2. Курс адміністративного права України: підручник / В. К. Колпаков, О. В. Кузьменко, І. Д, Пастух, В. Д. Сущенко [та ін.]. 2-ге. вид., перероб. і допов. К. : Юрінком Інтер, 2013. С. 24.

3. Даньшина Ю. Теоретичні засади надання адміністративних послуг в Україні. Державне управління та місцеве самоврядування. Збірник наукових праць. 2011. № 3(10). URL: http://www.dridu.dp.ua/vidavnictvo/2011/2011_03(10) (дата звернення: 20.02.2023).

3. Загальне адміністративне право: підручник. / за заг. ред. І. С. Гриценка. Київ : Юрінком Інтер, 2016. 568 с.

4. Авер'янов В. Б. Спрямованість на забезпечення прав громадян – демократична сутність влади. Виконавча влада і адміністративне право / за заг. ред. В. Б Авер'янова. К., 2002. 150 с.

5. Піляй А. М. Ґенеза та сучасний стан адміністративної функції держави. Кваліфікаційна наукова праця на правах рукопису: 12.00.07. К., 2020. 216 с.

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ANALYSIS OF THE FEASIBILITY OF USING MODERN REFRIGERANTS ON SHIP COOLING SYSTEMS

At the present time, the process of climate changes on our planet is playing an increasingly important role. And this trend is increasing from year to year. Among the influencing factors, the greenhouse effect, i.e. the increase in the amount of greenhouse gasses in the atmosphere, in particular CO_2, and the destruction of the ozone layer of our planet are considered the most important [1].

Taking into account the fact that the use of refrigerating plants, both in industry and in the everyday life of human society, is constantly growing, and as working fluids in such plants are usually used substances specified by the above-mentioned international documents, in the process of choosing a working fluid – a refrigerant, it is necessary to comprehensively evaluate its impact on the Earth's atmosphere.

On the other side, it is necessary to pay attention to the energy efficiency of the refrigeration plant, taking into account its purpose and operating conditions, depending on the selected refrigerant [2].

The best values of a sufficiently large number of indicators can create antagonistic conditions when choosing a specific refrigerant. This fact requires the designer to search for an optimal solution that will meet all existing requirements to the greatest extent [2].

One of the ways to solve the problem would be to obtain a comprehensive evaluation criterion for choosing a refrigerant, which would take into account both its influence on processes in the atmosphere and the fulfillment of technological requirements [3].

The decrease in the amount of ozone in the Earth's atmosphere, as is known, is a consequence of the introduction of halogens, which are a component of chlorofluorocarbons, which include a large part of traditional refrigerants. This property of these substances is evaluated by the *ODP (Ozone Depletion Potential)* coefficient, which varies from 1 (100%) for *R12*, the most common in the last century, to 0 for most refrigerants used today (*R507, R404A*, etc.) [1].

To assess the impact on the greenhouse effect, the factor *GWP (Global Warming Potential)* is used. The *GWP=1* for *R11* was taken as a base value. The *GWP* value can vary widely from one to three thousand for R404a, which is also used in some ship refrigeration units.

To finally take into account the effect of the operation of the refrigeration plant on the greenhouse effect, it is currently recommended to use the *TEWI (Total Equivalent Warming Impact)* indicator. This indicator accounts for not only the effect of the refrigerant, but also for the effect of the amount of energy used by the refrigeration plant during the entire period of operation.

$$TEWI = GWP \cdot M + \alpha \cdot B,$$

where M is the total mass of the refrigerant released into the atmosphere during operation, kg; α is the amount of carbon dioxide (CO_2) entering the atmosphere during the production of 1 kW hour of energy, kg/kW hour; B is total electricity consumption of the refrigerating unit during the entire period of operation, kW.

It is not difficult to conclude that the above indicators and their comparison under the conditions of use of different refrigerants do not allow the assessment the efficiency of operation of the refrigeration unit and its specific impact on the environment.

For a clearer comparison of the properties of refrigerants, it was chosen the ones that are quite common in transport refrigeration units: R 407C, R 134a, R 410A, R507. The refrigerant R22 was chosen as the base for comparison.

When choosing parameters that allow you to evaluate the efficiency of the use of a refrigeration unit, first of all, you should pay attention to the coefficient of performance, which evaluates the ratio of the heat removed from the object to the power consumption for the implementation of the process (ε) [3].

From a constructive point of view, the important indicators are the condensing (P_C) and evaporating (P_{Ev}) pressures for the given technological conditions of operation, the compressor volumetric coefficient λ.

It is possible to estimate power consumption by the values of theoretical capacity N_a, indicator capacity N_i, effective N_e capacity and shaft power of the electric motor $N_{m.e.}$ Considering cases of use of refrigerants selected for comparison under standard conditions, i.e.: evaporation temperature t_0 = –15 °C; condensing temperature t_C = +30 °C; t_{in} = –5 °C; subcooling temperature t_{sub} = +25 °C, it is possible to obtain the corresponding dependencies characterizing the relationships and changes of the parameters selected for comparison.

