III Всероссийская научная конференция с международным участием
«Наука, технологии, общество: Экологический инжиниринг в интересах устойчивого развития территорий» (НТО-III) при поддержке Краевого фонда науки

6 (2022)

УДК 62-529

EDN CEBMKE

Автоматическое определение причины брака холодильника при его обнаружении в ходе приёмо-сдаточных испытаний

Д.А. Шуринова[1,2,*], А.В. Мурыгин[1]

[1]Сибирский государственный университет науки и технологий имени академика М.Ф. Решетнёва, Красноярск, 660037, Россия
[2]Красноярский завод холодильников ОАО КЗХ «Бирюса», Красноярск, 660123, Россия

*E-mail: dasha.shurinova@yandex.ru

Аннотация. В данной работе представлена идея перехода производства на новую энергосберегающую методику приёмо-сдаточных испытаний и автоматической классификации причины брака холодильников. Авторами описана идея использования характерных особенностей графика потребляемой активной мощности прибора с целью определения причины брака. Рассмотрены основные причины брака холодильного агрегата: уменьшенная доза фреона, ошибочно заправленная в холодильный агрегат, отсутствие проходимости фреона (например, засорение или запай стыка капилярной трубки), ошибочная установка компрессора большей мощности, рассчитанной на холодильник другой модели, невозможность запуска компрессора (неисправность компрессора), описаны отличительные черты графиков в каждом случае. Представлено сравнение графиков неисправных холодильников с исправным, теплоэнергетические характеристики которого соответствуют стандарту. Проанализированы особенности каждого типа отклонения от нормы, сделан вывод о выраженной характерности у каждого типа, что даёт основание сделать вывод о возможности проведения автоматической классификации графиков потребления активной мощности посредством использования нейронной сети.

Ключевые слова: приёмо-сдаточные испытания холодильников, график потребления активной мощности, автоматическая классификация, нейронные сети.

Automatic determination of the reason of the incorrect refrigerator's work when it is detected during the acceptance tests

D.A. Shurinova[1,2,*] , A.V. Murygin[1]

[1]Siberian State University of Science and Technology named after Academician M.F. Reshetnev, Krasnoyarsk, 660037, Russia
[2]Krasnoyarsk plant of refrigerators OJSC KZH Biryusa, Krasnoyarsk, 660123, Russia

*E-mail: dasha.shurinova@yandex.ru

Abstract. This article presents the idea of transitioning production to a new energy saving method of acceptance tests and automatic classification of the cause of defective refrigerators. The authors describe the idea of using the characteristic features of the graph of the consumed active power of the device in order to determine the cause of the incorrect work. The main reasons for the rejection of the refrigeration unit are considered: a reduced dose of freon, erroneously charged into the refrigeration unit, lack of freon permeability (for example, clogging or sealing of the joint of the capillary tube), erroneous installation of a compressor of higher power, designed for a refrigerator of another model, the impossibility of starting the compressor (compressor malfunction), the distinctive features of the graphs in each case are described. A comparison of graphs of defective refrigerators with a serviceable one, the heat and power characteristics of which correspond to the standard is presented. The features of each type of deviation from the norm are analyzed, a conclusion is made about the pronounced specificity of each type, which gives reason to conclude that it is possible to automatically classify active power consumption graphs through the use of a neural network.

Keywords: acceptance testing of refrigerators, active power consumption graph, automatic classification, neural networks.

1. Introduction

Each refrigerator that leaves the manufacturing plant must have certain heat and power characteristics stated in GOST [1]. To confirm this compliance each product undergoes acceptance tests. The methodology for conducting such tests is not regulated, the manufacturer can either choose one of the existing ones [2] or develop it independently based on the fact, that refrigeration appliances that have been tested according to this method must comply with the requirements of the standard. The authors of the article developed a similar methodology [3], which consists of measuring the active power consumed by the device in the first 10 minutes after connecting to the electric net [3]. Based on the obtained data on the active power consumption of the compressor, it is possible to determine whether the device meets the standard or not. According to the same data, it is also possible to determine the cause of the incorrect work of the device.

2. Statement of the problem (Goal of the study)

It is necessary to detect regularities in the graphs of the active power consumption of the compressor during acceptance tests which are typical for certain types of device defects and also consider the possibility of using a neural network for this purpose.

