

UDC 622.692:665.7(045)

<sup>1</sup>**Oksana O. Vovk**, Candidate of Engineering, Assoc. Prof.<sup>2</sup>**Angela E. Guy**, Candidate of Physical and Mathematical Sciences, Assoc. Prof.<sup>3</sup>**Anna V. Yakovleva**, Master**ANALYSIS OF OIL PRODUCTS LOSSES IN FUEL POWER COMPLEX OF UKRAINE**

National Aviation University

<sup>1,2</sup>E-mail: img@nau.edu.ua<sup>3</sup>E-mail: pinchuk\_anya@ukr.net

*The problem of oil product losses in a result of evaporation in Ukrainian fuel power complex is presented in the article. It is described the objects, where hydrocarbons emissions may take place and their negative impact on environment. For investigation it was chosen a filling station as an object of fuel power complex. As a result it was developed a Multislice system for better comprehension of interconnections in system "environment – filling station - technosociosphere".*

*Розглянуто проблему втрат нафтопродуктів у результаті випаровування в паливно-енергетичному комплексі України. Описано об'єкти, на яких відбуваються втрати нафтопродуктів, та їх негативний вплив на навколишнє середовище. Для дослідження обрано автозаправну станцію як об'єкт паливно-енергетичного комплексу. Розроблено шарову систему для кращого розуміння взаємозв'язків у системі «навколишнє середовище – автозаправна станція – техносоціосфера».*

*Рассмотрена проблема потерь нефтепродуктов в результате испарения в топливно-энергетическом комплексе Украины. Описаны объекты, на которых происходят потери углеводородов, и их негативное влияние на окружающую среду. Для исследования выбрана автозаправочная станция как объект топливно-энергетического комплекса. Разработана слоевая система для лучшего понимания взаимосвязей в системе «окружающая среда – автозаправочная станция – техносоциосфера».*

**Statement of purpose**

Modern situation in Ukrainian fuel-power complex (FPC) is characterized by limitation of own oil deposits and low efficiency of oil refinery plants. As a result transport sector is provided with energy source due to import mainly. Ukrainian FPC during last years is demonstrating development of the main economical indexes. During last time it can be observed a positive tendency in growth of main activity indexes in fuel-power complex branches. However, there are a number of problems, which requires immediate consideration and search for their solutions.

While modern science and technology tend toward development and implementation of new alternative energy sources, oil is still the most important and widely used energy carrier all over the world.

Meanwhile numerous problems connected with production, processing and usage of oil are now of current importance.

Considering problems of Ukrainian FPC we suppose that special attention should be paid to losses of oil products during technological processes. The essence of this question looks as following. During storage, transportation, swapping, and application of oil fuels we can observe their significant losses caused by hydrocarbons evaporation [1].

Control of oil and oil products losses nowadays is stipulated by will to use hydrocarbon raw material more effectively. Oil products losses control is one of the most important ways to safe fuel-energy resources, which play leading role in economics development. Elimination of hydrocarbons losses in a result of evaporation may save up to 20% of oil products and money as well.

That why this problem is so important from economical point of view. However, damage, done by oil products losses consists not only of precious hydrocarbon raw material amount decreasing that is an economical aspect of the problem, but also of negative impact on the environment (ecological aspect of the problem).

### **Problem forming**

Negative impact of filling stations (FS) on environment is revealed much greater than comparing to other storages of oil products. It is explained in a following way. From one hand filling stations are displaced in large cities with high density of buildings and high concentration of motor transport; from another hand emissions at filling stations take place at height just 2 – 3 m above the ground [2]. Independently on the source of loss hydrocarbons get into the atmosphere, they negatively influence environment and human health in particular.

In our research the problem of oil products losses from evaporation is described on example of Filling Station as one of FPC objects. The FS was chosen for investigation due to its suitability according to many requirements for FPC in ecological and economical areas.

### **Analysis of researches and publications**

The problem of emissions of oil and oil products is one of key questions in providing energy and ecological safety of the country. During last 15 years in our country this question is also popularly discussed by such specialists as S. V. Boychenko, O. V. Boychenko, A.V. Kulagin and society as well. Much attention is paid to huge emissions of harmful vapors from oil and oil products and to losses of precious hydrocarbon raw material [3]. Theoretical investigations of F.F. Abuzova, N.D. Ivanov show that fuel losses from evaporation make about 2 – 5% from total volume of oil refining. . At the same time annual nonrenewable losses of oil and oil products for Ukraine is equal to 2,3 mln ton [1].