The obtained dependencies allow for a preliminary assessment of the energy feasibility of using the refrigerants selected for consideration, depending on the technological conditions.

Thus, at relatively high evaporation temperatures (close to 0 °C), R134a has noticeable advantages, however, when the temperature drops to –25 °C, R507 becomes more desirable, due to the highest value of the coefficient of performance.

The ratio of operational parameters under standard conditions has a somewhat different character, which is illustrated by the histogram shown in Figure 1.

Taking into account only operational indicators in the process of choosing a refrigerant for use in a specific refrigeration plant is not enough for a final conclusion. Condensation pressure (P_C), evaporation pressure (P_{Ev}) and their ratio are important both during design and in cases of the need to replace the refrigerant.

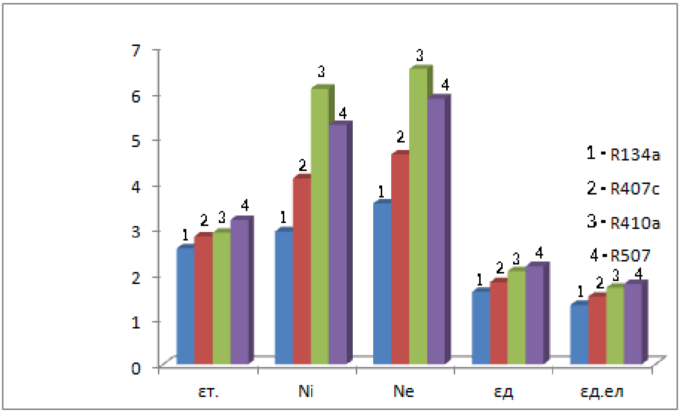

Fig. 1. Comparison of operational indicators under standard conditions

Based on the above, it is possible to come to the conclusion that when choosing a refrigerant for use in a specific refrigeration plant under specific conditions, it is advisable to take into account at least three groups of factors:

– impact on the Earth's atmosphere;
– energy efficiency of the refrigeration plant;
– structural requirements for elements of the refrigeration unit.

As the fourth factor, it is desirable to take into account the cost of operating the refrigeration equipment, including the price of the refrigerant to be selected.

At the present time, there is no comprehensive indicator that would allow making a decision taking into account the mentioned factors, although it is possible to claim that its presence significantly simplifies the formation of tasks, both at the design and operation stages, as well as in case of the need for modernization. As indicators that determine the environmental friendliness of refrigerants, it is advisable to offer such indicators as *GWP* and *ODP*, the values of which are known for almost all refrigerants and are not related to energy efficiency and design factors.

The energy efficiency of the refrigeration unit can be estimated by the value of the coefficient of performance ε and the consumption of electric power N_{me} (the use of effective power N_e is possible, which will not fundamentally affect the conclusions obtained).

The design features of the refrigeration equipment as a whole can be estimated by the values of the evaporation pressure P_{Ev}, condensation pressure P_C and compressor supply coefficient λ.

When determining the complex indicator, one should take into account the possibility of cases when *ODP=0*, as well as sufficiently large values of *GWP*. In this regard, it is suggested to use $ODP_C = ODP+1$ and $GWP_C = GWP \cdot 10^{-3}$ when calculating the numerical value of the complex indicator.

Thus, to determine the comprehensive indicator of the expediency of using a refrigerant, it is possible to propose the following dependence:

$$K = \frac{\varepsilon \cdot P_{Ev} \cdot \lambda}{GWP_C \cdot ODP_C \cdot P_C \cdot N_e}.$$

Analyzing the value of the complex indicator when changing the required evaporation temperature, it is possible to draw preliminary conclusions about the feasibility of using one or another refrigerant depending on the technological requirements.

It is possible to use the method of evaluating the expediency of choosing a refrigerant using a complex indicator for cases of comparison of any group of available refrigerants, moreover, if necessary, it is possible to add additional indicators to the proposed dependence, for example, specific cooling capacity and price index.

Bibliography:

1. Іщенко В. М., Брайковська Н. С., Щербіна Ю. В. Методичні підходи до ефективного використання альтернативних холодильних агентів в холодильному обладнанні рефрижераторного рухомого складу. *Збірник наукових праць ДУПТ. Серія «Транспортні системи і технології».* Вип. 33. Т. 1, 2019. С. 202–212.

2. Іщенко В. М., Щербіна Ю. В., Осьмак В. Є., Горлушко Ю. В. Взаємозамінність альтернативних холодоагентів в системах кондиціонування повітря пасажирських вагонів. *Вісник східноукраїнського національного університету ім. Володимира Даля.* 2021. Вип. 2. С. 96–100.

3. Галян І. С., Козьміних М. А. Аналіз ефективності застосування сучасних холодильних агентів в транспортних холодильних установках. *НТЗ Суднові енергетичні установки.* 2019. Вип. 38. С. 54–68.