3. Research methods and materials

As a source material it is necessary to develop a base of initial data for analysis, in our case it is the graphs of active power consumption of devices that have not passed the test and are marked like incorrectly working ones. We will also need data of the identified reasons for the rejection, which after the discovery of the malfunction were discovered by the operator during a more detailed study of the cause of the discrepancy. The most common reasons for an incorrect work are:

- a reduced dose of freon, erroneously charged into the refrigeration unit (figure 2)
- erroneous installation of a compressor of greater power which was designed for a refrigerator of another model (figure 4)
- inability to start the compressor (compressor malfunction) (figure 5)

A graph of a correctly working refrigerator is shown on figure 1.

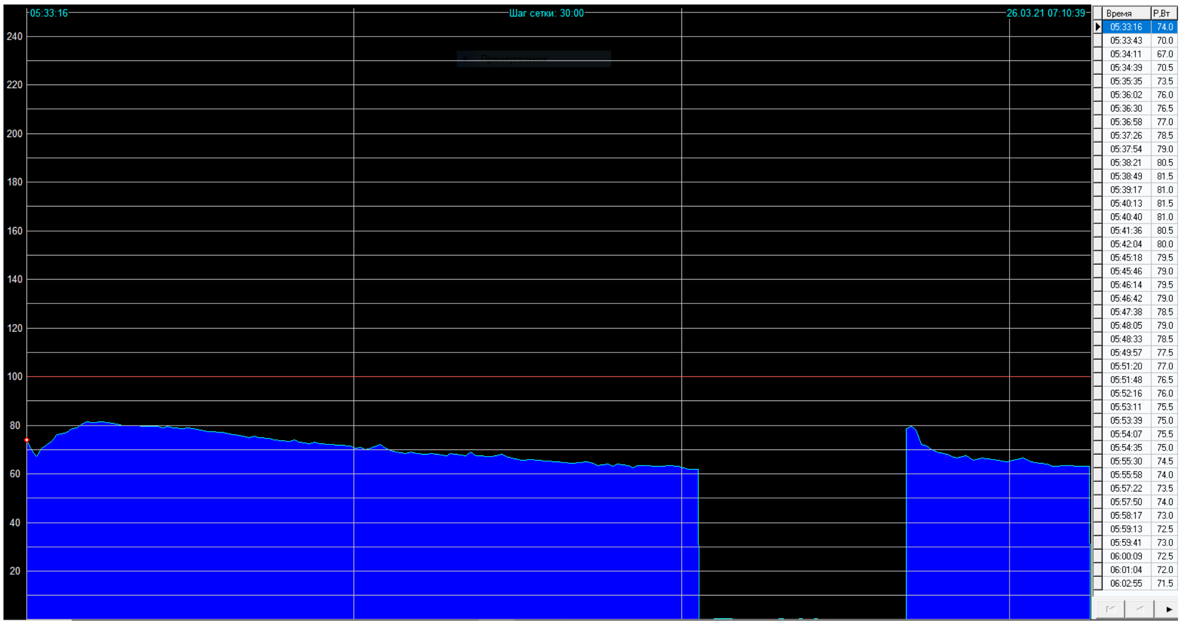

Figure 1. An example of a graph of active power consumption of a suitable refrigerator. Axis x-W, y-min. Grid step 30 min.

