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О МЕТОДЕ ДИАГНОСТИРОВАНИЯ УТЕЧКИ ХОЛОДИЛЬНОГО АГЕНТА ИЗ ХОЛОДИЛЬНОЙ СИСТЕМЫ БЫТОВОГО ХОЛОДИЛЬНИКА

Представлены теоретические основы и результаты экспериментальных исследований распределения температуры на поверхности испарителя и в объёме морозильной камеры бытового холодильного прибора (БХП) ДХ-239 работающего на изобутане. Обоснованы, место расположения датчика и параметры настройки прибора автоматики, сигнализирующего об утечке хладагента из холодильной системы БХП, работающем при различных положениях терморегулятора, в интервале температуры окружающей среды от16 до 43 °С.
Ключевые слова: *Бытовой холодильник – Испаритель – Изобутан – Доза заправки – Температура окружающей среды.*

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ПРО МЕТОДИ ДІАГНОСТУВАННЯ ВИТОКУ ХОЛОДИЛЬНОГО АГЕНТА З ХОЛОДИЛЬНОЇ СИСТЕМИ ПОБУТОВОГО ХОЛОДИЛЬНИКА

Представлені теоретичні основи та результати експериментальних досліджень розподілу температури на поверхні випарника і в об'ємі морозильної камери побутового холодильного приладу (ПХП) ДХ- 239 який працює на ізобутані. Обґрунтовано, місце розташування датчика і параметри настройки приладу автоматики, що сигналізує про витік холодоагенту з холодильної системи ПХП, працюючому при різних положеннях терморегулятора, в інтервалі температури навколишнього середовища від 16 до 43 °С.
Ключові слова: *Побутовий холодильник – Випарник – Ізобутан – Доза заправки – Температура навколишнього середовища.*

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USING METHOD ABOUT DIAGNOSING OF LEAKAGE OF THE REFRIGERATING AGENT FROM REFRIGERATING SYSTEM OF THE HOUSEHOLD REFRIGERATOR

In work demonstrated theoretical bases and results of experiment about distribution of temperature on a surface of the evaporator and in volume of the freezing chamber of the household DH-239 refrigerator (HR) working at isobutane are presented. The action principle, the location of the sensor and settings of the device of automatic equipment signaling about leakage of a coolant from the HR refrigerating system, working are proved at various ustavka of a temperature regulator, in the range of ambient temperature from 16 up to 43 degrees celsius.
Keywords: *The household refrigerator – the Evaporator – Izobutan – a filling Dose – Ambient temperature.*

I INTRODUCTION

The world practice knows several ways of cooling agent leak ascertainment from refrigeration system. One of them is analysis of thermodynamic process changing in the system, to wit: by decrease of pressure of working medium in the discharge line and (or) increase of working time factor (WTF) of compressor [1]. But change of the mentioned thermodynamic characteristics can't be reliable indicator of cooling agent leaks from household refrigerator compressor system as increase of WTF can also be connected to worsening of transmission from condenser top. There is a method of cooling agent leaks ascertainment from refrigerating plants by reacting to trace contaminants in the atmospheric air in the places of their placement [2] with special portable devices – leak detectors.

None of the mentioned methods is acceptable for cooling agent leaks diagnosis in the household refrigerating equipment because of impossibility of its current prophylaxis service, including the use of portable leak detectors and gas analyzers, and absence of small recording devices, adapted to the construction of small refrigerating equipment.

The indirect confirmation of isobutane leak from compressor system of the working refrigerator can be decrease of isobutane boiling point and as a result decrease of temperature on the top of evaporator in freezing section of refrigerator.

The aim of this work is substantiation of bases of cooling agent microleaks diagnosis from the refrigerating system of small refrigerating equipment and development of the device, signaling about leak in different positions of thermoregulator and ambient temperature.

For the achievement of this aim it's necessary to solve the following problems: to get data about temperature change on the top of evaporator depending on the dose of refrigerating system filling and ambient temperature; substantiate the position of device sensor of automatics HRD, signaling about the leak.

