13| Оригинални научни рад
Research paper
doi 10.7251/STP1813203T ISSN 2566-4484

ANALIZA EFIKASNOSTI RADA SISTEMA HLADNJAČE FRATELLO TRADE AD BANJA LUKA

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Abstract: Cilj ovog rada je pokazati važnost izbora rashladnog sredstva u rashladnim postrojenjima, te dobiti uvid na koji način taj izbor utiče na sistem u pogledu efikasnosti i ekonomičnosti sistema. Analiza uticaja rashladnog sredstva na efikasnost i ekonomičnost sistema urađena je na primjeru hladnjače za skladištenje smrznute ribe Fratello Trade AD, BanjaLuka. Pomoću parametara ovog sistema ispitano je da li bi postrojenje bilo efikasnije iekonomičnije da se odabralo drugo rashladno sredstvo. Postojeće rashladno sredstvo koje koristi ovo postrojenje je R-404A. Segmenti u pogledu efikasnosti i ekonomičnosti koji se ispituju su koeficijent performansi postrojenja i godišnja potrošnja električne energije, odnosno troškovi za istu. Koeficijent performansi postrojenja daje uvid u to koliko se za jedan kW unesene električne energije u sistem dobije kW hlađenja. Što je veći ovaj koeficijent, time je sistem efikasniji. Na nivou proračuna godišnje potrošnje električne energije dobija se uvid sa kojim rashladnim sredstvom sistem daje najmanje novčane troškove. U radu je dat sam postupak analize baziran na izboru rashladnog sredstva.

Ključne riječi: rashladno sredstvo, rashladno postojenje, efikasnost, ekonomičnost.

EFFICIENCY ANALYSIS OF THE REFRIGERATION SYSTEM IN FRATELLO TRADE AD BANJA LUKA

Abstract: The aim of this paper is to show the importance of choosing a refrigerant in cooling plants, and to provide an insight into how this choice influences the system in terms of its efficiency and cost-effectiveness. The analysis of the influence of a refrigerant on the system's efficiency and cost-effectiveness was done on an example of a refrigerator storing frozen fish in Fratello Trade AD, Banja Luka. Using the parameters of this system, this study examines whether the plant would be more efficient and economical if another refrigerant was chosen. The existing refrigerant used by this plant is R-404A. Segments that are examined in terms of efficiency and economy include the performance coefficient of the plant and the annual consumption of electricity, that is, their respective costs. The performance coefficient of the plant gives an insight about the correspondence between kW of input electricity and kW of cooling power generated in the system. The higher this coefficient, the more efficient the system is. The calculation of annual energy consumption helps to determine which refrigerantis most cost-effective. The paper shows the analysis based on the choice of the refrigerant.

Key words: refrigerant, cooling system, efficient, economical.

1. INTRODUCTION

Refrigeration facilities are intended for the preparation, processing and storage of light-duty foodstuffs using low temperatures. The foods are cooled or refrigerated in refrigerators and stored in fresh or frozen state under conditions of well-defined temperature and relative humidity regimes. The need for freezing and storing foodstuffs today is very high. With the increase of food standards, i.e. the need for a better quality and cleanliness of food, as well as the need for energy savings, design and construction of refrigerators should be conceived according to the latest standards, laws, professional rules and technologies offered on the market. Also, in order for food to be as good as possible, attention must be paid to all food handling procedures. One of the more important ways to conserve food is cooling. The basic modes of refrigerationare cooling and freezing. In the case of cooling, the air temperature in the refrigerator isabove 0 [°C], while the freezing temperature is lower. The division of thermal treatment methods based on the temperature of crystallization (freezing) of water is specific from the aspect of the treated product, since it should be kept in mind that the water contained in the plant material does not freeze at0 [°C] because it is a colloidal solution thatfreezes at temperatures lower than 0 [°C]. Refrigeration is mainly applied in the case where fresh fruit, vegetables and other food products are to be preserved as long as possible. In addition, semi-finished and ready-made food products are preserved in this way. By cooling, all types of fruit is preserved, a large number of varieties of fresh vegetables, as well as flowers, medicinal herbs, mushrooms, forest fruits, etc. In addition to agricultural products, refrigerators are important for the storage of semi-finished products and ready-made food products, such as fruit and vegetable porridges, aromas, cakes, etc. The air temperature rangesfrom 1 [°C] to 12 [°C]. Various agricultural products are stored at different air temperatures in refrigerators. For example, some types of fruit can only be held for a few days, and some for around ten months. Freezing is used for a wide variety of agricultural and food products. Air temperature in the freezer compartment can start at degrees below zero and reach - 70 [°C]. It depends on the type of food and from the planned storage time. Fruit must be prepared before freezing in accordance with the ultimate purpose of frozen fruits, or whether it is intended for export or distribution to the domestic market. When freezing vegetables, thermal treatments are applied in order to inactivate enzymes. Therefore, before the freezing process itself, it is necessary to take the necessary measures that a particular freeze product requires. When storing foodstuffs in the cooling chambers, the most commonly used warehouse racks are made of hot-dip galvanized steel structures, in which the so-called euro pallets of standard dimensions are used. Depending on the type of product, packaging can be different. The most common are plastic or wooden crates, boxes or cartons.