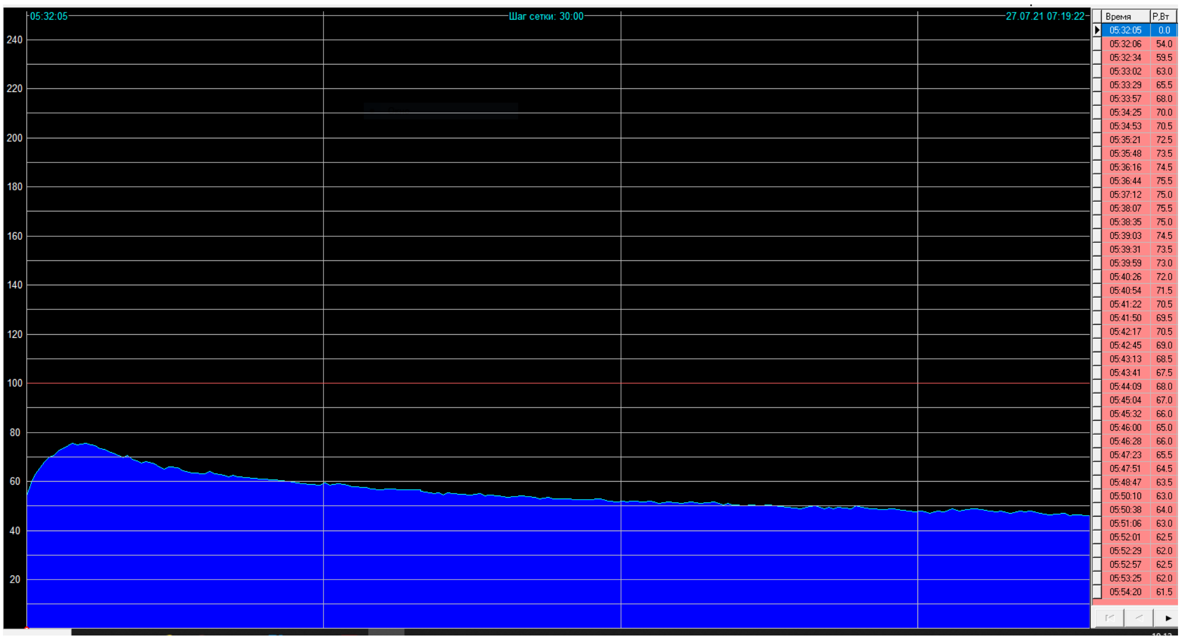

Figure 2. An example of a graph of active power consumption of a defective refrigerator. The reason for the incorrect work: a reduced dose of freon, erroneously charged into the refrigeration unit. Axis x-W, y-min. Grid step 30 min.

The graph shows that the power consumption remains lower by 8-12 percent over the working time of the compressor. Due to the insufficient amount of freon the gas flow through the compressor decreased and as a result the power consumed by the compressor electric motor decreased.

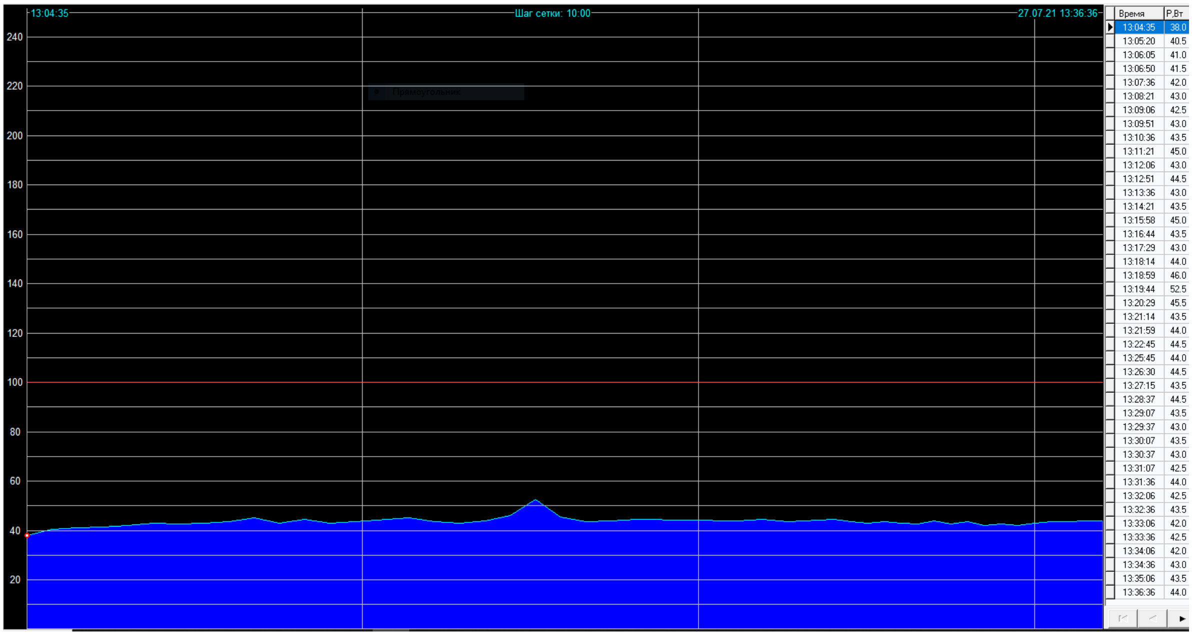

Figure 3. An example of a graph of active power consumption of a defective refrigerator. The reason of the incorrect work: the lack of permeability of freon through the capillary tube. Axis x-W, y-min. Grid step 10 min.

