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«ПАРНИКОВЫЙ» ЭФФЕКТ. ВЫМЫСЕЛ ИЛИ СЛЕДСТВИЕ ПРОЛОНГИРОВАННОГО ДЕЙСТВИЯ ТЕХНОГЕННЫХ СИСТЕМ?»

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«GREENHOUSE» EFFECT. FICTION OR RESULT OF THE PROLONGED ACTION OF THE TECHNOGENIC SYSTEMS?

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Аннотация

В статье приведены научно-технические публикации по прогрессирующему изменению климата на планете, обусловленное повышением среднегодовой температуры атмосферного воздуха, морской океанической среды и как следствие сопровождающееся нарушением, а в отдельных случаях разрушением природных экосистем, биотических сообществ, биом. Возможная причина изменения климата на планете – «парниковый» эффект. Мнения ученых и экспертов по вопросу «парникового» эффекта на планете и его последствий разделились на диаметрально – противоположные: 1) есть «парниковый» эффект, 2) нет «парникового» эффекта. И это противоречие на наш взгляд вполне объяснимо. Действительно провести исследования в глобальном масштабе в трех экологических нишах окружающей среды невозможно. Поэтому исследователями предлагаются различные модели, адекватность которых проверить в глобальном масштабе окружающей среды, космоса невозможно. Несмотря на противоречивость взглядов на «парниковый» эффект, можно констатировать, что последствия повышения среднегодовой температуры воздушного бассейна, морской океанической среды весьма отрицательные и прогнозируемо катастрофические. Нами проведен анализ и расчетные исследования в течение последних 60-ти лет, характеризующихся наиболее интенсивным потреблением углеводородного сырья невозобновимого характера, по накоплению диоксида углерода-маркера «парникового» эффекта-в трех нишах окружающей среды. Из результатов проведенных исследований напрашивается вывод о конгруэнтности роста эмиссии диоксида углерода антропогенного характера в воздушном бассейне и повышения среднегодовой температуры воздушного бассейна, можно предположить и повышения среднегодовой температуры морской среды, в зависимости от времени. Как выйти из создавшейся ситуации необратимого характера-пути имеются, сложнее с принятием решения общепланетарного масштаба. Приведены примеры реализации научно-исследовательских работ по снижению эмиссии компонентов «парниковых» газов на морском транспорте, что позволит решить двухвекторную задачу-повысить экономическую эффективность морских грузоперевозок и обеспечить экологическую безопасность морских грузоперевозок.

Abstract

The article presents scientific and technical publications on the progressive climate change on the planet, caused by an increase in the average annual temperature of atmospheric air, marine oceanic environment and, as a consequence, accompanied by the disruption, and in some cases destruction of natural ecosystems, biotic communities, biomes. A possible cause of climate change on the planet is the "greenhouse" effect. The opinions of scientists and experts on the issue of the "greenhouse" effect on the planet and its consequences were divided into diametrically opposed ones: 1) there is a "greenhouse" effect, 2) there is no "greenhouse" effect. And this contradiction, in our opinion, is quite understandable. Indeed, it is impossible to conduct research on a global scale in the three ecological niches of the environment. Therefore, researchers offer various models, the adequacy of which is impossible to verify on a global scale of the environment, space. Despite the contradictory views on the "greenhouse" effect, it can be stated that the consequences of an increase in the average annual temperature of the air basin and the marine oceanic environment are very negative and predictably catastrophic. We have carried out an analysis and computational studies over the past 60 years, characterized by the most intensive consumption of hydrocarbon raw materials of a non-renewable nature, by the accumulation of carbon dioxide, a marker of the "greenhouse" effect, in three environmental niches. From the results of the studies carried out, a conclusion suggests itself about the congruence of the growth of anthropogenic carbon dioxide emissions in the air basin and the increase in the average annual temperature of the air basin, it is possible to assume an increase in the average annual temperature of the marine environment, depending on time. How to get out of this situation of irreversible nature - there are ways, it is more difficult to make a decision on a planetary scale. The examples of the implementation of research work to reduce the emission of components of "greenhouse" gases in marine transport, which will solve the two-vector task - to increase the economic efficiency of sea freight and ensure the environmental safety of sea freight.

Ключевые слова: «парниковый» эффект, техногенные системы, морской транспорт, диоксид углерода, температура, окружающая среда, морская, океаническая среда, экономическая эффективность, экологическая безопасность, решение проблем, планета, зависимость, компоненты «парниковых» газов, судоходство.

Keywords: "greenhouse" effect, man-made systems, marine transport, carbon dioxide, temperature, environment, marine, oceanic environment, economic efficiency, environmental safety, problem solving, planet, dependence, components of "greenhouse" gases, shipping.

Introduction.

The technogenic systems, in particular marine transport, are the basic «suppliers» of components of «greenhouse» gases, such substances and connections as dioxide of carbon, hydrocarbons, nitrous oxide, organic mineral dust, soot, pairs of water behave to that.

Opinions of scientists and experts through question of planetary «greenhouse» effect are diametrically opposite. And it, in our view, under itself has basis. Really, to answer a simple question, whether there is a «greenhouse» effect on a planet or he is not present, necessary to have the reliable materials got as a result of research works. To conduct experiments in the global scale of planet and space in the direction of study of «greenhouse» effect on the modern stage is not possible. Therefore this work is conducted on the offered hypothetical models. The methods of mathematical design, on the basis of that preferentially drawn conclusion about of presence or nonpresence of «greenhouse» effect on Earth, are used in calculation researches. A lack of any offered models of «greenhouse» effect is the absence and/or impossibility of verification of them on adequacy in the real terms of experiment on a planet and in space.

Analysis of publications of the examined question in fact.

In works [1-8] the detailed analysis over of possible reasons of origin and consequences of «greenhouse» effect is brought.

Scientists from the Californian University in Irwine (USA) reported about the threat of flood for 400 million persons from a rise in temperature, «greenhouse» effect [9]. The melting glaciers of Greenland considerably heaved up the level of the World ocean - for two months he increased on 2,2 mm. Reason, melting became that a more than 600 milliard of tons of ice. These processes were accompanied by a too warm summer 2019 year. The last year was most warm in all history of Arctic. It was shown by calculations, that ice in Greenland began to melt sevenfold quicker, than it was in 1990th.