1.1. BASIC ELEMENTS OF REFRIGERATORS, BASIC SCHEME AND OPERATING PRINCIPLE

The task of acooling device is to cool certain bodies or objects below the ambient temperature and to keepthem at that temperature. Refrigeration devices are based on the natural propertyof gas. It implies that the gas is heated when it is compressed (it passes from the gas to the liquid state) and cools when it expands (it passes from the liquid to the gaseous aggregate state). These changes in aggregate states are achieved by a series of different elements in the cooling system, the most important of which are a compressor, a condenser, an evaporator and an expansion valve. There are a number of supporting elements, such as filters, receivers, various flow control valves, temperature and pressure regulators, and so on.

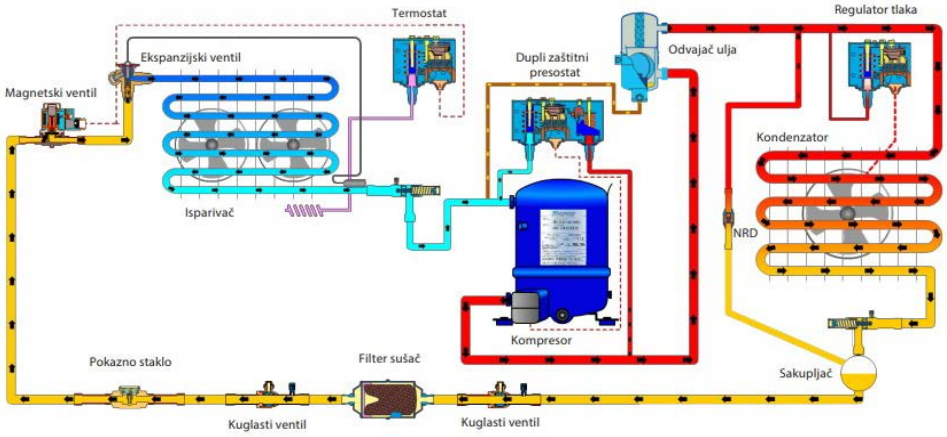


Figure 1. The basic scheme of a refrigerator [5]

1.2. REFRIGERATION

Refrigerants are materialsthat are found in cooling devices. They pass the heat cycle and serve as heat exchangers. The thermodynamic efficiency of aplant depends on the choice of arefrigerant. The most commonly used refrigerant systems are freons. Freons are actually a collective name for several types of gases used in cooling systems. Halogenated carbonate refrigerants include a group of artificial, synthetic refrigerants. The trade name for them is freons or F – gases.

Table 1 Groups of halogenated carbonate refrigerants [8]

Code	Chemical name	Characteristics	Composition
CFC	Chlorofluorocarbon	Fully halogenated saturated hydrocarbon derivatives	Mostly methane and ethane, e.g.
HCFC	Chlorofluorocarbon	Partially halogenated saturated hydrocarbon derivatives	Contains hydrogen and chlorine, e.g.
HFC	Hydrofluorocarbon	Partially halogenated saturated hydrocarbon derivatives	Contains hydrogen, does not contain chlorine, e.g. R-407c

Refrigeration plants that work with CFC and HCFC refrigerants have a good cooling coefficient because these agents have more favorable properties. They are primarily non-flammable, non-toxic, and compatible with the materials from which the plants are built. However, due to their properties to damage the ozone layer, CFCs were discontinued from use in 2010. According to the Montreal Protocol, these refrigerants will be used in Bosnia and Herzegovina by 2015, but as long as there are technically functional installations that use them, they will be replaced over time according to the rules of the Montreal Protocol and the Vienna Convention.

1.3. ENERGY EFFICIENCY OF REFRIGERATION PLANTS

The term energy efficiency is most often encountered with two possible meanings, one of which refers to devices, the other to measures and behaviors. An energy efficient device is one that has a high degree of beneficial effect, i.e. small losses when transforming one type of energy into another. Refrigeration machines and appliances in industry consume a significant share of energy in industry, according to some estimates, up to 20 %. Cooling energy costs in some industries, such as food industry, reach up to 70 % of the total energy costs. This is why when considering potential energy efficiency measures, attention must be paid to cooling devices.