The graph shows that the power consumption remains low over time as there is no freon flow through the compressor. The capillary tube is soldered or clogged (solder or specks from the silica gel from the cyalite cartridge got inside the capillary tube and blocked (muffled) it). The compressor pumped all the freon from the evaporator to the condenser (in about 20 seconds, we will not see this on the graph because the data is displayed with a time interval of 60 seconds). Freon remains in the condenser under high pressure. The outlet at the condenser tube is "plugged" by a clogged capillary tube, and the inlet is blocked by the compressor outlet valve. The compressor does not move freon through the refrigeration unit, the engine runs at low load (almost idle).

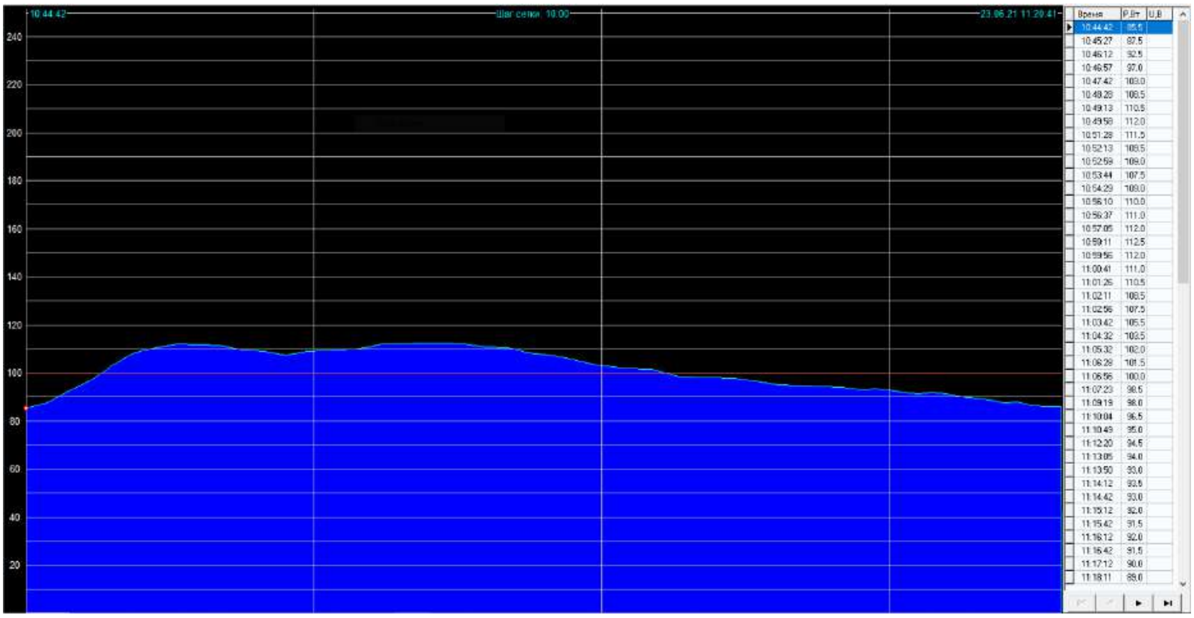

Figure 4. An example of a graph of active power consumption of a defective refrigerator. The reason of the incorrect work: erroneous installation of a compressor from a different refrigerator model (higher power). Axis x-W, y-min. Grid step 10 min.

The type of compressor installed on the refrigerator depends on the type of refrigerator [4-6]. If the compressor was selected incorrectly the curve of the power consumption graph goes beyond the permissible deviation from the norm.

