАРОВ В КОМБИНАЦИИ С ТРЕХПОТОЧНОЙ ВИХРЕВОЙ ТРУБОЙ НА АЗС

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В работе представлена значимость проблемы потерь от испарений светлых нефтепродуктов. Приведены статистические данные, демонстрирующие, что наибольший процент потерь связан с хранением продуктов в резервуарах. Обоснована целесообразность применения установок рекуперации паров на АЗС в комбинации с трехпоточной вихревой трубой для значительного снижения потерь светлых нефтепродуктов при заправке автомобилей и сливе продукта из автоцистерны в резервуары хранения.

Ключевые слова: Светлые нефтепродукты, АЗС, трехпоточная вихревая труба, большие дыхания, установка рекуперации паров, адсорбер, активированный уголь, эффект Ранка-Хилша.

PRACTICAL APPLICATION OF A VAPOR RECOVERY UNIT IN COMBINATION WITH A THREE-FLOW VORTEX TUBE AT FILLING STATIONS

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The paper presents the significance of the problem of evaporation losses of light oil products. The statistical data showing the largest percentage of losses related to bulk oil storage is presented. The expediency of using vapor recovery units at filling stations in combination with a three-flow vortex pipe is proved. Reasons of significant decrease of evaporation losses from oil-loading operations, filling stations and discharge from the oil truck into crude tanks are given in an article.

Keywords: Light oil products, filling stations, three-flow vortex tube, strong breathing, vapor recovery unit, adsorber, activated carbon, Rank-Hilsh effect.

The evaporation of light oil products is one of the most important process of petrol storing due to the effect on all technological stages of life of this valuable product. Storage in tanks, transportation by any possible transport and draining and filling operations are inevitably followed by huge losses from strong and inconsiderable breathing. It has an impact both on the quantity and quality of the final product. In this regard, it is necessary and rightly to develop and seek for modernization of current technologies, as well as search for fundamentally new ones. Thus, it will let us to ensure maximum leak proofness of all technological processes belonging the life cycle of light oil products.

According to Table 1, based on the information presented in [1], the main share of losses of light oil products falls on their storage in tank batteries at oil depots, refineries and filling stations (Table 1). Table 2 presents information on losses of light oil products in tanks (Table 2).

Table 1 – Total losses of light oil products

Losses of light oil products during transportation	Losses, %	Light oil product losses from evaporation in tank batteries, %
Motor transport	59,3	65-70
Water transport	17,5	
Pipelines and transshipment depots	11,1	

Source: Almakhanova, E. A. Losses of light oil products during transportation, storage and loading and unloading operations / E. A. Almakhanova, B. U. Zhamanbaev

Table 2 – Loss of oil products during storage in tanks

Sources of loss	Losses, %
"Strong breathing."	54,0
Deflation	4,6
Gas trap	0,9
From tank cleaning	5,3
At pump stations	2,3
With sewage drains	7,5

Source: Almakhanova, E. A. Losses of light oil products during transportation, storage and loading and unloading operations / E. A. Almakhanova, B. U. Zhamanbaev

It should be noted that evaporation losses are primarily associated with the volatilization of the most valuable fractions for light oil products - light hydrocarbon fractions (LHF). According to [1], the Russian oil and gas sector is marked by annual evaporation losses at oil depots of more than 100 thousand tones. This fact demonstrates the importance of developing preventing technologies for trapping vapors and volatilized hydrocarbons.

Nowadays, it is reasonable to use oil product vapor recovery units (VRU) at filling stations, which provide an opportunity to considerably reduce the share of petrol vapors, irrecoverably escaping into the atmosphere. Two options of vapor recovery units at petrol stations are applicable - for filling vehicles (Figure 1) and for discharging petrol products from oil trucks (Figure 2).

According to [3], the traditional design of VRU implies continuous process on three pairs of adsorbers. The first pair is the active working one. Its implementation is as follows: the stream of captured hydrocarbons passes only through one of two technologically connected adsorbers. During an operation, hydrocarbons are precipitated on the adsorbent (activated carbon was conventionally an adsorbent). The time of this cycle is strictly regulated depending on the volume of hydrocarbons flowing to the adsorber in a particular time interval. The next step is the transition to the operating state of the second adsorber, while the first adsorber switches for regeneration. Regeneration takes place by creating a vacuum in the adsorber body. Hydrocarbons are detached from the adsorbent due to the reduced pressure. Subsequently, they are sent to the reabsorption column. It can be concluded that the first adsorber is in operation while the other one is regenerated. Moreover, the necessity of regular stopping of both adsorbers for maintenance works is an essential part of the process. Every VRU system consists of three pairs, where the second one is a spare working pair. The third is a reserve pair in case the first pair is on regural maintenance or is out of order. In this case, the third pair becomes the spare working pair.