The content of carbon dioxide in the Earth's atmosphere in August 2019 increased by three points relative to the same indicator in 2018, which means that humanity cannot reduce CO2 emissions into the atmosphere and slow down global warming, said the National Aeronautics and Space Administration (NASA, USA) [10].

The specialists of NASA confirmed exactness of the recently obtained data on the temperature of air layer at the surface of sea, dry spell, and ice sheet by means of satellite Aqua, testifying to the rapid global warming (information over is brought in a press-release on Eurek Alert). According to the model calculations of scientists, if no measures are taken to reduce greenhouse gas emissions, then by the end of the 21st century the temperature of seawater in the upper layer 2,000 m thick will rise by 0.78°C. It will promote the level of world ocean only due to thermal by volume expansion on additional a 30 cm in addition to getting up of level of marine aquatorium of coastline from a melting glaciers. The increasing of temperature of marine environment and air pool will provoke more severe storms, hurricanes and extreme fallouts.

The scientists of Toronto University (Canada) found out that rise in temperature of climate in a region

Yukon on the north-west of Canada became the strongest after more, than ten thousand years (information over is brought in a press-release on Eurek Alert). Researchers believe that warming on Earth could destabilize permafrost, leading to even greater emissions of methane and carbon dioxide, the main components of «greenhouse» gases.

In work [11] scientists propose to spray aerosols into the atmosphere of the air basin so as to reduce warming by 50%. The idea itself is not new, but it has been criticized. Researchers have created a geoengineering model for targeting the Earth's climate with aerosol spraying in the stratosphere. In the model of scientists, sulfur dioxide was considered as an aerosol. It is noted that this measure will not solve the problem of global warming in general, but can only be considered as part of an integrated approach.

As a comment of authors of this article to work [11]:

1) from where to take in the enormous amounts of planetary scale dioxide of sulphur as a protective aerosol?

2) dioxide of sulphur in the stratospheric layer of atmosphere will be exposed to oxidization by an active oxidant by ozone to the sulphuric anhydride, and sulphuric anhydride at co-operating with the pairs of water, contained in atmospheric air, will result in formation of sulphuric acid.

As a result, not deciding the problem of the global warming of Earth, this suggestion will lead and to strengthening two other global problems - to destruction of «ozone layer» of planet and intensification of «acid» rains.

The transport sector accounted for 22% of global carbon dioxide emissions in 2010 [12], including the shipping sector in 2013 accounting for 2.2% of global CO_2 emissions compared to 2.7% of CO_2 emissions in 2008 (IMO, 2014).

In work [13] materials on carbon dioxide emissions from public transport are given: in Sydney (Australia), the level of carbon dioxide emissions per passenger-kilometer was, g: 188 for an average car, 120 for a bus, 105 for a train ride, 171-by light rail. CO_2 emissions from each chain were approximated by the sum of emissions from all stages of the trip.

Results - one cannot do without reducing technogenic (manmade systems) emissions of components of "greenhouse" gases, one cannot solve the global problem of climate warming on planet Earth.

Raising of task and possible ways of decision of global problem of «greenhouse» effect.

By us, in order of discussion, for the last 60 years an analysis [14], calculation researches, is conducted on the accumulation of dioxide of carbon - basic component of «greenhouse» gases on a planet. This period of time was accepted coming from that exactly he is characterized by the most intensive consumption of hydrocarbon raw material of unrenewable character (oil, natural gas, coal, slates) and, accordingly, most emission of dioxide of carbon in an atmosphere and environment. The results of researches are shown on a figure 1.

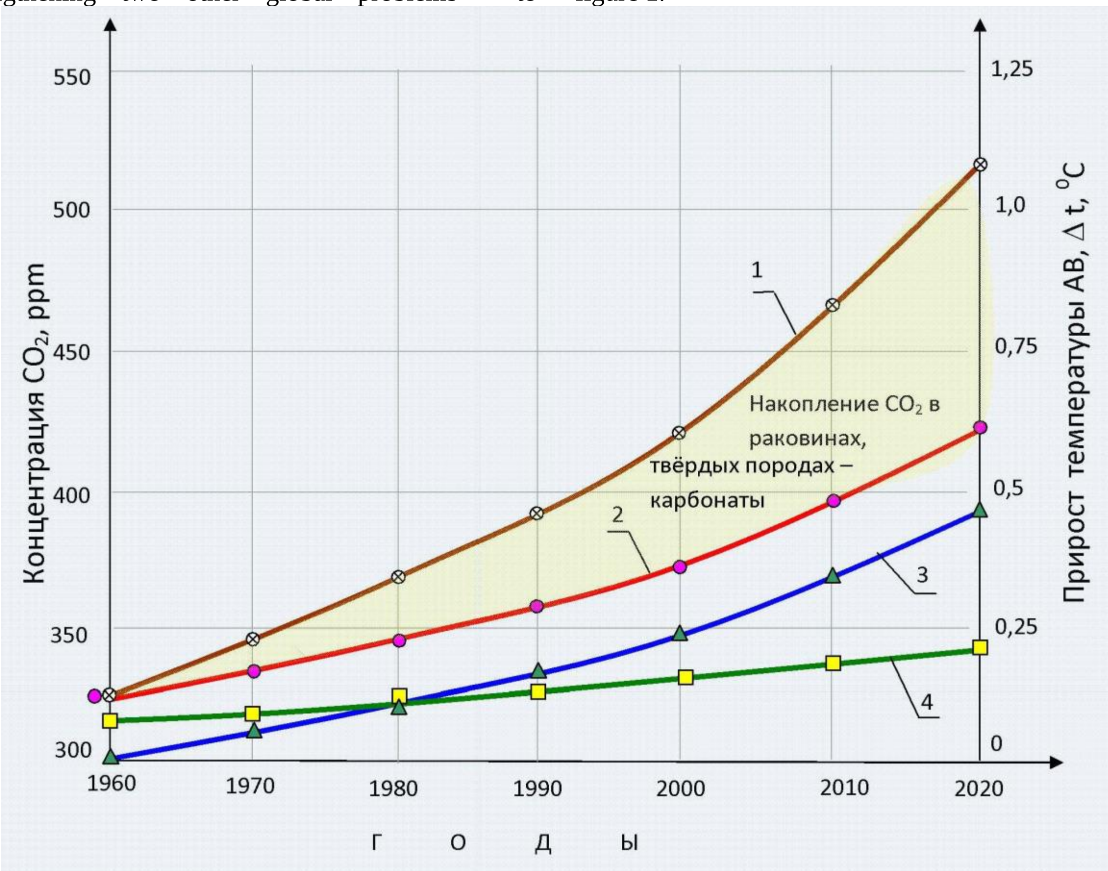


Figure 1 - Change in the concentration of carbon dioxide and the average annual increase in atmospheric air temperature depending on time (years):

Curve 1 - total anthropogenic CO_2 accumulation; curve 2 - anthropogenic accumulation of CO_2 in the atmospheric air; curve 3 - average annual increase in atmospheric air temperature; curve 4 - natural accumulation of CO_2 in the atmospheric air.