In cooling devices, the cooling fluid evaporatesat a low temperature evaporator, by cooling the environment in which the evaporator is located, e.g. cooling chamber. The compressor increases the temperature and pressure of the refrigerant, which is then cooled and condensed in the condenser, heating the environment in which the condenser is located. In some cases this heat can also be used for heating. In the liquid state, the coolant is compressed by the pressure and temperature by the pressure relief valve, and the fluid re-enters the evaporator in the liquid state.

Cooling devices use electricity so their components i.e. a compressor and auxiliary equipment can operate. In order to reduce the consumption of cooling energy as much as possible, it is obviously necessary to minimize the difference between evaporation and condensation temperature. The main consumer of electricity in refrigeration units is the compressor that consumes about 65 % of total energy consumption in thesystem. Savings in cooling devices can be basically achieved by efficient device design, as well as their proper use and maintenance.

1.4. MEASURES FOR A MORE EFFICIENT COOLING PLANT

Measures for a more efficient cooling system can be obtained bydesigning devices efficiently, bringing the equipment into the existing state, automating the system, improving insulation, refilling the cooling system, modernizing or replacing the compressor. These measures and what is meant by them are described in more detail in the paragraphs below.

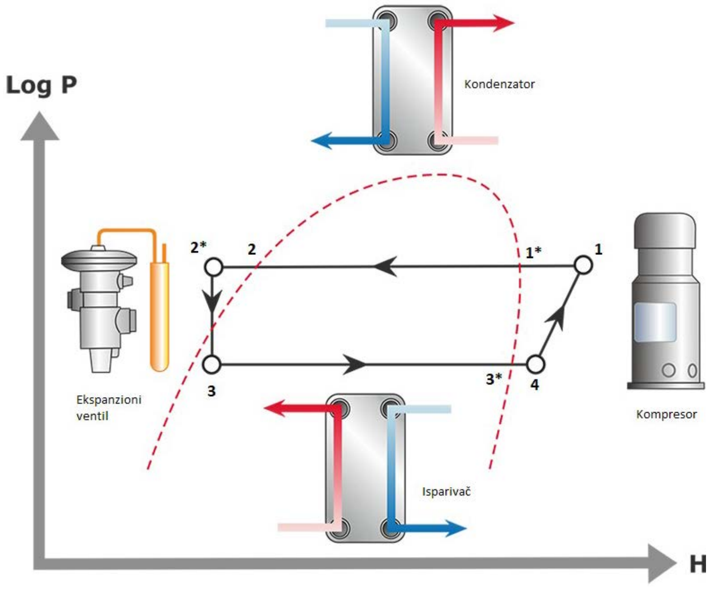


Figure 2. Cooling cycle inp-hdiagram of the workingfluid [14]

The cooling process [Figure 2] consists of evaporation of the working fluid in the evaporator 3-3 *, overheating 3 * -4 controlled by the thermoexpansion valve. Overheating is necessary in order to avoid hydraulic shock inside the compressor, i.e.so that the compressor would not withdraw the liquid phase.

After that, the compressor sucks the overheated steam and compresses it to a higher energy level 4-1. After the compressor, the overheated steam enters the condenser where it cools 1-1 *, condenses 1 * -2 and cools 2-2 *. Refrigeration is carried out so that the throttle valve only receives a liquid phase, as it can not function properly if it receives vapor. The pressure or expansion valve dampens the working fluid 2 * -3 from the condensation pressure to the evaporation pressure. The process is then repeated.

2. ANALYSIS OF REFRIGERATIONIN “FRATELLO TRADE” AD, BANJA LUKA

The “Fratello Trade” AD facility is located in Ramici, Banja Luka.

The structure is made of reinforced concrete, measuring 31.64 × 44 meters, and 7 meters high. The design was carried out in accordance with the requirements for storing frozen fish. The calculation of the plant in 2004 was done by the Soko Mostar company, whose data were used for this paper. The facility consists of three warehouse chambers, packing rooms and manipulative space, as well as office space. The total capacity of the storage chamber is 5700 cubic meters.

The temperature regime in all three chambers is -25 [°C]. Only cooling chambers will be considered as a wholein this paper. The compressor suppresses the overheated steam of the working medium. On the compressor supply line there is a shut-off and non-return valve with the function of closing the flow of the working fluid in one direction, and allowing the flow in the other direction. After passing through the valves, the working fluid goes into the oil separator. Next, the separated oil in the separator with special water goes into the oil collector, and then passes through the oil filter, and ultimately passes through the oil regulator where the lubrication of the compressor will be carried out.

The working fluid, after the oil separator, goes to the condenser, but first passes through the filter as an additional measure for removing possible residual oil particles. As the working fluid enters into the air condenser, its cooling is carried out, and it passes into the liquid phase.