World statistical data state that the total loss of oil and oil products from evaporation varies in a range 0,5 – 1,7% from the total volume of processed raw material [3].

According to Y. Surigala, O. Puhovich in Ukraine this number is much greater and varies from 3 to 7%. In reservoir parks losses reaches 75 – 80% from all losses. Investigations based on statistical analysis of production and use of fuel as an energy source have shown that in Ukraine it is evaporated and emitted into the atmosphere about 1 mln ton of various kinds of fuel. Among them about 500 000 t are motor petrols and about 300 000 t – diesel and jet fuel. Also it is defined that fuel losses for jet engines during flight can reach 7% of mass [1]. For example, M. P. Kovalko states that for reservoir park of oil refinery such losses are equal to 50 000 t of hydrocarbons per year. French scientists estimate losses of fuel from evaporation during car filling as 0,19% from fuel volume that is discharged (0,14 kg/m<sup>3</sup>), German scientists – 0,175%, English scientists – 0,18%, Japanese scientists – 1,44 kg/m<sup>3</sup>[4].

### **Task forming**

Oil products emissions at FSs are a complex problem, which concerns all aspects of human activity (legal, scientific-practice, nature preserve, social, medical, and economic one). There is a necessity in integral comprehension of this problem and cardinaly new approach to find opportunities for its solution. In our research we put the aim to explain the complexity of investigated problem, to show number of aspects to be taken into account for its solving. Our purpose is to create a system (approach), which may explain interconnections between natural environment, filling station and technosociosphere.

### **Main material**

Losses of hydrocarbon fuel at filling stations take place mainly in large cities with high density of building up and significant quantity of auto transport. According to the data of Tokyo office for pollution control it is known that from the moment of tank truck filling with oil product at petroleum storage depots up to its distribution in fuel tanks of auto transport at filling stations it is lost 0,64% of fuel in a result of evaporation [4].

CH<sub>x</sub> losses at filling stations take place during filling-discharge operations in reservoirs (“big breathing”), fuel storage in reservoirs (“small breathing”), filling of auto transport fuel tanks through fuel distribution pump and also in a result of spillages and disturbances in hermiticity of pumps, refueling hoses, absence of tightening gaskets [5]. Generalized fuel losses at filling stations are divided as it is presented on the following diagram (fig. 1).

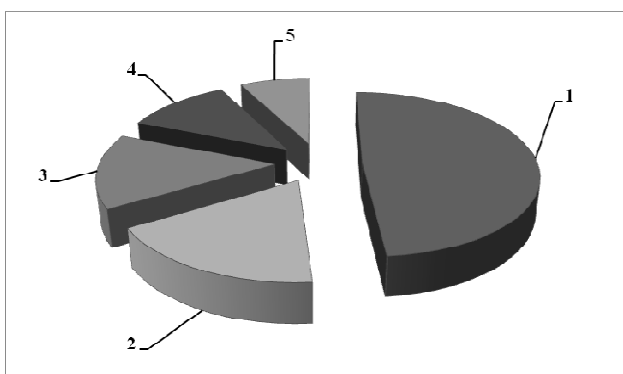


Fig. 1. The structure of generalized losses at filling stations:

- 1 – overfilling of fuel tank during filling (48,7%);
- 2 – in a result of evaporation (17,7%);
- 3 – driving during filing of fuel tank (14,6%);
- 4 – technical disrepairs of FDP (11,4%);
- 5 – technical disrepairs of discharge equipment (7,6%)

Situation with emissions of oil and oil products in Ukraine is intensified by significant deterioration of equipment, which is used in oil and gas industry. Mainly whole reservoir park of Ukraine consists of ground metal vertical reservoirs with stationary roofing, which were built 20 – 30 years ago. Only small part of them is equipped with pontoons and floating roofing. Park of railway and truck cisterns and filling-discharge equipment is already out of date as well.

Fuel losses from evaporation (natural losses) lead to worsening of fuel exploitation characteristics, such as triggering and antiknock stability, which limits technical resource of engines of transport means. Damage, made by these losses, is not only decrease of fuel resources quantity and cost of losing products, but it is also negative ecological consequences, which are a result of environment pollution by oil products.