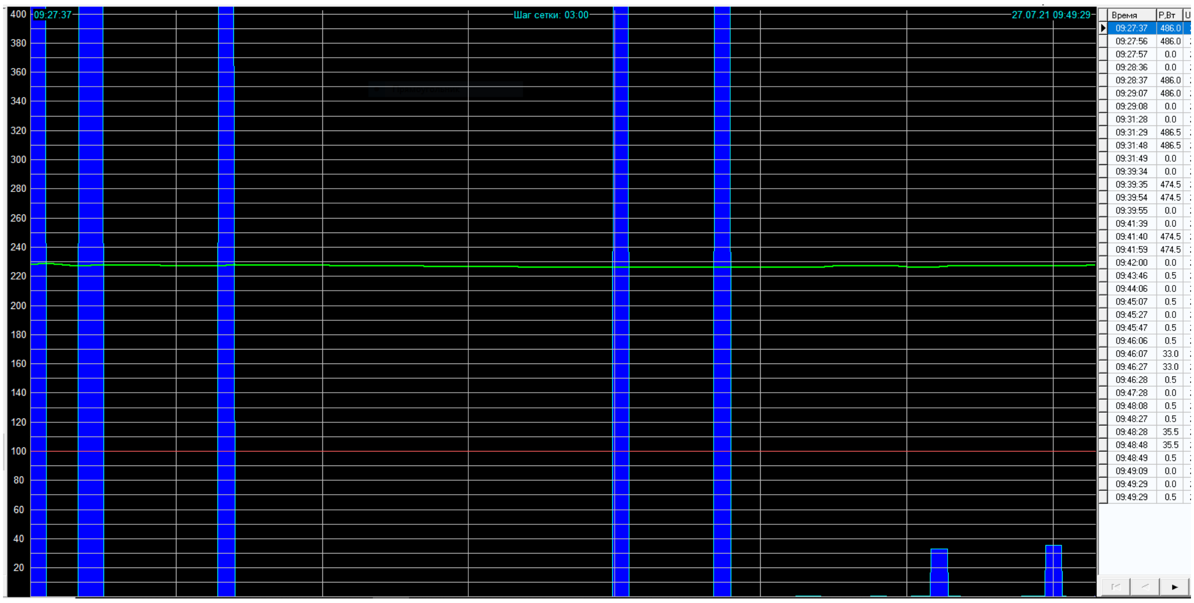

Figure 5. An example of a graph of active power consumption of a defective refrigerator. The reason of the incorrect work: compressor defect due to jamming of the piston group (non-start). Axis x-W, y-min. Grid step 3 min.

On the graph, we see short intervals of high power consumption because the compressor motor does not start to rotate, which causes a large current to flow through the compressor motor winding. Due to the high current, the motor windings heat up to 150 degrees. Compressor thermal protection trips in this case. As the compressor is disconnected from the power supply until it cools down. On the graph, we see several unsuccessful attempts of the system to start the compressor.

4. Results

When comparing the given graphs of the active power of the compressor of defective refrigerators with the graphs of refrigerators recognized as correctly working ones their difference becomes obvious both with the norm and with each other.

To automatically determine the cause of the incorrect work you can use both a convolutional neural network working with images (since we have determined that external differences in the graphs are quite significant) and a simpler type of neural network based on the gradient descent method. For the second method, it is rational to use power data in the form of a table (shown on the right in each of the graphs).

5. Conclusion

When conducting the studies described above the authors made the conclusions that there are characteristic features in the active power consumption graphs for each of the most common types of deviations from the normal operation of refrigeration units. This makes it possible to further automatically classify the types of defects by automatically analyzing active power consumption graphs using a neural network (it is possible to develop it ourselves via Python using special libraries).

Acknowledgment

Gratitude is expressed to the Krasnoyarsk plant of refrigerators "Biryusa" [7]. For cooperation in the launch of a large-scale project for the transition to a new method of acceptance testing and funding of related experiments and researches.

References

1. GOST 16317-87. Pribory holodilnue elektricheskie bitovye. Obshie tehnicheskie ysloviya. State Standard 16317-87: Household electrical refrigeration appliances. General technical conditions (with amendments N 1, 2, 3). Moscow, Standartinform Publ., 1987. – 22 p.
2. Shurinova, D.A. Review of existing methods for controlling the heat and power characteristics of household refrigerators. / D.A. Shurinova, A.N. Kovalenko, A.V. Murygin, A.G. Suvorov // Mechanics of the XXI century. – 2020. – Vol. 19. – P. 164-171.
3. Shurinova, D.A. Development of a new methodology for acceptance testing of refrigeration appliances / D.A. Shurinova // Magazine "Computer Science, Telecommunications and Management". – 2021. – Vol. 14(4). – P. 84.
4. Zafar, S. Design and construction of a pressure wave cryogenic refrigerator / S. Zafar, A. Gupta, T.K. Nandi // Refrigeration science and technology. – 2019. – Vol. 15. – P.421-427. DOI: 10.18462/iir.cryo.2019.0090
5. Mukhamadiev, A.A. Information measuring system for monitoring the parameters of a household refrigerator compressor / A.A. Mukhamadiev // Electrical and information complexes and systems. – 2017. – T. 13. – Vol. 4. – P. 109-114.
6. Torelló, À. Law of heat exchange in caloric regenerators / À. Torelló, E. Defay // International Journal of Refrigeration. – 2021. – Vol. 127. – P. 174-179.
7. ОАО КЗХ «Бирюса» (In Rus): Available at: https://biryusa.ru/ (accessed 10.09.2022).