The main disadvantage of VRU usage is the probability of high residual emission level at the VRU outlet, which occurs primarily due to the quality of vapor adsorption. VRU unit of filling stations get a mixture of hydrocarbons which is purified much worse than each individual component. Hence, it leads to estimations differs from the actual efficiency level of the process. In order to reduce residual emission of hydrocarbons it is needfully to carry out drying, cooling of vapor-air mixture and removing of "harmful impurities". For this purpose, it is reasonable to use a three-flow vortex tube (VT) (Figure 3).

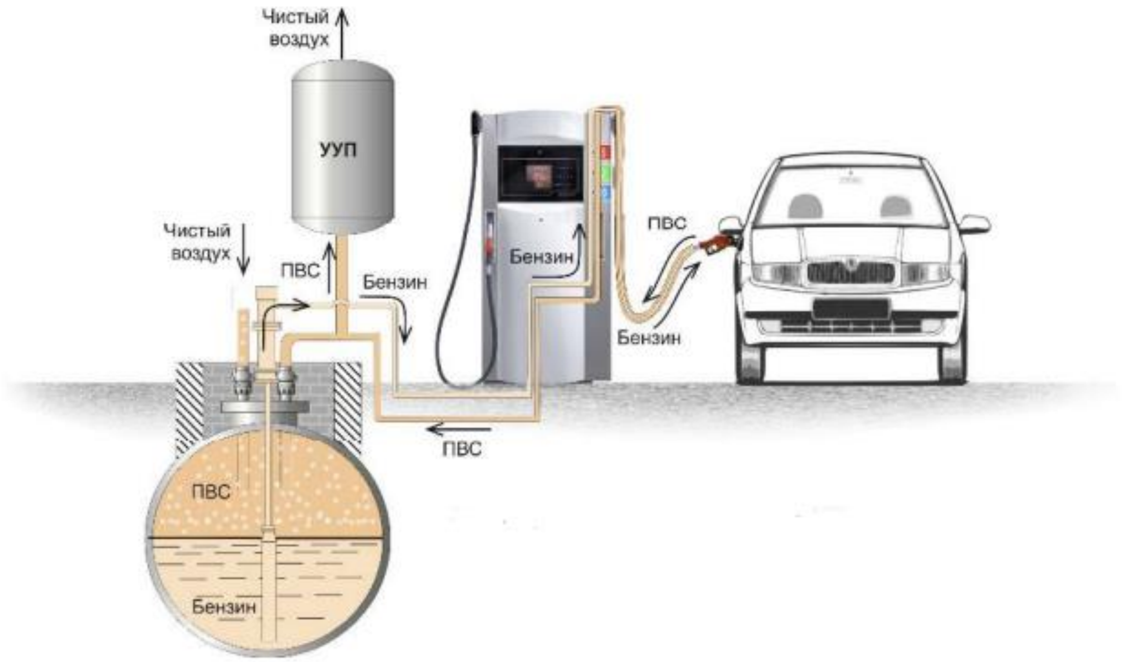

Figure 1 – Car refueling at the filling station with the use of VRU [2]
Source: Oil product vapor recovery system. JSC Prompribor

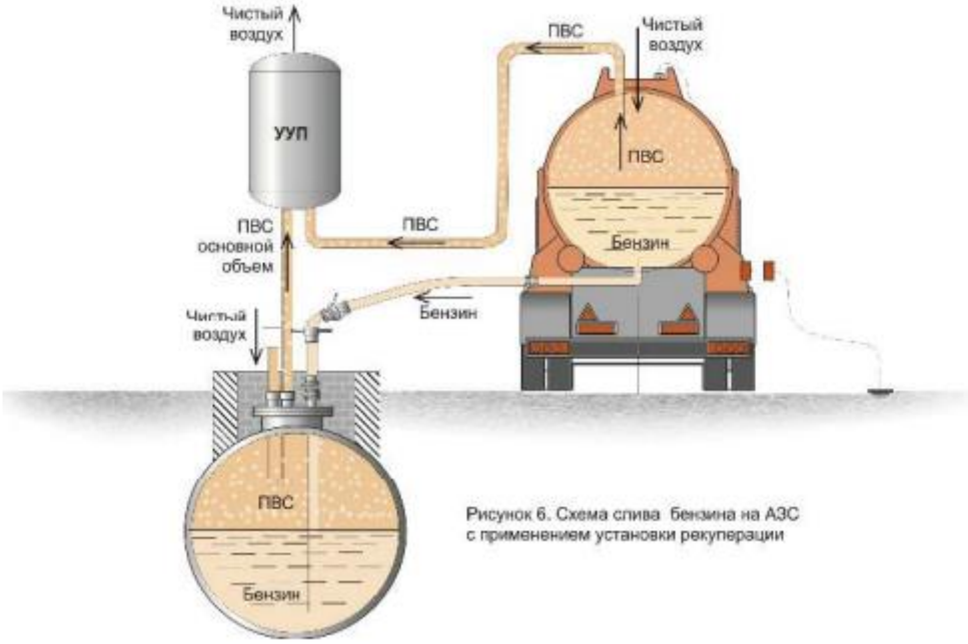

Figure 2 – Petrol draining at a petrol station with the use of FPS [2]