Exiting the condenser, it passes through another filter, then the shut-off valve goes into the receiver. The receiver has a safety valve that serves to monitor the pressure in the receiver; in case of too high pressure, the safety valve would open. On the line, two pressure switches, high and low pressure, are installed before the gas drier, which serves as protection against excessively low suction pressure and excessively high pressure.

The liquid fluid then passes through the filter gas drier, which serves to absorb moisture from the working medium and to filter it. The indicator glass shows the amount of liquid phase. This is followed by a shut-off valve. After the shut-off valve, the liquid agent goes to the evaporator. First, there is an electromagnetic valve which serves to control the flow of the liquid phase of the agent, after which it enters the evaporator through an expansion valve which also regulates the flow of the agent but in the function of the operating temperature at the exit from the evaporator. The working fluid now receives heat in the evaporator from the food in the chamber, that is, cooling occurs in the chamber. After that, leaving the evaporator, all the working fluid was not evaporated, and a mixture of superheated and saturated phases was obtained. This mixture goes into a suction accumulator, where the liquid part of the phase remains, and the overheated portion is sucked in through the suction filter which is further sucked by the compressors, its suction part carrying the shut-off valves. On their suction and pressure parts compressors have pressure regulators that control the pressure on the suction and pressure of the compressor. The cooling cycle is then repeated the same way. The operating principle of chambers 1 and 2 is the same.

2.1. ANALISIS PROCEDURE

The analysis of the efficiency and economy of the plant is based on the type of installed compressor, selected refrigerants, logp-h diagrams of refrigerants, and data taken from the project documentation obtained at the "Fratello Trade" AD Banja Luka cooling plant.

The compressor installed in the system is 6G - 34Y 40 HP, manufactured by Bitzer. It is a semi-hermetic piston compressor. It has six cylinders and is characterized by robust valve construction, high wear resistance of moving parts, and high efficiency of embedded engines that are cooled by suction gas. In addition, a patented oil return system ensures safe operation.

The refrigerants used in the analysis were primarily selected based on the installed compressor, that is, whether the compressor can operate with this refrigerant. The first refrigerant is R-404A with which the existing system works and the characteristics obtained with this refrigerant will serve as the basis and orientation in relation to which the comparison is made. The following refrigerants are selected: R-407C and R-449A.

2.2. PARAMETERS REQUIRED FOR ANALYSIS

Table 2. Parameters required for analysis

Cooling requirements in chambers	94.8[kW]
Compressor cooling capacity	123.2[kW]
Condensation temperature	40 [°C]
Evaporation temperature	-35 [°C]
Temperature of cooling the working medium in the condenser	15 [K]
Temperature of the overheating of the working medium in the evaporator	7 [K]
Refrigerants	R-404A, R-407C, R-449A

The necessary data are entered in the Bitzer and CoolPack software. All data, except refrigerant, remain constant. So considering all input data only the refrigerant changes. In this way, the compresor characteristics are obtainedfor each refrigerant.

The most important characteristics used for further analysis include

- Cooling capacity of compressors and
- Compressor power.

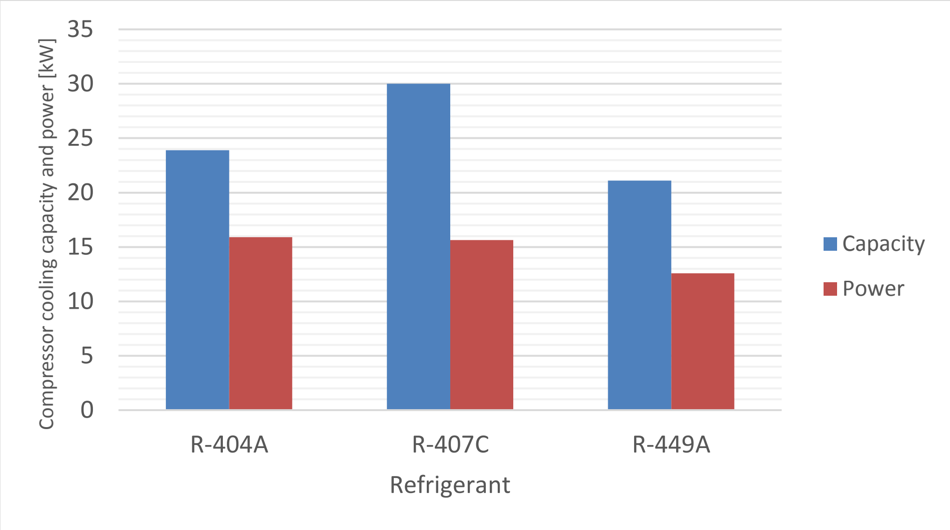
It is used a Bitzer software program; where a working medium was entered in the *Refridirent* field, the evaporation temperature was entered in the *Evaporatind SST* field, the condensation temperature entered in the *Condensind* SDT field, operating temperature of the condenser in *Liq.sub (in condenser)* and the overheating temperature of the working medium in the evaporator entered in the *Suct.gas superheat* field. After entering the parameters, the necessary results were read. From the *Coolond capacity* field, the cooling capacity of the compressor was read, and the power of the compressor from the *Power input* field.

