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REFRIGERATION CYCLE SYSTEM

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Undergraduate Thesis

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HISTORY

1. Ancient origins

Ancient Iranians were among the first to invent a form of cooler utilizing the principles of evaporative cooling and radiative cooling called yakhchāls. These complexes used subterranean storage spaces, a large thickly insulated above-ground domed structure, and outfitted with badgirs (wind-catchers) and series of qanats (aqueducts)

2. Pre-electric refrigeration

In modern times, before the invention of the modern electric refrigerator, icehouses and iceboxes were used to provide cool storage for most of the year. Placed near freshwater lakes or packed with snow and ice during the winter, they were once very common. Natural means are still used to cool foods today. On mountainsides, runoff from melting snow is a convenient way to cool drinks, and during the winter one can keep milk fresh much longer just by keeping it outdoors. The word "refrigeratory" was used at least as early as the 17th century.

3. Artificial refrigeration

The history of artificial refrigeration began when Scottish professor William Cullen designed a small refrigerating machine in 1755. Cullen used a pump to create a partial vacuum over a container of diethyl ether, which then boiled, absorbing heat from the surrounding air. The experiment even created a small amount of ice, but had no practical application at that time. In 1805, American inventor Oliver Evans described a closed vapor-compression refrigeration cycle for the production of ice by ether under vacuum. In 1820, the British scientist Michael Faraday liquefied ammonia and other gases by using high pressures and low temperatures, and in 1834, an American expatriate in Great Britain, Jacob Perkins, built the first working vapor-compression refrigeration system. It was a closed-cycle device that could operate continuously. A similar attempt was made in 1842, by American physician, John Gorrie, who built a working prototype, but it was a commercial failure. American engineer Alexander Twining took out a British patent in 1850 for a vapor compression system that used ether. The first practical vapor compression refrigeration system was built by James Harrison, a Scottish Australian. His 1856 patent was for a vapor compression system using ether, alcohol or ammonia. He built a mechanical ice-making machine in 1851 on the banks of the Barwon River at Rocky Point in Geelong, Victoria, and his first commercial ice-making machine followed in 1854. Harrison also introduced commercial vapor-compression refrigeration to breweries and meat packing houses, and by 1861, a dozen of his systems were in operation. The first gas absorption refrigeration system (compressor-less and powered by a heat-source) was developed by Edward Toussaint of France in 1859 and patented in 1860. It used gaseous ammonia dissolved in water ("aqua ammonia"). Carl von Linde, an engineering professor at the

Technological University Munich in Germany, patented an improved method of liquefying gases in 1876. His new process made possible the use of gases such as ammonia (NH3), sulfur dioxide (SO2) and methyl chloride (CH3Cl) as refrigerants, which were widely used for that purpose until the late 1920s despite safety concerns.

4. Electric refrigerators

In 1894, Hungarian inventor and industrialist István Röck started to manufacture a large industrial ammonia refrigerator which was powered by electric compressors (together with the Esslingen Machine Works). Its electric compressors were manufactured by the Ganz Works. At the 1896 Millennium Exhibition, Röck and the Esslingen Machine Works presented a 6-tonne capacity artificial ice producing plant. In 1906, the first large Hungarian cold store (with a capacity of 3,000 tonnes, the largest in Europe) opened in Tóth Kálmán Street, Budapest, the machine was manufactured by the Ganz Works. Until nationalisation after the Second World War, large-scale industrial refrigerator production in Hungary was in the hands of Röck and Ganz Works. Commercial refrigerator and freezer units, which go by many other names, were in use for almost 40 years prior to the common home models. They used gas systems such as ammonia (R-717) or sulfur dioxide (R-764), which occasionally leaked, making them unsafe for home use. Practical household refrigerators were introduced in 1915 and gained wider acceptance in the United States in the 1930s as prices fell and non-toxic, non-flammable synthetic refrigerants such as Freon-12 (R-12) were introduced. However, R-12 proved to be damaging to the ozone layer, causing governments to issue a ban on its use in new refrigerators and air-conditioning systems in 1994. The less harmful replacement for R-12, R-134a (tetrafluoroethane), has been in common use since 1990, but R-12 is still found in many old systems. The glass-fronted beverage cooler is mostly used as a commercial refrigerator. These types of appliances are usually designed for specific load requirements, resulting in a larger cooling mechanism. This ensures that they are able to cope with a large throughput of drinks and frequent door opening. As a result, it is common for these types of commercial refrigerators to have energy consumption of over 4 kWh per day.[citation needed]Commercial refrigerators efficiency is primarily dependent on the compressor that moves. Refrigerators can be able to cause technical harm to the compressor in certain cases.[clarification needed] It can be restored or mounted again, depending on the degree of damage. Other kinds of damage, such as a cooler leak, can go undetected until serious problems arise. Health concerns are chief among these problems, with refrigerant poisoning being the most alarming. In order to detect harmful leaks early on, refrigerant levels need to be regularly monitored. Regular routine maintenance should avoid the risk of keeping food products at the right temperature. Even the slightest change in circumstances can affect consistency, resulting in breaches of food safety and potential penalties.