That’s why oil products losses control gives not only economical benefit but it is also vitally important to provide nature protection [1].

Ecological aspect of this problem is also of current importance, because evaporation of fuel significantly increases technogenic loading on environment. Negative impact of filling stations on environment is revealed much greater than comparing to other storages of oil products. Independently on the source of loss hydrocarbons get into the atmosphere, they negatively influence environment and human health in particular [2]. High concentration of hydrocarbons in air cause increased morbidity disturbances of respiratory system, functional changes of nervous system and other health disturbances.

Considering the problem of oil products losses we came to conclusion that it concerns all spheres of human activity. That is why this problem requires a complex approach to its solution. As a result of our research there was developed a Multicomplex approach for integral comprehension of this problem and search for new opportunities to its solution.

The essence of this approach is that any existing problem in FPC should be understood as a complex problem and considered from different points of view. Because it is impossible to overcome the whole problem, solving only one of it’s components. This approach is very convenient, because it may be applied to any object of FPC. Investigating the problem of oil products losses in a result of evaporation we included the following aspects, which may contribute into solving of this problem: legal aspect, scientific-practical aspect, nature preserve aspect, social aspect, medical aspect, and economical aspect. All of these components are tightly connected with each other by multiple connections and any of them can be chosen as a starting point for the problem solution.

The damage, which is done by losses of oil products at filling stations (discharge, storage, filling) consists not only in decrease of fuel resources and cost of lost products, but also in negative impact on components of environment

(atmospheric air, soils, water objects, flora and fauna) and components of urbocomplexes (cities, rural areas, etc.).

Usually estimation of transport impact on environment analyzes such negative products of fuel combustion as nitrogen oxides, sulfur oxides, carbon oxides, dust, soot, and various unburned and newly formed hydrocarbons. Their toxic impact on human health and environments is already well-known. However, too many aspects in hydrocarbons life-cycle are still unknown [6]. The main source of hydrocarbons' entrance into environment is not auto transport emissions, but places of fuel and lubricating materials storage before they get into fuel tank of a car. Taking into account a great number of fuel stations in Kyiv the problem of environmental pollution from filling stations becomes more popular day by day and requires detailed investigation.

Main source of fuel entrance into environment are spills from reservoirs (23%), and pipeline systems (37%) of objects of fuel supply (they determines pollution of soil and ground waters), evaporation from reservoirs during short and long winds (28%) and from petrol pumps (they determines air pollution) [7].

An important reason of loss of fuels and lubricating materials (10%) is spills during filling of tanks, reservoirs, vessels, transport vehicles due to violation by workers of rules of execution of certain operations.

According to Multicomplex approach, the problem of oil products losses at FSs should be considered from different points of view. Nowadays this question is understood mainly as an economical problem. However, modern world trends to ecologization of all spheres of human life and activity lead to consideration of ecological aspect of FS functioning.

As FSs' functioning is tightly connected with human activity (beginning from driving personal motor transport) in Ukraine there is a quite well-developed net of FS. The greatest number of filling stations is in Kyiv (more than 220) and its region, then in Crimea, Donetsk, Harkiv, Odessa, Dnepropetrovsk, Zaporizhzhya and Lviv regions.

In regional centers there is about quarter of filling stations, about 40% is situated in other towns and about one third is on routes and in villages. However, numbers vary greatly from region to region; the greater population of regional center – the greater concentration of filling stations there. So, nowadays FSs are present in big industrial centers, small villages and along highways and routes. But independently on the place of displacement FSs' activity causes its negative impact on urbocomplexes, in which FS is functioning and environment. As nowadays more and more territories become urbanized it is rational to consider urbocomplexes consisting of subcomponents: rural areas and cities. Urbocomplexes are not only industrialized territories with high density of buildings.

They are also a high number of population, which is also subjected to FSs' impact and somehow tries to solve this problem. That is why it is correctly to use wider notion "technosociosphere" instead "urbocomplex", describing negative impact of FSs and ways to eliminate or diminish it. However, urbocomplexes are integrally connected with components of environment (air, water, soil, flora and fauna). So influence of FSs' activity penetrates through urbocomplexes, and leaves its negative impact on environment components. For better comprehension of this complex interconnection between Filling Stations, Natural Environment and Technosociosphere it was created a Multislice system. The main idea of this system: it is volumetric or 3-dimensional. FSs' activity negatively influences on urbocomplexes, and penetrating through them leaves its impact on environment components. We have also shown schematically how Multicomplex approach is applicable to this system. From each aspect of the Multicomplex approach it was chosen one component and shown it's role for integral understanding and solving of the above mentioned problem. The Multislice system (fig. 2) is presented in a form of 3-dimensional block-scheme, which consists of many correspondent layers and contains informative loading by its components.