Legend: ppm-parts per million , Δ t - the average annual increase in atmospheric air temperature °C; AB - atmospheric air.

Carbon dioxide, regardless of the nature of its formation, can accumulate in shells, solid rocks with the formation of carbonates, dissolve in seawater, participate in photosynthesis reactions, and excess of carbon dioxide accumulates in the atmospheric air.

The dynamics of an intensive increase in the total concentration of carbon dioxide in the environment (Curve 1, Fig. 1) is fully consistent with the intensive consumption of hydrocarbons over the same period of time. Curve 2 (Fig. 1) characterizes the growth dynamics of the concentration of carbon dioxide in the atmospheric air, which includes two sources of carbon dioxide formation - anthropogenic (predominant) and natural (Curve 4, Fig. 1). We had found that curve 2 (increasing of CO_2 concentration in the atmospheric air) and curve 3 (average annual increasing of atmospheric temperature over the same period of time) are practically parallel (congruent), which indicates that the accumulation of CO_2 in atmospheric air is related to the average annual increasing of atmospheric air temperature. And this, in turn, determines the role of carbon dioxide as the main component of "greenhouse" gases that stimulate the "greenhouse" effect, leading to a warming of the climate on Planet.

Interesting, in our opinion, is the nature of the change in the natural concentration of CO_2 in the atmospheric air, why there is a monotonic increase in the concentration of CO_2 over the analyzed period of time. It can be assumed with a high degree of certainty that over the indicated period of time, as a result of human actions and technogenic systems, the organic base for the photosynthesis reaction (forests, blue-green algae) is depleted, inhibited, which leads to a decrease in the productivity of the photosynthesis reaction and, as a consequence, to a decrease in the mass of carbon dioxide involved in the photosynthesis reaction. Excess natural carbon dioxide accumulates in the atmospheric air, which is consistent with the course of curve 4 (Fig. 1).

Based on the foregoing about the technogenic prerequisites for the emergence and intensification of the "greenhouse" effect, it is possible to propose a "scenario" of the impact of planetary climate change on the environment, ecosystems, biota, biome, biosphere, and humans (Fig. 2).

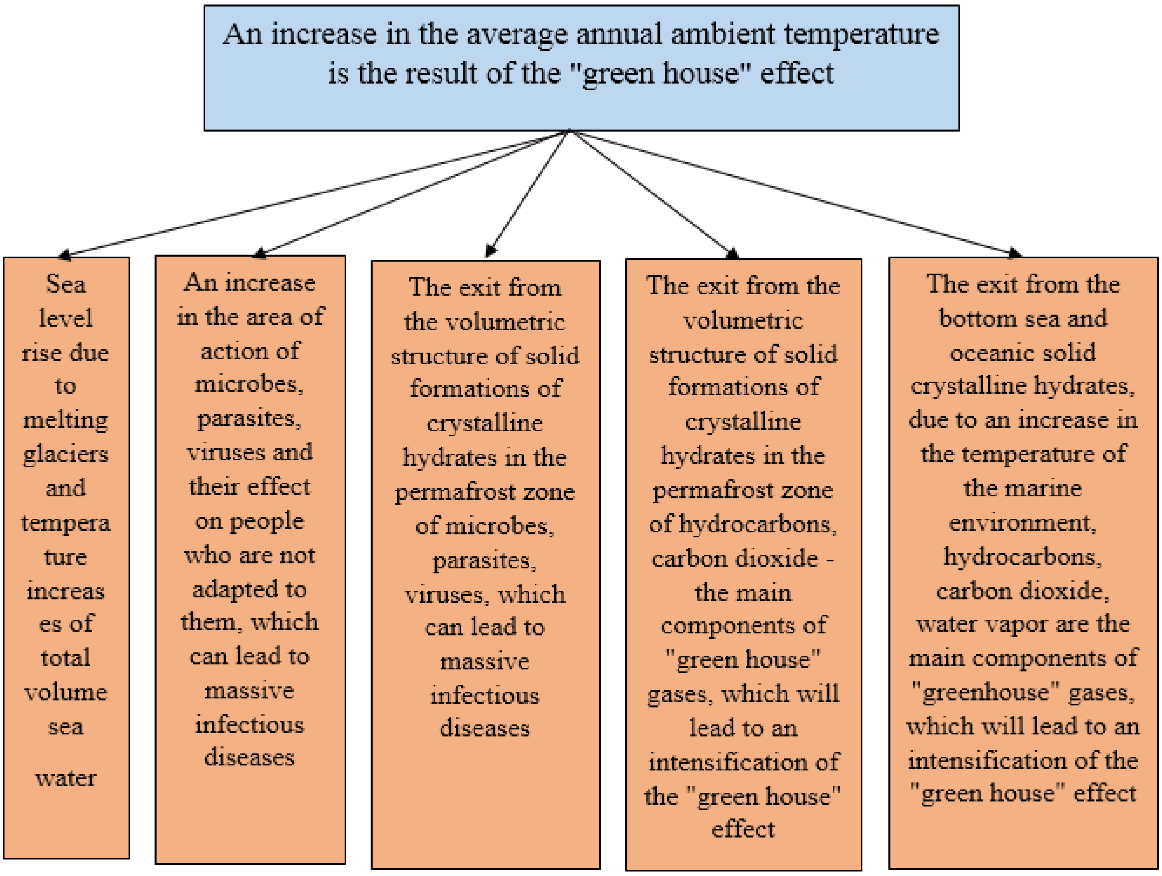


Figure 2 - The impact of an increase in the average annual temperature of the environment on the negative impact on ecosystems, biota, biomes, biosphere, humans

The certainly offered model (Fig.2) has hypothetical character, but in her basis indirect confirmations of the climatic phenomenon lie from data of change of some meteorological parameters of environment for the long period of time.