2.3. ANALYSIS OF COOLING CAPACITY AND COMPRESSOR POWER

The obtained results are given in Table 3 and shown graphically in Chart 1. Based on the results, cooling capacity was first analyzed and then compressor power.

Table 3. Cooling capacity and compressor power [16]

Refrigerant	R-404A	R-407C	R-449A
Capacity [kW]	23.9	30.0	21.1
Power [kW]	15.91	15.65	12.57



Graph 1. Compressor capacity and power for the existing and replacement refrigerant

2.4. ANALYSIS OF COMPRESSOR COOLING CAPACITY

Based on the cooling capacity of the compressor, the number of compressors needed to meet the total system requirements of 123.2 [kW] is determined.

1. Using R-404A, five compressors are required, which is identical with the number of compressors in the existing system.
2. Using R-407C, four compressors are required, as the compressor for this refrigerant has a slightly higher cooling capacity.
3. Using R -449A, six compressors are required due to the lower cooling capacity of one compressor.

2.5. COMPRESSOR POWER ANALYSIS

As for the compressor power is concerned, R-404A has the greatest power, R-407C compressor has a slightly lower power, while the lowest power is provided by a compressor using R-449A. If only power is to be analyzed for one compressor, it could be seen that the compressors for R-404A and R-407C refrigerantsare at the very top of their electricity consumption, while the compressor using R-449A has the lowest power consumption. However, taking into account the number of compressors needed to meet the needs of the system, the question is whether therewill remain such a schedule in terms of electricity consumption or it is likely to change. The answer to this will be obtained from a part of the analysis that includes annual electricity consumption.

2.6. SYSTEM EFFICIENCY – COP PERFORMANCE

The system performance coefficient will be tested using the compressor power and chambercooling requirements.

2.7. ANALYSIS OF SYSTEM EFFICIENCY USING COMPRESSOR POWER AND COOLING REQUIREMENTS

Input data needed to obtain the value of system performance coefficient are taken from the first part of the analysis. The required data include the compressor power and the number of compressor. The analysis is done to sum up the power of all compressors, for each refrigerant.

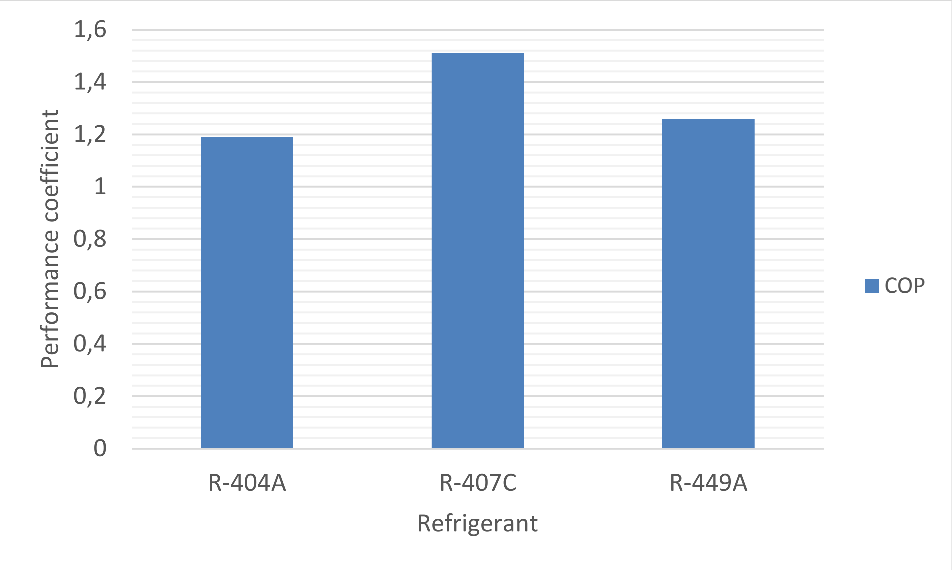
Table 4. Data needed to analyze the system performance coefficient

Refrigerant	R-404A	R-407C	R-449A
Compressor power[kW]	15.91	15.65	12.57
Number of compressors	5	4	6
Total power in the system[kW]	79.55	62.6	75.42

Using the data in Table 4 and cooling requirements in chambers of 94.8 [kW], the values of performance coefficient are obtained. The results are shown in Table 5.