5. Residential refrigerators

In 1913, the first electric refrigerators for home and domestic use were invented and produced by Fred W. Wolf of Fort Wayne, Indiana, with models consisting of a unit that was mounted on top of an ice box. His first device, produced over the next few years in several hundred units, was called DOMELRE. In 1914, engineer Nathaniel B. Wales of Detroit, Michigan, introduced an idea for a practical electric refrigeration unit, which later became the basis for the Kelvinator. A self-contained refrigerator, with a compressor on the bottom of the cabinet was invented by Alfred Mellowes in 1916. Mellowes produced this refrigerator commercially but was bought out by William C. Durant in 1918, who started the Frigidaire company to mass-produce refrigerators. In 1918, Kelvinator company introduced the first refrigerator with any type of automatic control. The absorption refrigerator was invented by Baltzar von Platen and Carl Munters from Sweden in 1922, while they were still students at the Royal Institute of Technology in Stockholm. It became a worldwide success and was commercialized by Electrolux. Other pioneers included Charles Tellier, David Boyle, and Raoul Pictet. Carl von Linde was the first to patent and make a practical and compact refrigerator. These home units usually required the installation of the mechanical parts, motor and compressor, in the basement or an adjacent room while the cold box was located in the kitchen. There was a 1922 model that consisted of a wooden cold box, water-cooled compressor, an ice cube tray and a 0.25-cubic-metre (9 cu ft) compartment, and cost $714. (A 1922 Model-T Ford cost about $476.) By 1923, Kelvinator held 80 percent of the market for electric refrigerators. Also in 1923 Frigidaire introduced the first self-contained unit. About this same time porcelain-covered metal cabinets began to appear. Ice cube trays were introduced more and more during the 1920s; up to this time freezing was not an auxiliary function of the modern refrigerator. General Electric "Monitor-Top" refrigerator, introduced in 1927, priced at $525, with the first all-steel cabinet, designed by Christian Steenstrup The first refrigerator to see widespread use was the General Electric "Monitor-Top" refrigerator introduced in 1927, so-called, by the public, because of its resemblance to the gun turret on the ironclad warship USS Monitor of the 1860s.

The compressor assembly, which emitted a great deal of heat, was placed above the cabinet, and enclosed by a decorative ring. Over a million units were produced. As the refrigerating medium, these refrigerators used either sulfur dioxide, which is corrosive to the eyes and may cause loss of vision, painful skin burns and lesions, or methyl formate, which is highly flammable, harmful to the eyes, and toxic if inhaled or ingested. The introduction of Freon in the 1920s expanded the refrigerator market during the 1930s and provided a safer, low-toxicity alternative to previously used refrigerants. Separate freezers became common during the 1940s; the term for the unit, popular at the time, was deep freeze. These devices, or appliances, did not go into mass production for use in the home until after World War II. The 1950s and 1960s saw technical advances like automatic defrosting and automatic ice making. More efficient refrigerators were developed in the 1970s and 1980s, even though environmental issues led to the banning of very effective (Freon) refrigerants. Early refrigerator models (from 1916) had a cold compartment for ice cube trays. From the late 1920s fresh vegetables were successfully processed through freezing by the Postum Company (the forerunner of General Foods), which had acquired the technology when it bought the rights to Clarence Birdseye's successful fresh freezing methods.