In 2015 the international climatic summit of COP-21 took place in Le Bourget (France), that was sanctified to the problem of rise in temperature of climate on a Planet and development of ways of overcoming of this crisis. More than 137 states of the world signed final Protocol of this summit. The USA is the most meaningful consumer of hydrocarbon raw material of unrenewable character and separate countries the less meaningful in a plan consumptions of hydrocarbon raw material did not sign final Protocol of climatic summit, releasing itself from financial expenses, nature protection measures. It follows from this that greater part of the states of the world is disturbed by the global warming and his consequences.

In Kyoto and Parisian Protocols on issue of «greenhouse» effect on a Planet a Shipping and Aviation were not plugged into final formulation of Agreement.

International Marine Organization, International Organization of Civil Aviation, made enough an effort, that this error never repeated in future. Both these international organizations draw line on the change of eco law in part of toughening of requirements to emitters of the technogenic systems, including the Shipping and Aviation, on the basic components of «greenhouse» gases. It is necessary to mark that some Shipping and Aviation Companies are fully satisfied with that Agreement «went round them a side», as they fear additional material and financial charges on introduction of measures with the purpose of providing of the ecological safety related to the risk of intensification of «greenhouse» effect.

It should be noted that certain steps on business of defence of environment are nevertheless done. For example, for the sea and river vessels an additional certificate is entered on protecting of air space from contamination from ship engines, that is **IAPP - International Air Pollution Prevention Certificate.** Fulfillment of requirements of this Certificate by sea and river vessels undoubtedly brings the contribution to defence of ecology.

«A navigation needs some progressive eco law, - J. Carnerap Bang considers, senior expert on a climate in the Danish company Maersk Group - it must be universal, independent of flag and controlled by International Marine Organization. Conception of COP-21 must become a starting point for his making. First, in the preliminary variant of the Parisian agreement COP-21, 200 countries-participants worked on that, the Navigation and Aviation were mentioned, but this division of Agreement was abolished afterwards. It is necessary to mark that this Division did not contain concrete binding prescripts, just appeal to pay attention to problems of maritime and aviation vessels, but even in such kind could have influence on both industries» [14].

Really, this just professional's opinion, responds conception of ecological safety on the whole, the Shipping and Aviation are in the first ten on a contribution to the «greenhouse» effect and integral contamination of planet, as a result of functioning of the manmade systems.

From 1990 to 2010 mass of emission of harmful toxic components and connections in Aviation increases on 80 %, and in a Shipping - on 40 %.

Rapid development of these industries of the manmade system can increase this contribution to the «greenhouse» effect to 40 % in general balance even to 2050.

So insolvency of ignoring of Shipping and Aviation in a rise of temperature of climate on Earth.

Besides material wastes, the Shipping and Aviation distinguish the considerable level of energy wastes - thermal, noise, vibration, electromagnetic fields, ultrasonic and infrasonic radiations, radio frequencies of all levels and spectrums, satellite navigational, radar and radio contamination.

«A Parisian agreement will be specified and finished off, − considers P. Khinchliff, Secretary general of the International Chamber of Shipping (ICS). - I am quite sure that on some stage we will carry the opinion to the countries-founders and will enter a necessary to us paragraph in a document».

In accordance with the analysis and calculations of marine cargo transportation conducted by us a modern marine transport expends an about 1 billion tons per year of hydrocarbon ship fuel, that corresponds to emission an about 3,2 billion tons per year of carbon dioxide.

It is necessary to mark that in 2019 the total emissions of dioxide of carbon - result of action of the manmade systems is made 40 billion tons. At the same time only from a Shipping, including ports and port facilities, the emissions of carbon dioxide made an about 4,5 billion tons per year.

Thus, deposit on the whole Shipping industries as manmade system in a general «greenhouse» effect (on dioxide of carbon) is 11,3 %. Possible to assume that in an Aviation approximately the same size on a contribution to the «greenhouse» effect. In the total on the Shipping and Aviation part in a general «greenhouse» effect is more than 22 %, and with it it is necessary to be considered at prognostication of development of intensity of «greenhouse» effect on a Planet.

To eliminate emission of components of «greenhouse» gases - dioxide of carbon, hydrocarbons, mineral dust, soot is impossible when use of hydrocarbon materials.

On the basis of our calculation researches it is possible to establish executed, that emission of dioxide of carbon is a consequence of processing of hydrocarbon material. Emission of dioxide of carbon at processing (incineration) settled accounts as general on equalization:

$$e\sum CO_2 = e^{доб}CO_2 + e^{тр\cdot}CO_2 + e^{пер\cdot}CO_2 + e^{сж}CO_2, \quad (1)$$

где $e^{доб}_{CO2}$, $e^{тр.}_{CO2}$, $e^{пер.}_{CO2}$, $e^{сж}_{CO2}$ – accordingly, the emission of carbon dioxide during the extraction of carbon dioxide, its transportation, processing and combustion, g CO_2 - equivalent / kg of reference fuel, and as a result of only combustion of hydrocarbon– $e^{сж}_{CO2}$-.

Results over of calculations are brought on a figure 3.

From a figure 3 follows that emission of carbon dioxide, both general and only as a result of incineration, goes down in a row «coal → fuel oil → natural gas → hydrogen». As an oxidant when incineration of hydrocarbon raw materials was used the air.