Table 5. System Performance Coefficient – COP

Refrigerant	Qh/P	COP
R-404A	94.8/79.55	1.19
R-407C	94.8/62.6	1.51
R-449A	94.8/75.41	1.26



Graph 2. System Performance Coefficient – COP

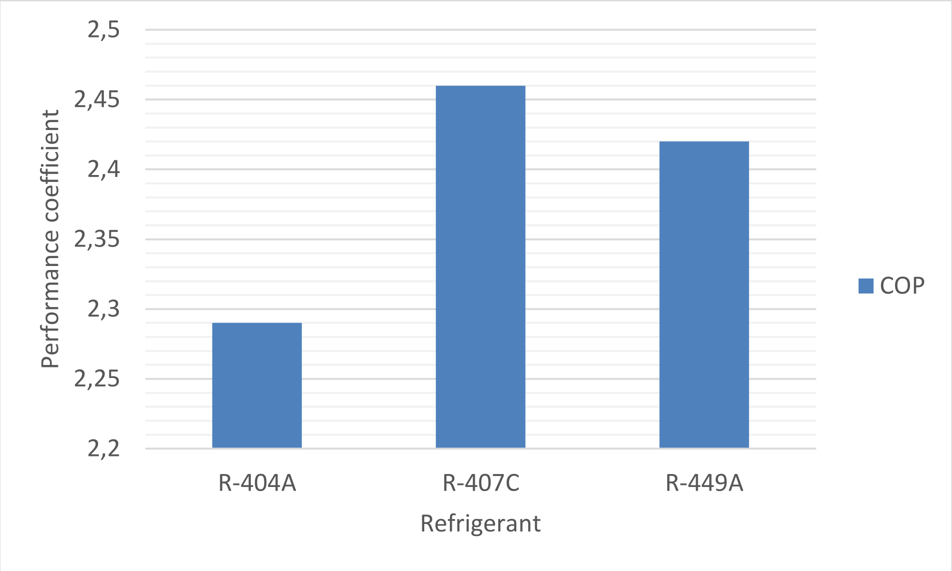
In Figure 2 it can be seen that, depending on the refrigerant used, the value of the system performance coefficient changes. With the R-404 refrigerant, the system has the smallest coefficient. This means that for the introduced kilowatt of electricity in the system, it receives the least cooling of kilowatts, more precisely 1.19 [kW]. A slightly higher coefficient of performance is obtained by the R-449A refrigerant, which means that 1.26 kW of cooling is obtained for one kilowatt of electricity. The R-407C refrigerant has the best results, and has the highest performance coefficient of 1.51, which means that 1.51 kW of cooling is obtained for 1 kW of electricity.

3. ANALYSIS USING A P-H DIAGRAM OF REFRIGERANTS

The enthalpy values are read from the p-h refrigerant diagram, literature. The values of enthalpy are shown in Table 6, as well as the values of the system performance coefficient for the selected refrigerants.

Table 6. Enthalpy values and system performance coefficient – COP

-	R-404A	R-407C	R-449A
1.	352.63	397.41	386
2.	402.97	465.59	450
4.	237.4	229.4	230
$COP = \frac{h_1 - h_3}{h_2 - h_1}$	2.29	2.46	2.42



Graph 3. Performance coefficient – COP

The results of system performance coefficient obtained by p-h diagram show the same results in terms of refrigerant efficiency as in the previous analysis. The lowest coefficient is obtained by R-404A, then R-449A, whereas R-407C has the highest performance coefficient. There are differences between the numerically determined COP values and

COP values from the p-h diagram. They are alone because it is about reading the values from the diagram, and on the other hand, the more precise reading and definition of the values of enthalpies from thermodynamic tables.

4. ANNUAL CONSUMPTION AND THE SYSTEM'S ELECTRICITY COSTS

The input data required for this analysis are the sum of the compressor power of each refrigerant, the number of hours the compressor performs during one day and the agreed price of electricity. The number of hours spent by the compressor is taken from the project documentation of the plant, and the agreed price of electricity is taken as the average price in the industry per kilowatt-hour. Input data are given in Table 7.