REFRIGERATOR

A refrigerator, colloquially fridge, is a commercial and home appliance consisting of a thermally insulated compartment and a heat pump (mechanical, electronic or chemical) that transfers heat from its inside to its external environment so that its inside is cooled to a temperature below the room temperature. Refrigeration is an essential food storage technique around the world. The lower temperature lowers the reproduction rate of bacteria, so the refrigerator reduces the rate of spoilage. A refrigerator maintains a temperature a few degrees above the freezing point of water. The optimal temperature range for perishable food storage is 3 to 5 °C (37 to 41 °F). A similar device that maintains a temperature below the freezing point of water is called a freezer. The refrigerator replaced the icebox, which had been a common household appliance for almost a century and a half. The United States Food and Drug Administration recommends that the refrigerator be kept at or below 4 °C (40 °F) and that the freezer be regulated at −18 °C (0 °F).[2] The first cooling systems for food involved ice. Artificial refrigeration began in the mid-1750s, and developed in the early 1800s. In 1834, the first working vapor-compression refrigeration system was built. The first commercial ice-making machine was invented in 1854. In 1913, refrigerators for home use were invented. In 1923 Frigidaire introduced the first self-contained unit.

The introduction of Freon in the 1920s expanded the refrigerator market during the 1930s. Home freezers as separate compartments (larger than necessary just for ice cubes) were introduced in 1940. Frozen foods, previously a luxury item, became commonplace. Freezer units are used in households as well as in industry and commerce. Commercial refrigerator and freezer units were in use for almost 40 years prior to the common home models. The freezer-over-refrigerator style had been the basic style since the 1940s, until modern, side-by-side refrigerators broke the trend. A vapor compression cycle is used in most household refrigerators, refrigerator–freezers and freezers. Newer refrigerators may include automatic defrosting, chilled water, and ice from a dispenser in the door. Domestic refrigerators and freezers for food storage are made in a range of sizes. Among the smallest are Peltier-type refrigerators designed to chill beverages.

A large domestic refrigerator stands as tall as a person and may be about one metre (3 ft 3 in) wide with a capacity of 0.6 m3 (21 cu ft). Refrigerators and freezers may be free-standing, or built into a kitchen. The refrigerator allows the modern household to keep food fresh for longer than before. Freezers allow people to buy perishable food in bulk and eat it at leisure, and make bulk purchases.