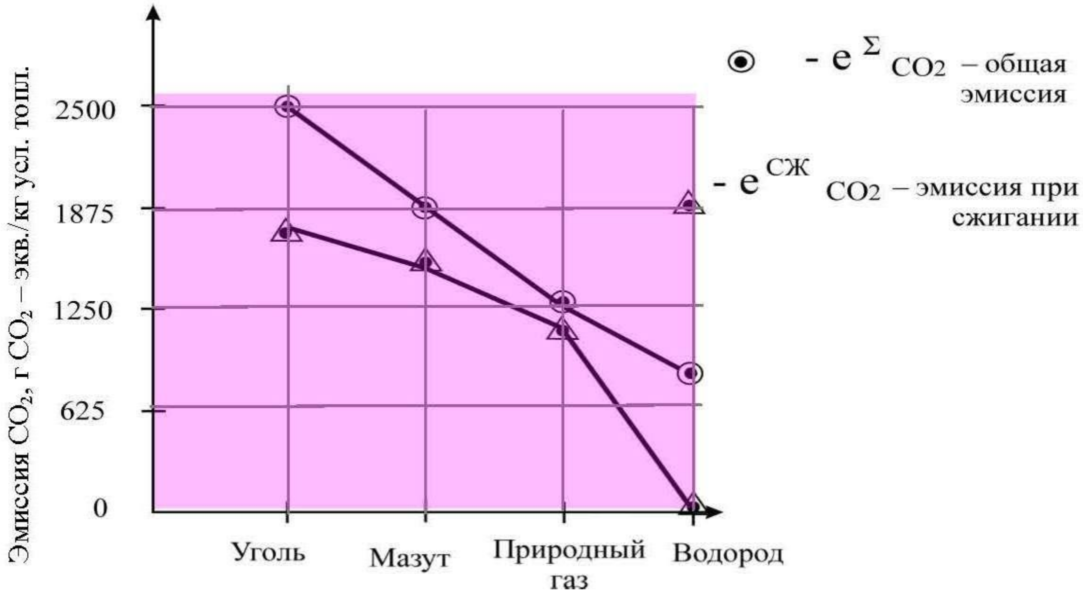


Figure 3 - Emissions of carbon dioxide depending on the type of fuel burned

In case of incineration of hydrogen in the stream of oxygen emission of dioxide of carbon at incineration is equal to the zero, and general emission of dioxide of carbon is equal 833 g CO_2 - equivalent / kg of reference fuel. (fig. 3).

Resource-saving technologies allow, from one side, to bring down the specific consumption of hydrocarbon raw material per conditional ton of having special purpose products, and from other - to bring down the emission of material and level of energy wastes of the manmade systems.

Technical suggestions, that will allow to bring down emission of dioxide carbon and, accordingly, bring down the action of «greenhouse» effect, are below given:

1. Development and realization of low-waste, resource-saving technologies, allowing to bring down formation of material wastes and, as a result, bring down the emission of dioxide of carbon.

2.Extraction, concentration, collection, translation in the liquid aggregate state, storage and transporting of the liquefied dioxide of carbon.

3. Chemical conversion of dioxide carbon by the method of the catalytic hydrogenization in methanol [14] and on the basis of methanol production of the plastic masses, urea-formaldehyde resins, hydrocarboxylic acids, fertilizers, pharmaceutical products, high-octane components of motor fuel, hydrogen, ethylene, protein-vitamin concentrate, hydrate inhibitor when mining of hydrocarbon gases.

In the Kherson State Marine Academy (a scientific leader is professor Leonov V.Ye.) research, experienced and experienced-industrial works are conducted on development of resource-saving, ecologically safe technologies and use of nonhydrocarbon raw material for providing of functioning of the manmade systems.

A pool of the Black sea is the powerful source of unconventional energy resources, namely: the sulphuretted hydrogen and ground crystallohydrates. The ground crystallohydrates are a hard-phase alloy of ice and dissolved (adsorbed) hydrocarbons of C_1- C_{5+}. The Technical problem in the use of crystallohydrates consists of their extraction, transporting on the surface of marine environment [14], and regasification and processing of crystallohydrates in compounds and motor fuel does not present industrial complications and can be realized in existent petrochemical complexes.

The hydrogen sulfide contained in the area of the Black sea presents an enormous potential danger for the countries of Black Sea Region [1,2,14].

The scientific and technical problems of deployment of the hydrogen sulfide for the production of motor fuels and compounds include the next stages [1,2,14]:

- deep-water extraction of the sulphuretted hydrogen;
- effective processing of the sulphuretted hydrogen in a motor fuel and chemical compounds.

We have been worked out an original technical decision on the deep-water marine of the sulphuretted hydrogen (≈10000 м). A decision is protected by the patent of Ukraine [16].

By a technical decision [16] a stationary marine platform, on that, collection, storage and preparation of the obtained sulphuretted hydrogen to the subsequent complex processing, comes true, is foreseen. The last comes true also on a marine platform.

The methods of processing of the sulphuretted hydrogen, sulfur-containing compounds are offered by patent [1,2,14] in valuable chemical compounds. Methods differs in high technical and economic indexes, namely, emission of harmful toxic components with exhaust gases of vessels engine in an atmosphere is fully absent.

At a complex extraction and processing of the sulphuretted hydrogen of the Black Sea the basic problems of ecological safety, financial viability, resource-saving, defence of marine environment are deciding:

1) the potential danger of «breach» through the seawater of toxic, explosive and fire-hazardous hydrogen sulfide is reduced;

2) the dependence of countries on imports of hydrocarbon energy is reduced;

3) the socio-economic and environmental damage to the environment of the Black Sea countries is sharply reduced.

Based on the real state of affairs with stocks of hydrocarbon raw material, the time of their depletion, we can suggest three stages of transition from hydrocarbon raw material to nonhydrocarbon raw material:

1) remaining time of action and exploitation hydrocarbon raw material for providing of the manmade systems, to the requirements of resource-saving;

2) transitional period, when the part of hydrocarbon raw material in general energy balance will make 50 % and more, up to a complete substitution hydrocarbon raw material - on 100 % nonhydrocarbon raw material;

3) set period of realization of nonhydrocarbon raw material for functioning of the manmade systems.

The completed epoch of hydrocarbon raw material is characterized by the substantial «change» of civilization toward unsteady development of society [1,2,14]. This instability is characterized by substantial influence of «greenhouse» effect, destruction of ozone layer of Planet and ecosystems, intensive exhausting of unrenewable and renewable energy, oxygen, natural fresh water sources.

As recommendations it is possible to offer next basic directions of activity within the framework of the first stage is hydrocarbon raw material:

1) «to preserve» further exploration, development and hydrocarbon production, to leave remaining hydrocarbon raw material to the future generations as reserve;

2) to transfer the manmade systems on resource-saving and ecologically safe technologies [1,2,14];

3) to reduce the manmade impact on the development of the "greenhouse" effect.

When extraction, storage, transporting of oil, and also at her processing in petrol, diesel, boiler fuel, fuel oil, besides casual and emergency losses, the systematic losses of hydrocarbons, conditioned by evaporation of liquid hydrocarbons from a surface at the «large» and «small» breathing in a capacity apparatus take place. The «large» breathing is emphasizing of air with the pairs of hydrocarbons from reservoirs when loading in its oils and light oil products. The «small» breathing of reservoirs is conditioned by the difference of temperatures of air on day and night. The general losses of hydrocarbons in the world reach of tens millions per year. A direct economic damage due to the losses of oil and oil products and ecological-economic damage are thus inflicted because of contamination of air pool by hydrocarbons - the components of «greenhouse» gases.