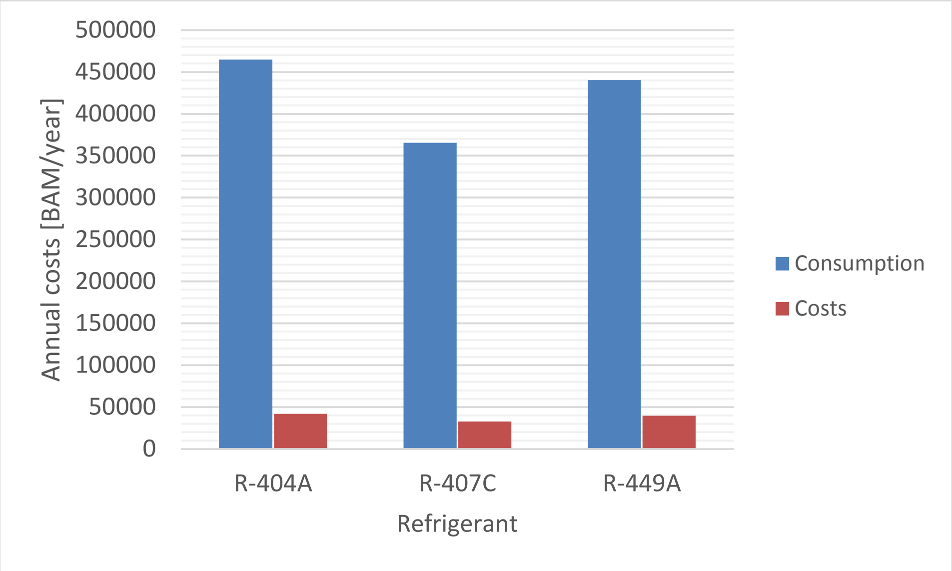
Table 7. Data necessary for analysis of annual consumption and electricity costs

Name	R-404A	R-407C	R-449A
Compressor power[kW]	79.55	62.6	75.42
The number of hours the compressor performs during one day [h/day]	16	16	16
Contracted price of electricity [BAM/kWh]	0.09	0.09	0.09

After defining input data, the daily and annual consumption of electricity, as well as the annual costs, are calculated. Daily electricity consumption is defined as the product of the compressor power and the number of hours that the compressor is in operation for one day. Annual consumption of electricity is obtained as a product of daily electricity consumption and the number of days in the year when the compressor is in operation. Finally, annual costs are obtained as a product of annual electricity consumption and contracted electricity prices. The results obtained are shown in Table 8.

Table 8. Annual consumption and electricity costs

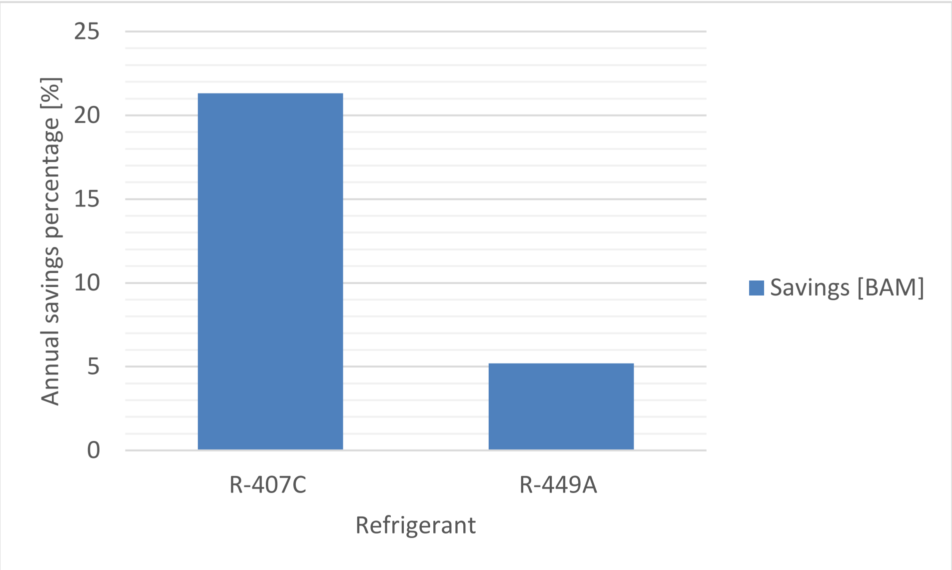
-	R-404A	R-407C	R-449A
Daily consumption el.en. [kWh/day]	79.55*16=1272.8	62.6*16=1001.6	75.42*16=1206.72
Annual consumption el. en. [kWh/year]	1272.8*365=464572	1001.6*365=365584	1206.72*365=440452.8
Annual costs [KM/year]	464572*0.09=41811.5	365584*0.09=32902.6	440452.8*0.09=39640.8



Graph 4. Annual electricity consumption and costs

Based onthe results obtained, it can be seen that the system has the highest consumption of electricity, and therefore its costs, when using R-404A, followed by R-449A showing the mean value of consumption, while R-407C has the lowest value of consumption and costs.

In order to gain easier insight into the electricity consumption and costs, Graph 5 shows annual percentage savings with the R-407C and R-449A refrigerants in comparisonto the refrigerant in the R-404A system.



Graph 5. Percentage savings of electricity per year compared to refrigerant R-404A

In Graph 5, we can see that the R-449A refrigerant has a 5.19 % savings in consumption compared to the R-404Arefrigerant. While, the refrigerant R-407C shows significant savings of 21.31 %.