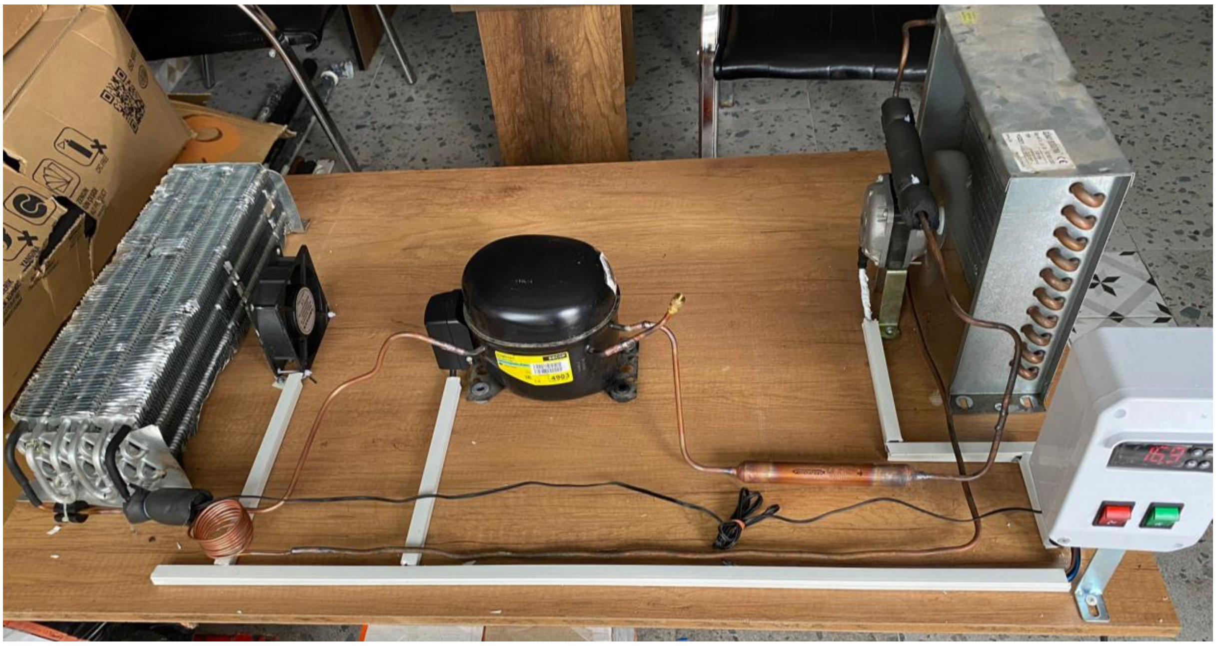


Figure 1: Refrigeration Cycle System

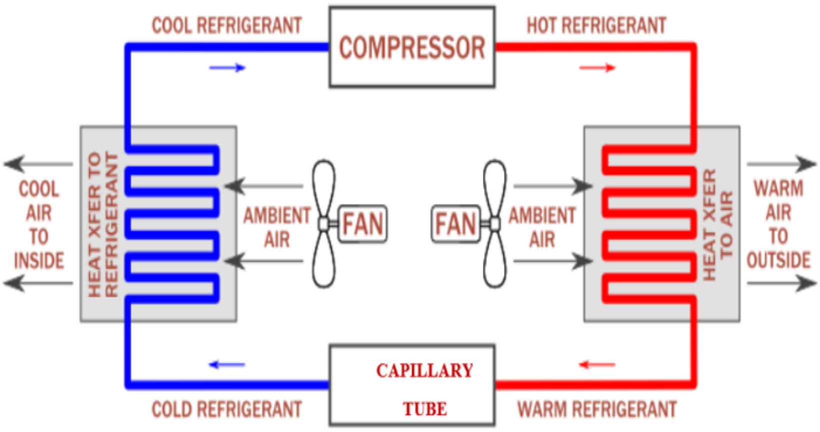


Figure 2: Refrigeration cycle

6. The purpose of the device and the learning objectives:

The purpose of making this device is a thesis study that aims to learn the basic skills of engineering by practicing both in practice and technically.

7. Learning objectives:

The ability to understand the positions and functions of the elements that can be used in a cooling system on the cooling system, the ability to observe the efficiency and use cases that may occur by ensuring that they are operated together with the evaporator and condenser.

The effect of changes in the settings of the control elements used on the thermodynamic cycle (log p-h) diagram.

8. Experimental setup modules and elements1 Control panel

1. Compressor
2. Drayer
3. Capillary tube
4. Air-cooled evaporator
5. Air-cooled condenser
6. Temperature sensor
7. Evaporator fan
8. Condenser fan
9. Digital
10. Module power cable

HAND TOOLS USED IN BASIC REFRIGERATION AND AIR CONDITIONING

Simple Hand Tools

Tools used in workplaces based on manual dexterity outside of power tools and machines are called hand tools

Figure 3:Hand Tools

Copper Pipe Reamer

The apparatus used to clean the burrs that form on the inner and outer surfaces of copper pipes after cutting is called a reamer. The copper pipe reamer is shown in Figure 4. The cleaning process performed on the copper pipe is called reaming. It is necessary to pay attention to the end of the reamer so that the hands are not cut off during the reaming process.

Figure 4: Copper Pipe Reamer

Copper Pipe Shears

Designed in accordance with various diameters, the copper pipe shears perform the cutting process of copper pipe smoothly and without burrs. After measuring the lengths of the copper pipes to be used, the pipe is Decently placed between the moving rollers of the scissors and the insert tip for the cutting process, making a 90 degree angle. The drum is turned clockwise and the attachment process is performed to the pipe. Care should be taken not to crush the pipe during this operation. The scissors are rotated around the pipe in order to perform the pipe cutting process. After each round of rotation, the drum should be tightened by a quarter turn. Care should be taken not to get burrs into the pipe during the cutting process (Figure 5).