The losses of hydrocarbons only at priming and storage of oil and oil products make a 1100 g/м3 of airily-hydrocarbon mixture. According to the operating directives of the European Union the concentration of hydrocarbon in the vaporous state must not exceed a 35 g/м3, i.e. the losses of hydrocarbon should reduce more than on 30 times by the requirements of European Union [1,2,14].

For the decline of emission of hydrocarbons in atmosphere in the process of exploitation of tankers, gas carriers, chemical tankers, LPG carriers, innovative technical decisions are worked out to practical realization on a marine transport [1,2,14].

On a figure 4 a fundamental chart of adsorption of steams of hydrocarbons is brought from the reservoir of oil tanker.

Pairs of hydrocarbons from a reservoir 1 act on suction compressor 2, where compressed to 0,3 MPa. In a recuperative heat-exchanger 3 hydrocarbon-air mixture cools down to minus 3°C, further on in a heat-exchanger 6 cools down by freon to 5°C and enters underbody of adsorber 4, in the pores of adsorbent 5 the pairs of hydrocarbons are assimilated. As far as absorption of hydrocarbons sorption capacity of adsorbent 5 goes down and comes to the satiation (working capacity).

For renewal of absorptive ability of sorbent conduct his regeneration as follows: exhaust gases of СЭУ at the temperature 450 - 500°C enter baghose 11, where soot is distinguished. Instead of baghose electrostatic precipitator can be used.

Purged from soot waste gases act at the temperature 350°C in a regenerative heat-exchanger 10, in that the heat of waste gases is utilized with making of steam (0,4 MPa, 240°C). In a catalytic reactor 9 at the temperature 250 - 300°C, pressure 0,3 MPa on an oxide catalyst the oxide carbon and hydrocarbons are neutralized. Cleared waste gases at the temperature 250 - 300°C enter to underbody of adsorber 4, here from the internal surface of adsorbent 5 hydrocarbons removed which then with waste gases at the temperature 120°C enter refrigerator-condenser 7, in which waste gases and hydrocarbons cool down to 25°C.· In a separator 8 the division of phases passes - gas, presenting the cleared exhaust gases, given in a reservoir 1 as a protective «pillow» for prevention of explosion, and a liquid phase presenting liquid hydrocarbons goes back into a depository 1. Surplus of waste gases after a separator 8 thrown out in an atmosphere.

The presented technological scheme is resource-saving, environmentally safety, and allows solving the issues of fuel economy and environmental protection.

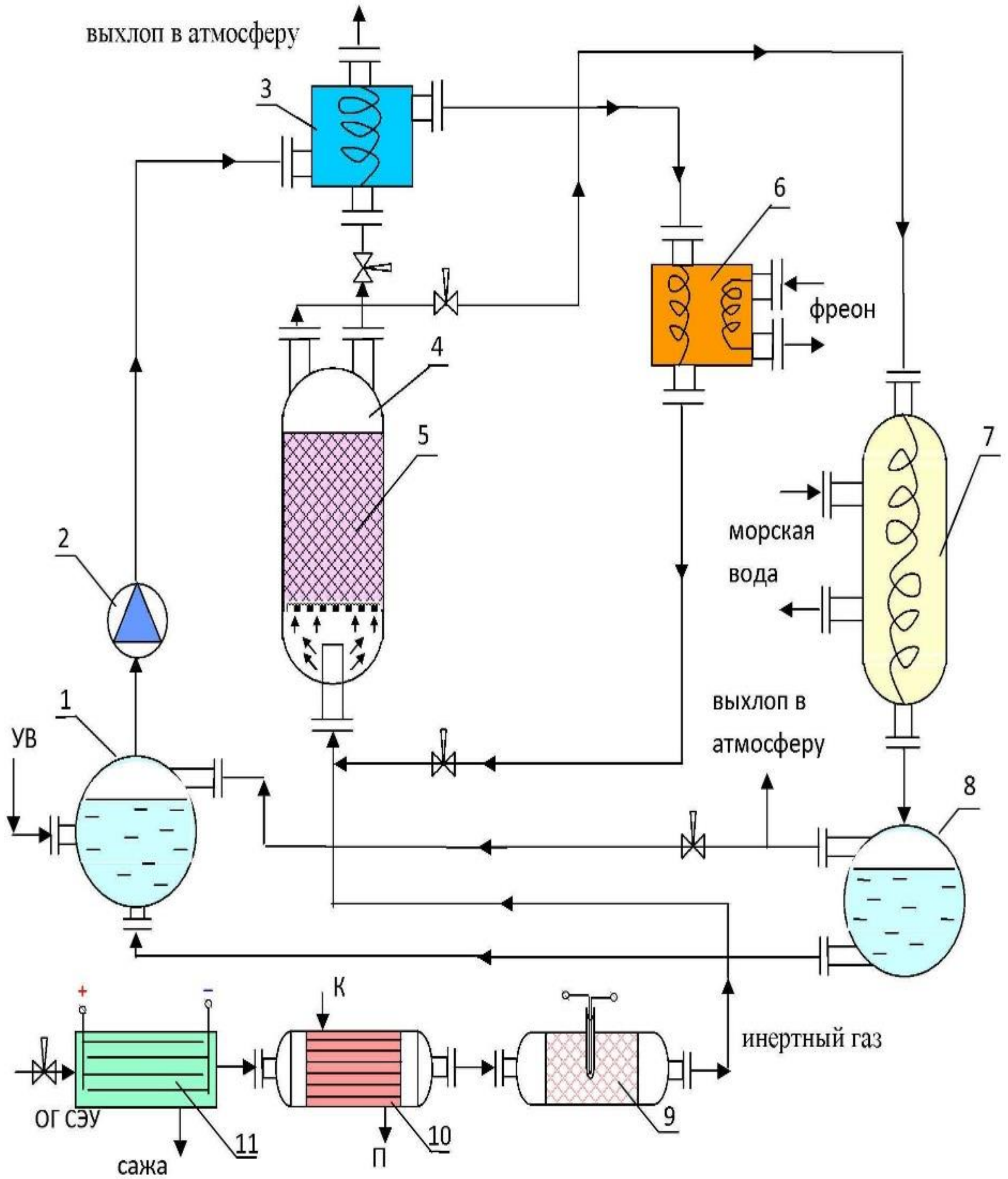
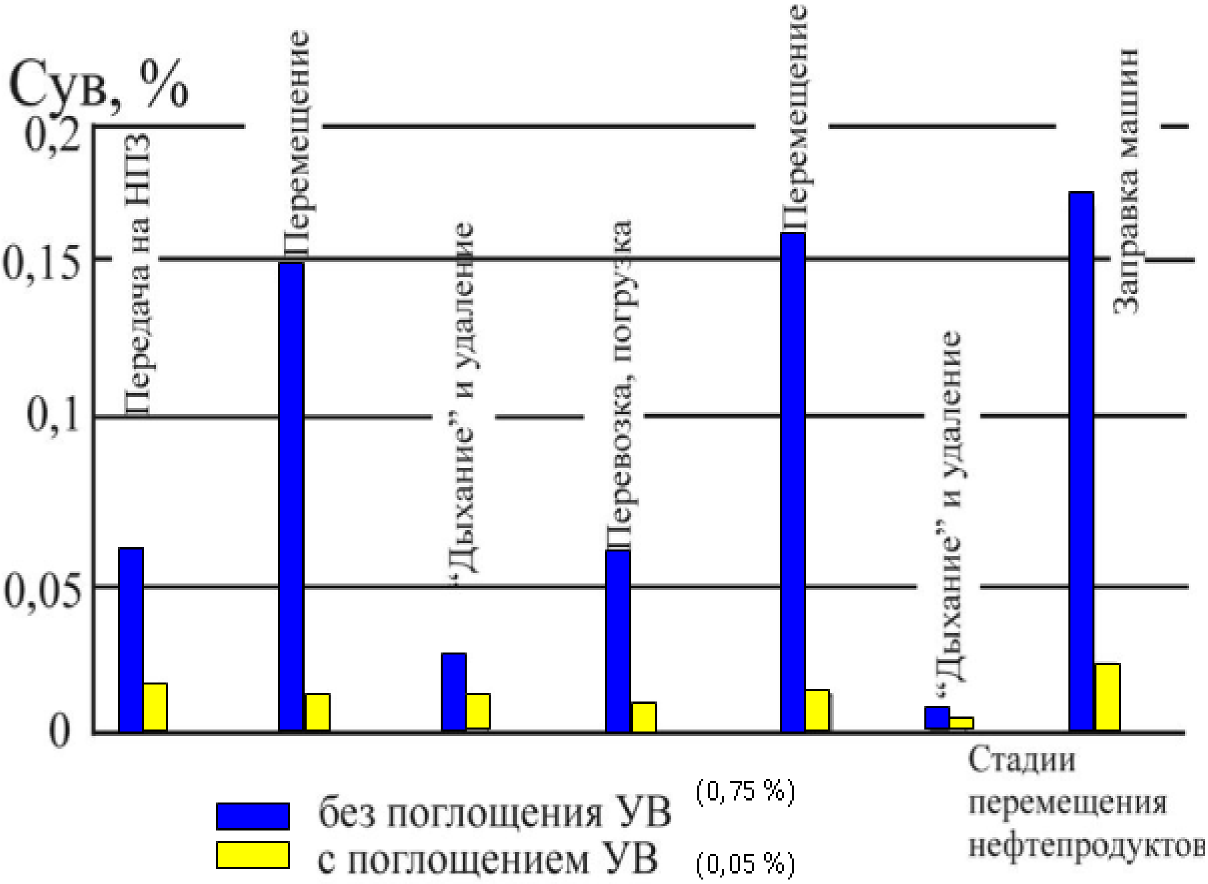


