Method for Refrigerators Efficiency Increasing

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Abstract. The article shows that in condenser-type domestic refrigerators the condenser is one of the main parts of the refrigeration system where the refrigerant (freon) compressed by the compressor condenses from the vapor state to the liquid. The condensation process is an exothermic process, i.e., the condensation of steam generates thermal energy. The condenser is heated and, to perform the refrigeration cycle, this heat must be removed from the refrigeration system. Heat removal is carried out in household refrigerators due to the natural circulation of ambient air around the condenser, which must have a significant heat-reflecting area to do this. Although the condenser is most often made of thin tubes that occupy almost the entire rear wall of the refrigerator, the cooling process is not effective enough. A new method for the condenser cooling is proposed which will improve the efficiency of the condenser and household refrigerators as a whole.

1. Introduction
From the analysis of the operation of a number of household refrigerators of compression type, it can be noted that at the inlet to the condenser the refrigerant has a temperature of 30-40 degrees above ambient temperature, and at the outlet it should be only 10-15 degrees above ambient temperature. Therefore, for an efficient operation of the refrigeration system, it is important that the condenser is well cooled. For these purposes, sometimes a knot is supplemented with a fan that avoids overheating of the condenser and helps it to work more productively. This is especially true when using large refrigerating units. In household refrigerators, in spite of the ineffectiveness of the method of cooling the condenser due to the natural circulation of the ambient air, it still remains practically uncontested. At the same time, it should be noted that the search for a rational design of capacitors of domestic refrigerators, which intensively divert heat and methods of their forced cooling during operation, is not stopping.

The urgency of the problem of the cooling efficiency of the condenser of domestic refrigerators is dictated by the massiveness of this product in the population and the significant energy consumption, as well as the existing energy-saving possibilities in the operation of this type of equipment [1–7].

For example, methods for cooling a condenser using humidification or blowing air, and also jointly moisturizing and blowing air are known [8-11], which increases the intensity of the condenser. However, these methods are complex in terms of constructive design and create inconveniences in the operation of household refrigerators, since not only the condenser of the refrigerator but also the environment of the room is exposed, and the air cooling by the fan generates increased noise and power consumption. The scientific and practical significance of this problem is reflected in a number of publications [12-16].
Similar problems have been solved in recent years at the Russian State University of Tourism and Service, where structural and design versions of units and mechanisms of refrigeration equipment are studied in the branch problem research laboratory "Household refrigerators and heat pumps", the tasks of optimizing their functional parameters and the thermodynamic cycles different refrigerants.

2. Statement of the problem

As a current stage of work, a group of laboratory researchers proposed a high-tech method for cooling condensers of household refrigerators of compression type. An application for the invention "A way to improve the energy efficiency of refrigerators" was filed.

The purpose of the proposed method is to increase the efficiency of the operation of refrigerators by selecting a portion of the thermal energy from the condenser surface by heat transfer to multilayer film thermocouples and converting it into electrical energy. At the same time, the received electrical energy is accumulated and utilized to ensure a more comfortable operation of the refrigerator itself. For example, to ensure the short-term operation of the refrigerator in the event of an emergency power failure or to ensure the operation of additional devices that increase the comfort level of the refrigerator.

The theoretical basis for the proposed method for cooling the capacitor was the Seebeck effect, which consists in the fact that an electromotive force is generated during the operation of a thermoelectric transducer due to a temperature difference between hot and cold junctions. The magnitude of the electromotive force of a thermocouple battery depends on the number of thermocouples that are connected in series or in combination (series-parallel). This kind of thermoelectric converters is environmentally friendly, simple in design, technologically in production, which allows to automate the production of thermobatter with any number of thermocouples.

Multilayer film thermocouples are used to convert thermal energy into electrical [17]. In this case, they are attached to the surface of the condenser by means of a foil plate. In the second case, the foil plate is a substrate on which multilayer film thermocouples are fabricated by the thin-film deposition method [18].

The content of the technical proposal is presented in the form of a schematic diagram (figure 1).

![Figure 1. Schematic diagram of the refrigeration unit with a device for recycling the heat of the condenser.](image-url)

The method is implemented as follows. A foil plate 6, for example an aluminum foil, is mounted on the capacitor 2. The method of fastening the plate 6 can be different, for example, using clamps (not shown in the figure). Placing the plate 6 on the condenser 2 does not prevent the free approach for the
diagnosis and care of the elements of the refrigeration unit: the motor-compressor 1, the evaporator 3, the capillary tube 4 and the desiccant 5.

On the foil plate 6, as on the base surface, a multilayer film thermocouple 7 is fixed. The thermocouple 7 can also be made directly on the plate 6 by using known techniques for depositing thin films on a substrate [18]. In this case, the foil plate 6 will serve as such a substrate. The electricity received from the film thermocouple 7 by means of commutation buses is fed into the energy store - a battery with adapters and a controller to control the distribution of the received electricity (not shown in the figure). As noted above, the thermocouple 7 can be made according to the patent [17], as a thermoelectric transducer is a battery.

3. Results and discussion

To determine the possible temperatures on the surface of the condenser of domestic refrigerators of compression type, depending on the operating conditions (environmental parameters, temperature load, etc.), the thermodynamics of the working process of the refrigeration unit was simulated using the cloud calculation technique [19].

According to the simulation results in particular, it is found that when the load is increased by the products of the refrigerator, the temperature of the dry refrigerant vapor on the saturation line in the evaporator decreases and the temperature of the refrigerant vapor after the compressor and, accordingly, in the condenser increases, which must be taken into account when choosing the film thermocouple parameters for cooling the condenser. In addition, there is a significant reduction in the theoretical energy conversion factor of the refrigerator (COP).

The thermodynamic cycle of the working process of the refrigerator is shown in Figure 2.

![Figure 2. PH-diagram of the thermodynamic cycle of an ideal refrigeration unit.](image-url)
For normal loading of the refrigerator by the products, the value of the dry steam temperature on the saturation line in the evaporator is \( t = -5 \, ^\circ C \), the temperature of the refrigerant vapor in the condenser is \( t = 41.41 \, ^\circ C \), and COP = 7.822. The thermodynamics of other types of refrigeration units, of course, will have some differences.

The next stage of the research of household refrigeration equipment will be connected with the modeling of the compressor operation using the developed experimental stand “The bench for the study of the parameters of the operation of domestic heat pumps”, to which the application for the invention is also submitted. The realizability and practical significance of the stand structure were evaluated by a number of analogues. Including the stand, which works for real production [20].

4. Conclusions
1. The technical result of the research is to provide a perspective for improving the design of household refrigerators in order to improve efficiency and a higher level of comfort.
2. For the efficient operation of the refrigeration system of household refrigerators, it is important that the condenser is well cooled. To this end, a high-tech method for cooling a capacitor is proposed.
3. The task of the proposed method is to increase the efficiency of the operation of refrigerators by selecting a portion of the thermal energy from the condenser surface by heat transfer to multilayer film thermocouples and converting it into electrical energy.
4. This type of thermoelectric converters is environmentally friendly, simple in design, technologically in production, which allows them to be used in household appliances.
5. The conducted studies, having practical significance (two applications for invention were filed), can give a certain economic effect when using the proposed new method of cooling the condenser units in domestic refrigeration technology.

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