Figure 5: Copper Pipe Shears

Countersunk Sets

In copper pipe joining, the countersinking method is used when the detachable connection is to be made. The countersink set consists of pipe fixing vise, clamping jaw and countersink cone. Copper pipe to be countersunk; the appropriate anchor in the block located in the countersunk set is placed at the height of the wall thickness and the pipe is countersunk. With the development of technology, countersinking tools show a variety. The two most commonly used countersink sets, the torque countersink set and the countersink opening set, are shown in Figure 6.

Figure 6: Countersunk Sets

Pipe Bending Springs

They are simple tools used to prevent the pipe from being crushed when bending. It is produced in different diameters and sizes. The bending process is performed by inserting the pipe into the spring or the spring into the pipe. It is not preferred in places where a delicate twist is sought (Figure 7).

Figure 7 Pipe Bending Springs

Lever Type Copper Pipe Bending Tools

In places where soft and hard drawn small diameter pipes are used, it is often both more convenient and more economical to bend, bend the pipe according to the characteristics of the application instead of using ready-made Decoupled fittings. Even if this process can be done manually, it is quite difficult and time-consuming to obtain a healthy bending measurement. The most sensitive and safe way to bend pipes is to use tools. There are many bending tools, bending tools and machines developed for this job. A service in most cases, a lever-type pipe bending tool, which can bend to several degrees, will be sufficient for its element. With bending tools made in different sizes 1/4", 5/16", 3/8", 1/2", 5/8", 3/4" and pipes with outer diameters of 6, 8, 10, 12, 15 mm can be bent at various angles. Some types are designed to make bending pipes of two or three different diameters. The pipe bending apparatus is seen in Figure 8. This tool is able to bend both soft and hard drawn pipes. Bending can be performed at any angle up to 180º in precise dimensions with shaping wheels and molds of different diameters.

Figure 8 Lever Type Copper Pipe Bending Tools

Muf Opening Kits

The muf opening process can be performed with many different tools and techniques. The first of these is the process of opening the muf with a countersink tool. In this process, muf opening process is performed especially on copper pipes up to 1/2" diameter. Another muf opening set is the inflation set. It is used for expanding large diameter copper pipes. Copper pipe blow-up heads are manufactured in a form suitable for the pipe diameter. The selection is made according to the diameter of the pipe to be inflated. Then, the inflation apparatus is inserted into the pipe and the muf opening process is performed (Figure 9). If the pipe diameter is 5/8" and larger, the copper pipe is heated (annealed) and the muf opening process is performed with a blow molding apparatus.

Figure 9 Muf Opening Kits

9. Copper Pipe Connection and Hose Fasteners

Copper pipe fittings are used for the installation of copper pipes and hose connections in air conditioning and refrigeration systems. Copper pipe fasteners are shown in Figure 10.

The materials of copper fittings are:

1. 2 internal gears, 1 external gear Te
2. Service end switch
3. The service tip opening switch is on the blind
4. Fittings
5. Countersunk-headed blind
6. Fitting blind
7. nipple from 1/2” to 1/4”
8. External gear Te
9. nipple from 1/4” to 5/8”
10. Welded external threaded nipple
11. Straight and reverse threaded nipples
12. Service end pipe
13. Blind tapa

Figure 10 Copper Pipe Connection and Hose Fasteners

10. Oxyacetylene Welding Equipment

1. Bek
2. Blower
3. Flame retardant valves
4. Gas hoses
5. Oxygen regulator
6. Acetylene regulator
7. On-off shut-off valve
8. Oxygen tube
9. Acetylene tube