Figure 4 - Technological scheme of adsorption of hydrocarbon vapors.

Equipment explication: 1-tank; 2- compressor; 3,6,10-recuperative heat exchanger; 4-adsorber; 5-adsorbent; 7-condenser refrigerator; 8-separator; 9-reactor; 11-filter.

Legend: П-steam; К-condensate; ОГ - waste gases; СЭУ-ship power plant; УВ- hydrocarbons.

When hydrocarbons are released into the atmospheric basin, economic damage and environmental-economic damage are caused, which is clearly illustrated in Figure 5.



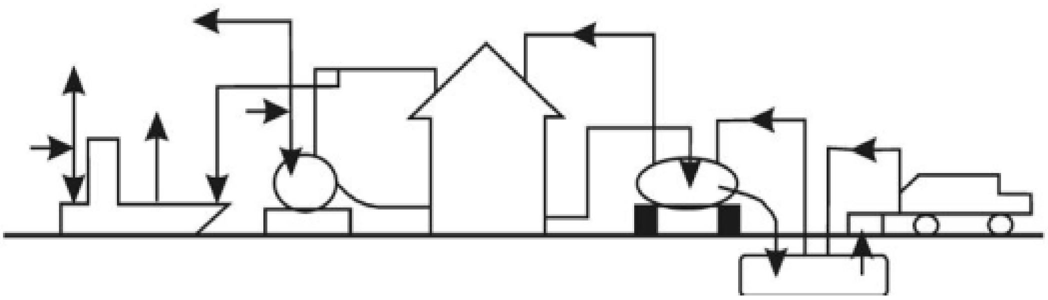


Figure 5 - Utilization of hydrocarbon vapors during storage and transportation of petroleum products

Three versions of the technology for absorption of hydrocarbons from gas-air environ have been developed for "large" and "small" breathing of reservoirs. The choice of this or that technology depends on the volume of supplied oil and light oil products, design features and hardware design of a particular facility. The technologies have been tested in pilot industrial conditions. The technology of hydrocarbon absorption by the adsorption method has been developed (Fig. 6).