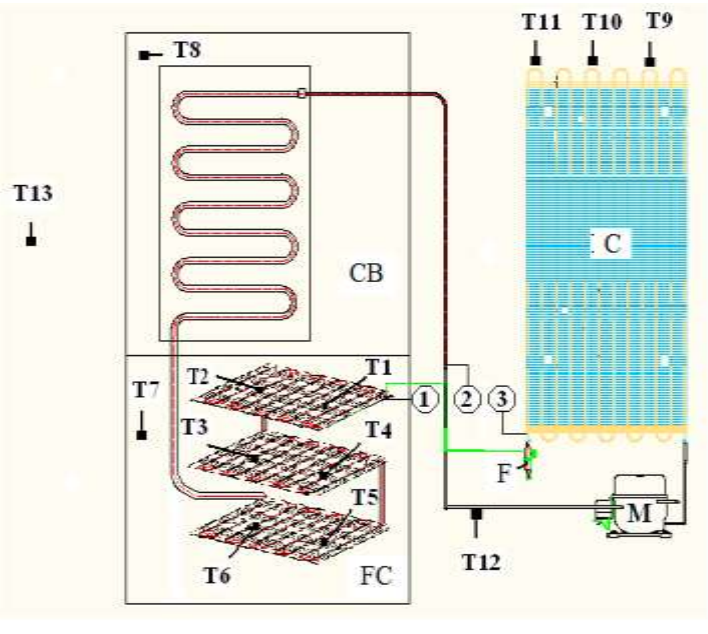
II EXPERIMENTAL STUDIES

For the solving of these problems we realized the researches with the use of experimental stand, the scheme of which is shown on the picture 1.

The stand is created on the basis of the household refrigerator DH-239 [3], filled with cooling agent R600a (optimal mass of filling, fixed by the producing plant, - 38g). On the lines of absorption and discharge of refrigerator compressor system there are devices for measuring of pressure and temperature.

During experimental researches the following was recorded: the temperature on the top of evaporator and condenser, the temperature of absorbed cooling agent fume directly before compressor; the pressure in the entrance to the evaporator block and while going out, in the discharge line; electric energy consumption (supply meter is used).

The researches were done in the conditions of fixed outdoor temperature value 25ºC, with thermoregulator settings, corresponding to minimal, average and maximal cooling. During researches isobutane was taken away from the refrigerating system HRD in 1,5g. After each letting out of isobutane from the refrigerating system the temperature and pressure were fixed, the daily electric energy consumption was determined, WTF was calculated. Taking isobutane out of the system was made with a help of the graduate during the stopping of the refrigerating device.



Picture 1 *– Scheme of temperature sensors position (thermopair) on the experimental stand: T1 – T6 – on the top of evaporator, T7 – in the volume of freezing camera, T8 – in the volume of freezing section, T9 – T11 – on the top of condenser, T12 – on the top of absorbing conduit, T13 – ambient HRD temperature. 1-2 – pressure-and-vacuum gage, 3 – manometer. CB – chill box, FK – freezer compartment, C – condenser, M – compressor, F – filter dehydrator.*