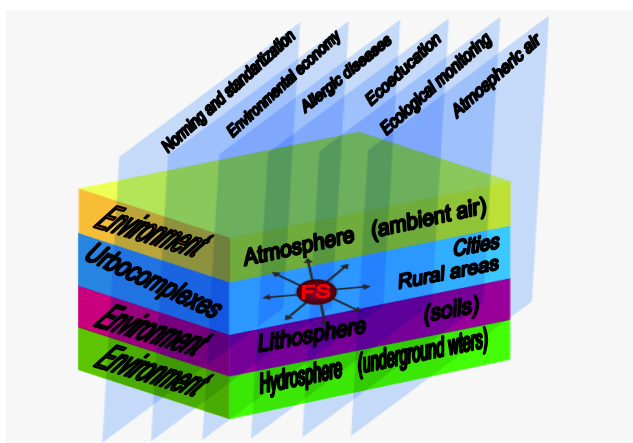


Fig. 2. Multislice system

The Multislice system combines FS as a part of urbocomplex and its impact on the components of environment with aspects of early developed Multicomplex approach, which consider the existing problem of oil products emission in FPC.

### Conclusion

Ecological tasks solving – is a complex functions of multiple variables with unknown function values. For simplification of decision-making it is necessary to present these decisions in a form of schemes-models, which include correspondent components that are responsible for certain factor of impact on technosociosphere.

Given model visually illustrates multiple interconnections among involving components (on example of FS). Taking into account necessity in modern methods and approaches to forecasting of consequences in technosystems, block-scheme is presented in 3D format. Proposed format “multislice system” allows more clear comprehension of interconnections, which arise in a result of interaction between human and natural environment and choice of optimal solutions depending on current tasks.

There are many difficulties in ecological tasks solving in the area of FPC objects activity. It was proposed a 3D format model “Multislice system” using, which consists of many correspondent layers. Each of these layers is placed one over another and contains informative loading by components of multicomplex model for further optimization of possible solutions.

The next step in development of the Multicomplex approach to FPC analytical system is creation of mathematical models to describe proposed schemes in order to optimize search for new solutions to existing problems in Ukrainian FPC.

### References

1. Бойченко О. В. Моніторинг природних втрат палив при зберіганні та застосування сорбентів для їх зменшення: дис.: 21.06.01 / О.В. Бойченко. – К., 2001. – 133 с.
2. Кулагин А. В. Прогнозирование и сокращение потерь бензинов от испарения из горизонтальных подземных резервуаров АЗС: автореф. дис. на соиск. учен. степ. канд. техн. наук: спец. 25.00.19 «Строительство и эксплуатация нефтегазопроводов, баз и хранилищ» / А. В. Кулагин. – Уфа, 2003. – 25 с.
3. Обеспечение сохранения количества и качества нефтепродуктов при хранении / С.В. Бойченко, А.А. Литвинов, О.В. Бойченко, С.М. Еременко // Вісник КМУЦА. – 2000. – № 1–2. – С. 196 – 199.
4. Втрата вуглеводнів під час виконання технологічних процесів переробки, транспортування, зберігання та заправки / С.В. Бойченко, Л.А. Федорович, Л.Н. Черняк та ін. // Нефть и газ. – 2006. – № 3. – С. 90 – 94.
5. Сидоренко Н. О. Вплив компонентного складу автомобільних бензинів на їхню стабільність / Н. О. Сидоренко // Вісник НАУ. – 2009. – № 1. – С. 173 – 176.
6. Франчук Г.М. Аналіз даних про токсичність паливно-мастильних матеріалів для людини / Г.М. Франчук, М.М. Николяк // Вісник НАУ. – 2008. – № 1. – С. 161 – 164.
7. Огняник М.С. Забруднення геологічного середовища нафтопродуктами – загроза якості підземних вод України / М.С. Огняник, Н.К. Парамонова, О.М. Шпак // Вода і водоочисні технології. – 2003. – №3 (вересень). – С. 63–67.

The editors received the article on 15 March 2010.