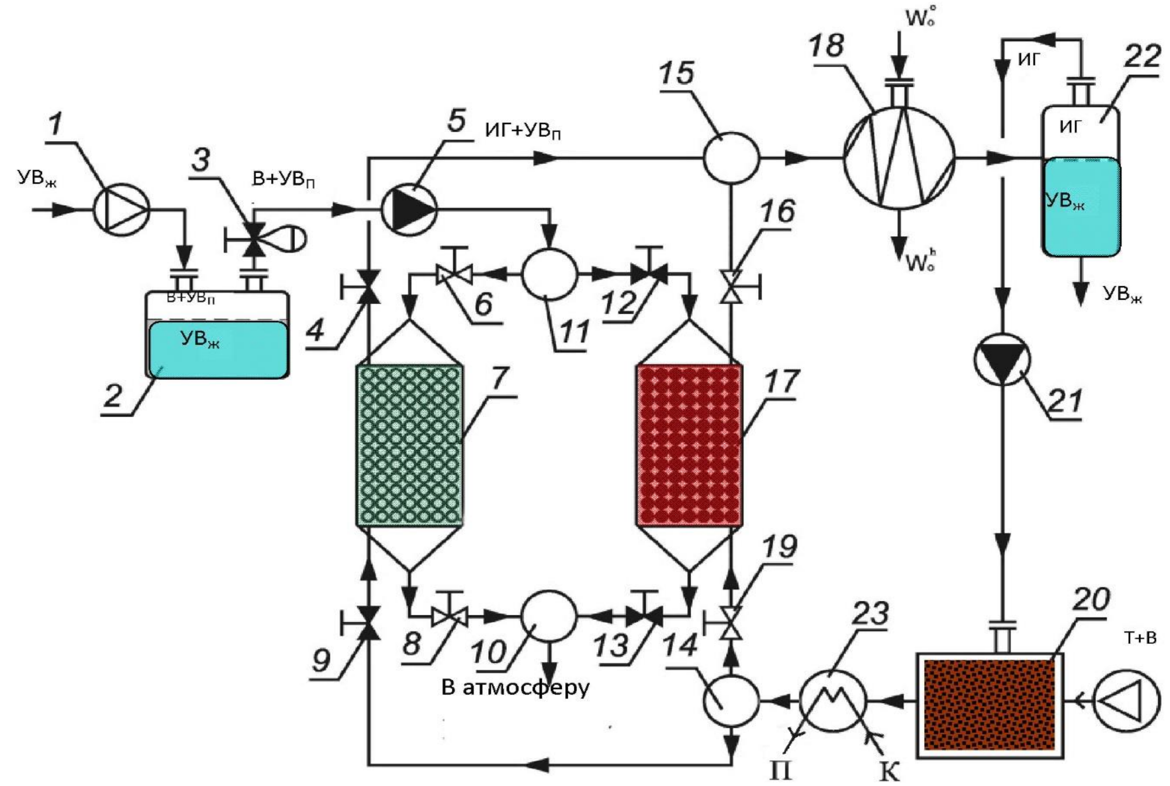


Figure 6 - Schematic diagram of vapor recovery hydrocarbons [2, 14].

Equipment explication: 1 - pump; 2 - storage; 3 - reducer; 4, 9, 12, 13 - shut-off valves in the closed position; 5, 21 - compressor; 6, 8, 16, 19 - shut-off valves in open position; 7 - adsorber in absorption mode; 10, 11, 14, 15 - mixer-distributor; 17 - adsorber in the regeneration mode; 18 - condenser refrigerator; 20 - installation for inert gas production; 22 - separator; 23 - heat exchanger;

Legend: $УВ_ж$ - liquid hydrocarbons; $УВ_п$ - hydrocarbons in vapor phase; В- air; ИГ - inert gas; Т - fuel; Woo, Woh - respectively, cooling and heated water;

ИА - the initial adsorbent for absorption of hydrocarbons. НА - adsorbent saturated with HC_v; П - steam; К - condensate.

The technology includes the following main stages:

1. Collection and compression of the air-hydrocarbon mixture outgoing from the storage pos. 2
2. Adsorption of hydrocarbons vapors in the adsorber pos. 7.
3. Regeneration of the saturated adsorbent in the adsorber pos. 17 in an inert gas stream at increased temperature.
4. Cooling of hydrocarbons vapors in the refrigerator-condenser pos. 18
5. Separation of inert gas and liquid hydrocarbons in the separator pos. 22.
6. Return of inert gas after separator pos. 22 in the regeneration cycle.
7. Return of gasoline (liquid hydrocarbons) to the storage pos. 2.

The developed hydrocarbon absorption scheme is resource-saving and environmentally safety. This is especially becoming relevant at the present time, since the world's reserves of non-renewable hydrocarbon raw materials are intensively depleted and limited, dangerous for the environment, biosphere and humans.

Hydrocarbon vapors released from storage 2 are absorbed by the adsorbent in adsorber 7. The saturated hydrocarbon adsorbent is regenerated in adsorber 17 in an inert gas (IG) flow at a temperature of 65–80 ºС. As a result of the regeneration, hydrocarbon separated from the adsorber 17 are condensed upon cooling in the refrigerator-condenser 18, collected in the separator 22, in which they are separated into liquid B and gaseous IG phases. Further on, the adsorber 7 operates in the regeneration mode, and the adsorber 17 - in the hydrocarbon absorption mode.

Characteristics of the refueling process

When 1 m^3 of air is displaced, 1 kg of gasoline vapor is lost. Let's take the storage volume of 1000 m^3, then the gasoline losses during one refueling-delivery will be:

1 kg • 1000 • 2 = 2000 kg = 2 tons of gasoline.

With 100 refueling gasoline losses will be: 1.19 · 200000 / 0.743 = 320 323 USD,

where 0.743 is the density of gasoline, kg / l;

1.19 - the price of 1 liter of AI-95 gasoline, USD.

Economic efficiency from the implementation of a gasoline vapor recovery unit with an absorption rate of 95% is: 320323 × 0.95 = 304307 USD.

The technology for capturing hydrocarbon vapors complies with the Kyoto Protocol on 1997 (Japan), Paris Agreement COP-21 (2015) on the reduction of emissions of “greenhouse” gas components.

The payback period for a hydrocarbon vapor recovery unit is 2–5 years, depending on the unit's productivity and the price of oil on the world market.

The field of application of the development are: small, medium, large gas stations, terminals, railway, water, sea, river, automobile, air transport.

The technology of the process of capturing hydrocarbon vapors is protected by patents of Ukraine.

Conclusions.

Thus, as a result of the work performed, the following conclusions can be drawn:

1. Losses of hydrocarbons during transportation and storage of petroleum products have two negative vectors - economic and environmental.

2. Research on the absorption of hydrocarbon vapors under static and dynamic conditions has been carried out.

3. Resource-saving technologies for absorption of hydrocarbons from vapor-air environ have been developed.

4. Experimental-industrial tests of the hydrocarbon absorption process were carried out.

5. The technical and economic considerations of the expediency of introducing the technology for the utilization of hydrocarbon vapors have been developed.

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