Source: Oil product vapour recovery system. JSC Rompribor. [Electronic resource]

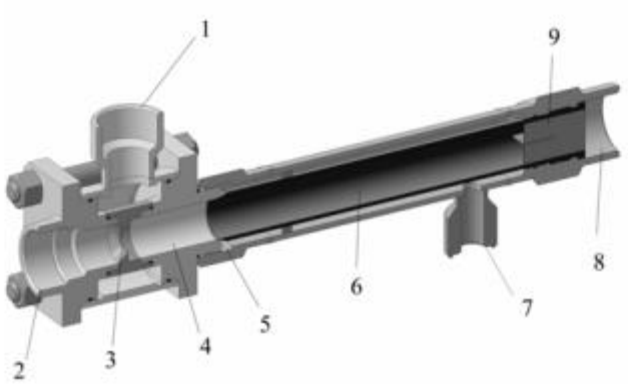

Figure 3 – Three-flow vortex pipe in section:

1 - nozzle inlet, 2 - cold end of the pipe, 3 - diaphragm, 4 - nozzle, 5 - separation unit, 6 - energy separation chamber, 7 - condensate outlet, 8 - hot end of the pipe, 9 - cross piece [4]

Source: Vlasenko, V. S. Development of a unit with a three-flow vortex tube for hydrocarbon vapour recovery / V. S. Vlasenko, V. V. Slesarenko, D. N. Shkredov

The operation concept of a three-flow vortex tube is based on the Rank-Hilsh effect, the essence of which is that a swirling vortex flow is divided into two with a high temperature difference. At this point, the hot flow located at the periphery exits through the flow ratio controller, while the cold flow is concentrated in the center of the tube and exits in the opposite direction to the hot flow through the central orifice in the diaphragm [5]. An application of a three-flow vortex tube into the technological process of VRU work at the filling station will allow to send only the cold flow to the adsorber by means of flow separation. At the same time, hot flow goes to the compressor inlet for the purpose of cyclic feeding to the vortex tube through the plate heat exchanger. Consequently, only cold hydrocarbons will flow into the adsorber, which leads to achieving a significant reduction of residual hydrocarbon emissions at the outlet of the VRU. Figure 4 shows the scheme of the FPSO in combination with the VT (Figure 4).

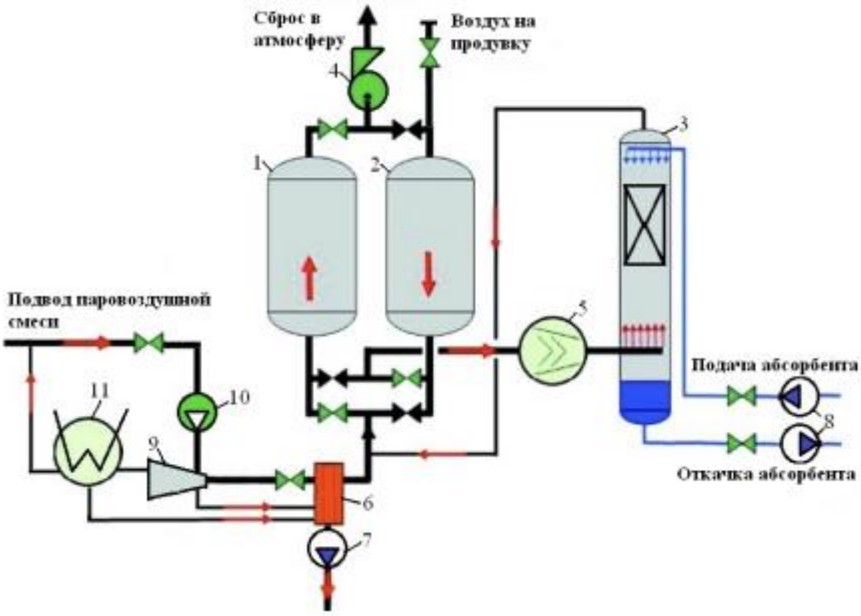

Figure 4 – Flow diagram of VRU in combination with VT:
1 - adsorber in operating mode; 2 - adsorber in regeneration mode; 3 - absorber column; 4 – air cooler; 5 - vacuum pump; 6 - condensate collector;
7 - condensate pump; 8 - absorbent pumps; 9 - three-flow WT; 10 - compressor; 11 - heat exchanger-cooler [6]
Source: Slesarenko, V. V. Improvement of oil vapour recovery units to reduce harmful emissions into the atmosphere / V. V. Slesarenko, V. D. Lapshin, P. A. Sokolova

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