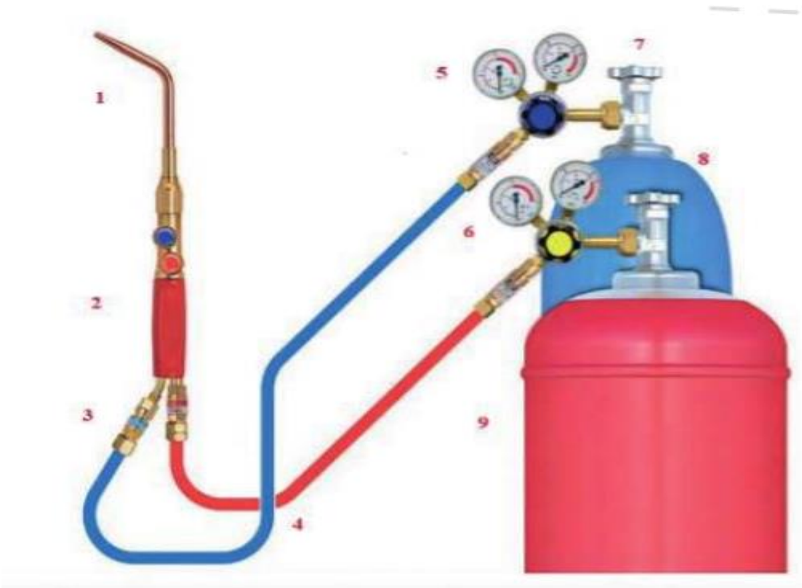
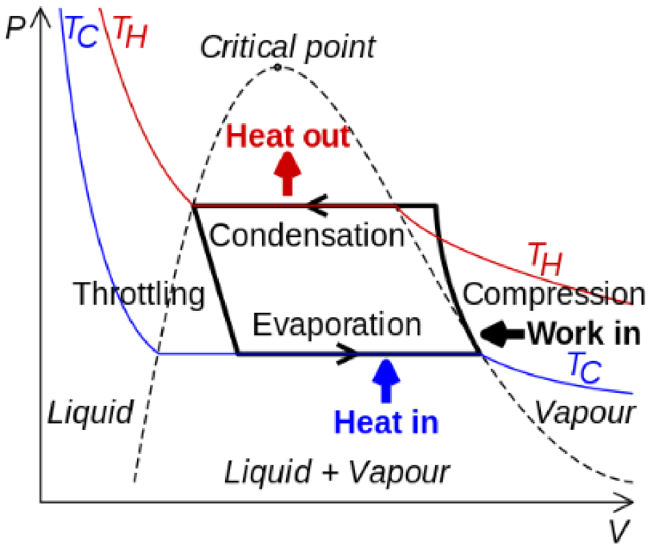


Figure 11 Oxyacetylene Welding Equipment

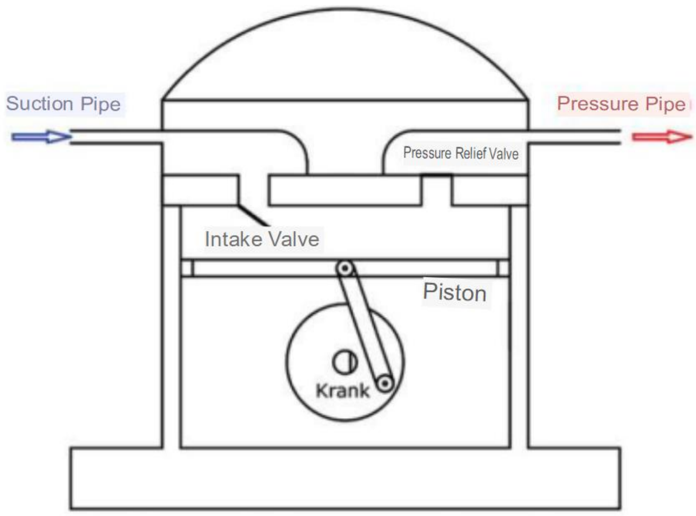
STRUCTURE AND TYPES OF COMPRESSOR

The compressor, which is the most important element of the steam compression cooling machines, is a refrigerant pump that sends the refrigerant from the evaporator return line to the condenser. In addition, during the operation of the compressor, the refrigerant is constantly cycling through the system. The choice of compressor according to the capacity of the cooling circuit is of great importance. Large capacity compressors selected according to small capacity affect both cooling performance and cause excessive electricity consumption.