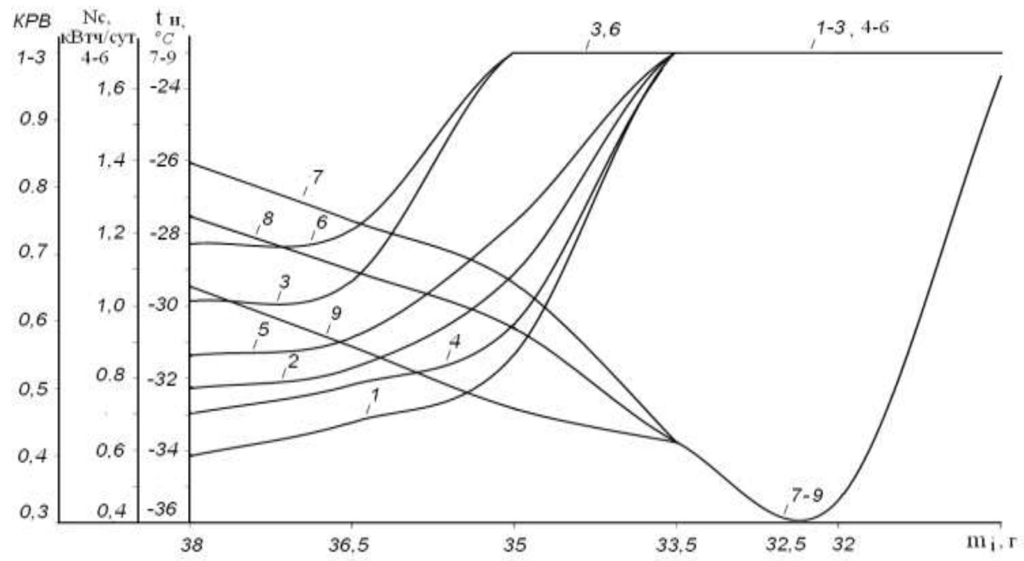
During the experiment we determined the zone of the freezer compartment evaporator, the top temperature of which corresponds to the temperature and pressure of isobutane on the saturation line. This zone for the model HRD DH-239 is situated between the sixth and the tenth screws of freezer compartment evaporator [4,5]. The sensitive element of the device of refrigerator automatics signaling about cooling agent leak can be placed on the shown zone of the evaporator (place of thermopair position T3).

Picture 2 shows diagram of dependence from izobutan mass in refrigerating system of the refrigerator DH-239of temperature on the surface of evaporator (7-9), WTF (1-3), diurnal power consumption (4-6) under minimal, average and maximal settings of thermoregulator.

According to the picture 2 small leakages of cooling agent from the refrigerating system of HRD influence on heat-and-power engineering characteristics of household refrigerator. The temperature fall on the surface of evaporator which is recorded can be the indicator of leakage of R-600a izobutan cooling agent from the refrigerating system of working household refrigerator.

When moving away from 3,0 to 4,5g. of izobutan from the compressor system the linearity of temperature fall t_u falls to – 33,8 °C. Its further fall in connection with decrease of izobutan mass in the compressor system does not depend from the thermoregulator setting now. This dose of filling can be considered as critical as starting from it the working time factor of refrigerating machine becomes equal to one under any settings of thermoregulator (diagrams 1, 2, 3).

Absence of compressor disconnection from the electric net (WTF = 1) is a diagnostic indication of abnormal work of HRD. Compressor starts to work in this way when there is leakage of 4,5 g of izobutan from the system. This mass of izobutan can be enough for appearance of its combustible concentration in the refrigerating box [1]. Diurnal power consumption increases in proportion to increase of WTF. Moving away 3g of izobutan from the compressor system under maximal thermoregulator setting is characterized by unceasing work regime of compressor (WTF = 1) and power consumption 1,7 kilowatt-hour/day. With decrease of filling dose to 32,5 g the temperature on the surface of evaporator falls to – 35,9 °C. However during further moving away of izobutan it begins to increase linearly: reaches value – 23,7 °C under residual mass of cooling agent 30,5g.



Picture 2 *– Diagrams of dependence from izobutan mass (m_i) in compressor system of HRD Nord 239 of temperature on the surface of evaporator t_u (7-9), WTF (1-3), diurnal power consumption N_c (4-6) under minimal, average and maximal settings of thermoregulator (ambient temperature is 25°C).*

According to the research data when increasing filling dose of cooling agent the temperature in the freezer falls, accordingly: at 2,4 °C under moving away 1,5g of izobutan; at 3 °C under moving away 3,0g; at 4,3 °C under moving away 4,5g. Such temperature fall is not desirable as its values become lower than declared passport values. WTF and power consumption increase sharply. Regime of disconnection absence from the electric net (WTF = 1) is set under the filling dose of izobutan 35,0g and maximal set of thermoregulator. Moving away more than 4,5g of izobutan from the system causes exceeding of temperature in refrigerating box and freezer in comparison with the passport values.

Thus, small leakages of cooling agent from the refrigerating system of household refrigerator influence its thermodynamic characteristics in connection with discrepancy of filling dose to the characteristics of structure components of refrigerator (compressor, condenser, evaporator, hydraulic hookups) and essential change of thermodynamic characteristics of working cycles of its compressor system.