All listed parameters are given in Table 9, for each of the analyzed refrigerants.

Table 9. Parameters required for final analysis

	R-404A	R-407C	R-449A
Total cooling capacity of the compressor [kW]	11,5	120	126.6
Number of compressors compressors	5	4	6
COP	1.19	1.51	1.26
COP (p-hdijagram)	2.29	2.46	2,42
Annual costs of el. en. [BAM]	41 812	32 903	39 641
ODP	0	0	0
GWP	3943	1624	1273
Critical temperature [°C]	73	87	83.7
Security class	A1	A1	A1
Slip temp. [°C]	1.1	7.4	8.5

5. CONCLUSION

If the results obtained in the analysis of given parameters are summarized, it can be seen that there are advantages and disadvantagesfor each refrigerant. The following points the parameters are presented on the basis of which a conclusion is made as to which refrigerant shows the best results.

- Cooling compressor capacities. It is important here that the resulting cooling capacity covers the needs of the calculated compressorcapacity.
- Number of compressors. It refers to the economic aspect or price. A larger number of compressors also means more expensive investment. Also, a larger number of compressors also requires higher maintenance costs. However, the maintenance costs that increase with the increased number of commuters are not considered in more detail in this paper
- Performance coefficient of the plant. How many kilowatts of cooling we get for one kilowatt of energy input into the system.
- Annual electricity costs. The aim is to get as cost-effective system as possible with as little cost as possible.
- Characteristics of analyzed refrigerants. ODP and GWP factors, safety class, critical temperature and slip temperature.

When taking into account the efficiency and cost-effectiveness of the system relative to the refrigerant being selected, the comparison of results shows that R-407C has the best properties.

This refrigerant requires the lowest number of compressors which directly implies the lowest expenses in regards with the compressor and auxiliary equipment, such as valves, pressure regulator and oil flow regulator. R-407C has the highest perforamnce coefficient, meaning that it provides the highest kilowatts of cooling for one kilowatt of input electrical energy. Also, the same results in terms of the efficiency, that is, performance coefficient, were obtained by using p-h diagrams for the refrigerants.

Annual electricity costs for R-407C are the lowest, which in comparison to R-404A shows a considerable savings in the amount of 21 % annually. If refrigerant properties are considered, R-407C is the best choice. Its GWP factor is one third lower than the GWP factor of R-404A, which implies that the greenhouse effect is lower. Critical temperature is also higher which is another advantage as it is easier to achieve higher condensation temperature. The above given conclusion imply that the refrigerant choice surely has an impact on the overall system, starting from its efficiency to the economic factor. Therefore, before the selection of a particular refrigerant it is crucial to consider a number of options and select the one showing the best results.

LITERATURE

[1] Midhat Jašić: Types and types of CA refrigerators. [Online source: www. food technology.com]

[2] Refrigeration Finelco, Belgrade. [Online izvor: www.finelco.rs]

[3] Bitzer. catalogs. [Online izvor: www.masterfrigo.com]

[4] Introduction to retroffitting, National refrigirants, INC.[Online izvor: www.nationalref.com]

[5] Danfos catalogs. danfoss.com

[6] Rapid replacement of refrigerant R-22, Slavica Bilić, prof. 26-07-, 2008.

[7] Sintehetic alternatives for R404 A refrigerant replacement, Miloš Stojanović, Florida Int.System, limited company, Belgrade, Uroš Milovvančević, Faculty of Mechanical Engineering, University of Belgrade, Belgrade

[8] Gordana Tica – Hladnjače, 2015

[9] In good practice, working with substances that damage the ozone layer, Ministry of Environmental Protection of Physical Planning and Construction,

[10] Ice Age refrigerationn. [Online source: www.iceage-hvac.com]

[11] Association of mechanical and electrical engineers and technicians of Serbia (SMEITS). [Online source: www.i editions of newspapers. smeits.rs]

[12] Air conditioning portal. [Online source: www. air conditioners.com]

[13] Šamšalović, S.: Rashladni uređaji, Mechanical Faculty, Belgrade, 1983.

[14] Đuričković Veljko: Transformatori toplote, Faculty of Mechanical Engineering, Banja Luka, 1995.

[15] Frattello Trade, AD, Banjaluka, material from the company's ownership

[16] bitzer- sotware, material from the company's ownership

[17] coolpack.sotware, material from the company's ownership

[18] Đ. Kozić, B. Vasiljević, V. Bekavac: Manual for thermodynamics, Mechanical Faculty, Belgrade, 1980.

[19] Vujić Sava: Refrigeration devices, Faculty of Mechanical Engineering, Belgrade, 1983.