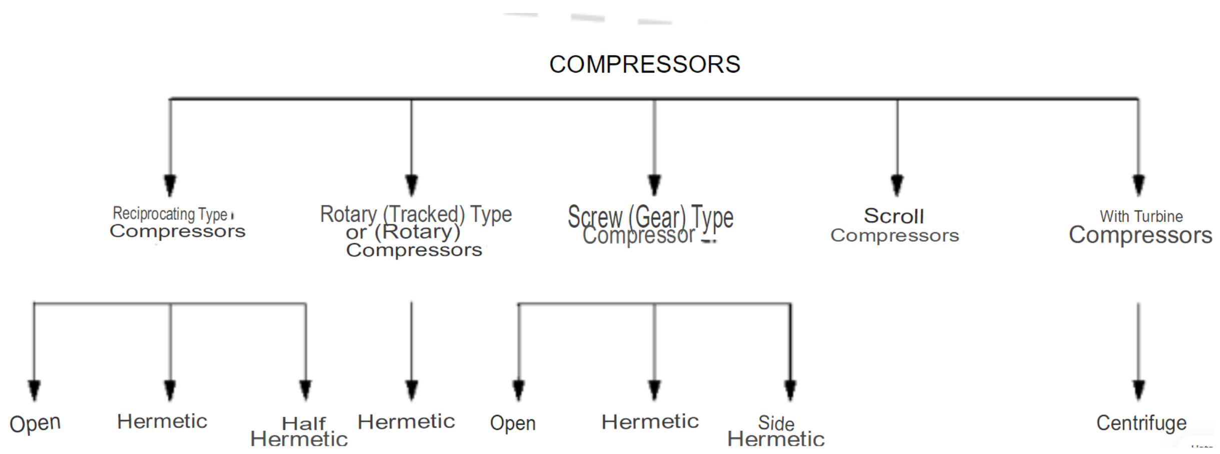


11. Compressor

The compressor; The coolant in the form of cold steam coming from the suction pipe in the system enters through the intake valve and exits from the pressure valve in the form of steam, the temperature and pressure increase as a result of the piston compression process. When the piston inside the compressor moves up, it compresses the refrigerant fluid, and when it moves down, it absorbs the refrigerant fluid.



Due to the fact that the mechanical and volumetric efficiency of the compressor has a great impact on the economy of the facility to be used, various compressors have been developed according to the type and size of the cooling facility. Compressors can be mainly grouped into five main groups.



11.1 Piston Type Compressors

Reciprocating compressors are divided into three types: open-piston, hermetic and semi-hermetic.

Open Piston Compressors

This type of compressor is also sometimes known as externally driven. In refrigeration compressors, the function of the intake and pressure valves is performed through a special unidirectional flap placed on the piston. When the piston moves from the upper dead point to the lower dead point, the refrigerant flows from the crankcase into the cylinder; when moving from the lower dead point to the upper dead point, the refrigerant filled in the cylinder is compressed and pressed into the condenser. Single or double piston upright compressors are usually used on ships (Figure 12). The main elements of a compressor are

- Cylinder
- Crankcase
- Piston, piston rod, crankshaft, pulley
- Intake and pressure valves
- Cutting elements (valves)

Figure 12 Oxyacetylene Welding Equipment

Semi-Hermetic Compressors

Although the design of semi-hermetic type compressors is similar to open types, the difference is that the electric motor is directly connected to the compressor and is located in a removable indoor environment (Figure 13). Therefore, in this type of compressors, the refrigerant and oil are in contact with the engine windings. The advantage is that it can be disassembled and repaired. It is usually used in large commercial facilities such as cold warehouses and grocery stores.

Figure 13 Semi-Hermetic Compressors

Hermetic Compressors

In this type of compressors, the electric motor is directly connected to the compressor and placed in a container (dom) combined with welding (Figure 14). The engine is in constant contact with oil and refrigerant. It is usually not possible to repair. The engine Deceleration is between 0-7.5 kW. It is used in household chillers, small type commercial chillers and freezers.

Figure 14 Hermetic Compressors

Rotary (Rotary, Rotor, Rotary) Compressors

This compressor consists of a cylindrical body with a rotor. There are movable fins on the rotor that touch the fuselage. Since the rotor is placed out of axis in the body, the refrigerant vapor is absorbed from the expanding region and compressed from the contracting region during the rotational movement (Figure 15). The output power of the engine is between 0.6–200 kW.Dec. Large compressors have more than ten valves. These compressors are used in large plants, small household refrigerant and air conditioning applications.