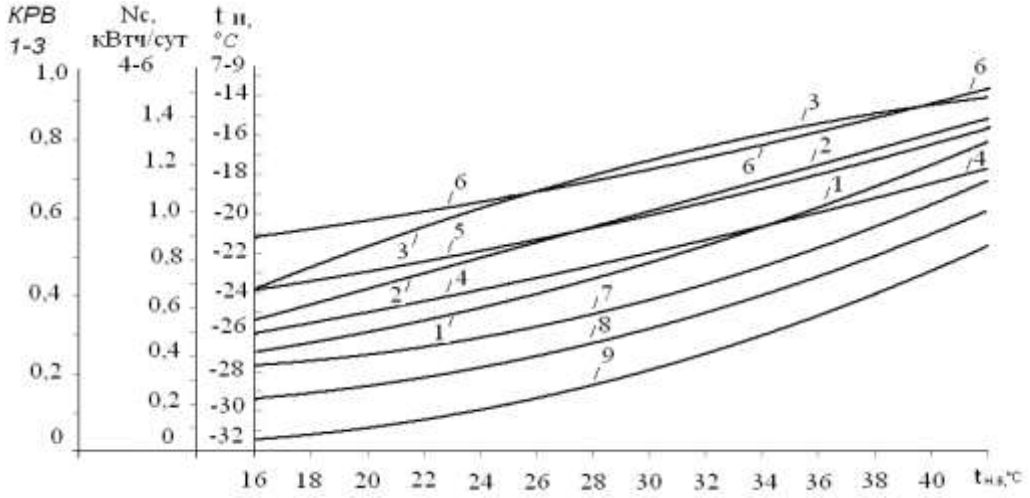
However, heat-and-power engineering characteristics of working household refrigerator also depend on the ambient temperature. Apparently, this circumstance must be taken into consideration while developing method of diagnosis of leakages of cooling agent from the refrigerating system of refrigerator according to change of its thermodynamic characteristics.

Researches were being fulfilled under fixed values of temperature of outside air: 16, 25, 32, 38, 43°C under the setting of thermoregulator corresponding to minimal, average and maximal cooling.

On the basis of experimental data the diagrams in Picture 3 are built which show dependence of WTF (1-3), diurnal power consumption (4-6), the temperature on the surface of evaporator (7-9) from the ambient temperature.

According to the data of the picture 3, the change of temperature conditions of environment influences essentially the thermodynamic characteristics of household refrigerator.

Worsening of heat-and-power engineering and thermal characteristics of working test-bench refrigerator in connection with increase of ambient temperature is conditioned by increase of heat leakages to its refrigerating box, worsening of air interchange processes in the compressor-condensing section, as a result of which the temperature of cooling agent condensation increases which causes the increase of temperature of its boiling in the evaporator. The lowest temperature on the surface of evaporator - 31,35°C is recorded under the ambient temperature + 16°C, under the set of thermoregulator to maximal cooling – before stopping cyclically working compressor, its highest value – 12,13 °C is recorded under the ambient temperature + 43 °C, under setting of thermoregulator to minimal cooling – before the compressor starts to work.



Picture 3 *– Diagrams of dependence of numerical values of WTF (1-3), diurnal power consumption N_c (4-6), temperature on the surface of evaporator t_u (7-9) from the ambient temperature under the settings of thermoregulator to cooling, accordingly, minimal, average, maximal.*

III CONCLUSION

Thus, device reacting to leakage of cooling agent from the compressor system of working household refrigerator according to temperature fall on the surface of evaporator must be adjusted in accordance with diagram dependences in the pic. 2 and pic. 3. The initial parameter is the value of outside air temperature which, depending on the setting of thermoregulator, determines the predictable temperature on the surface of evaporator ($t_и$). Temperature fall on the surface of evaporator at 1,0…1,5 °C is a signal for disconnection of refrigerator form the electric net, switching on light and sound signalization. Change of ambient temperature causes reconfiguration of device to another predictable value of temperature on the surface of evaporator.

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