Figure 15 Rotary (Rotary, Rotor, Rotary) Compressors

Scroll Compressors

Scroll compressor is a fairly new type of compressor and is mainly used in small type split air conditioning devices (Figure 16). It consists of two metal plates, each of which is in the form of a spiral (scroll). One of the plates is stationary, and the other makes a rotational movement. As the two spirals rotate forehead to forehead, the steam is compressed towards the center of the spiral.

Figure 16 Scroll Compressors

Screw (Helical) Compressors

This type of compressor has a twin working helical rotor group similar to a screw thread (Figure 17). One of the screws has lobes (tooth protrusion), and the other has lobe gaps. The rotors are precisely positioned inside the housing. One of the rotors is connected to the motor and activates the other. The refrigerant vapor is compressed by being transported through the lobe spaces on the rotors. In the past, only open and semi-hermetic types of this type of compressors were available for large plants. Hermetic types have also been developed for small commercial systems

Figure 17 Scroll Compressors

Turbo (Centrifugal) Compressors

There are open and semi-hermetic types of this type of compressors and these compressors produce cold water (Figure 18). The steam is sucked from the center of the rotating wheel at high speed and thrown to the outlet side by centrifugal force. With the help of a snail-shaped envelope outside the impeller, the steam is directed to the pressing side under pressure. The compression ratio of these compressors is not high, but the steam flow rate is high. It is usually used in large air handling units.

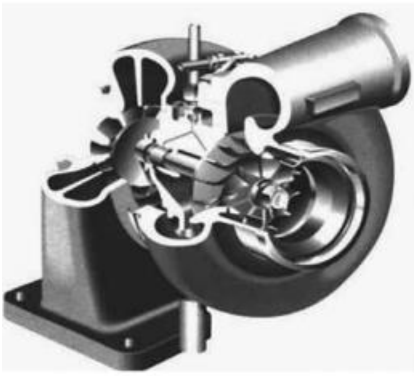


Figure 18 Turbo (Centrifugal) Compressors

CONDENSER STRUCTURE AND TYPES

Condensers, which are one of the basic elements of the cooling system, are an element that allows the refrigerant, which is in the form of hot vapor at high pressure and temperature, to become liquid by giving its heat to the external environment (Figure 2.15). In other words, the refrigerant that evaporates with the heat it receives from the evaporator and whose temperature and temperature increase as a result of the compression process in the compressor becomes liquid here. The condensers are installed on the high pressure side of the system. The ability of the condenser to remove heat from the hot refrigerant vapor to the cold environment is called the condenser capacity. A condenser is a device that stays between the compressor and the drayer (Decanter-filter) during the cooling cycle, is compressed by the compressor, takes heat from the refrigerant vapor, whose pressure and temperature are raised, releases it to the external environment at this point, and thus allows the vapor to condense.

The Structure of the Condenser

In general, there are three types of condensers:

- Air-cooled condensers
- Water-cooled condensers
- Evaporative (air-water) condensers

Which of them will be used in practice will be determined by an economic analysis. In this analysis, the organization and operating costs should be analyzed together.

Air Cooled Condensers

The reasons for choosing this type of condensers, which are usually used in systems with a capacity of up to 1 hp, are: their simplicity, low installation and operating costs, ease of maintenance and repair. It is also suitable for all kinds of refrigeration applications (such as household or commercial refrigerators, cold rooms, window-type air conditioners). In most applications, the air circulation fan is integrally connected to the motor pulley of the open type compressor and there is no need for a separate drive motor (Figure 19).

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Figure 19 Air Cooled Condensers

Water Cooled Condensers

Generally, it can be considered as the condenser type that is the most economical in terms of both establishment and operating costs in places where clean water can be found in abundance, cheaply and at low temperatures (Figure 20). It is usually considered as the only choice in large capacity cooling systems.

Figure 20 Water Cooled Condensers

Evaporative Condensers

These are condensers made on the basis of using the cooling effect of air and water together. They are used less and less due to maintenance and service difficulties, rapid contamination, and frequent failure.

EVAPORATOR STRUCTURE AND TYPES

In a cooling system, an evaporator is a heat exchanger that allows the refrigerant entering as a saturated liquid-vapor mixture to exit as at least saturated vapor or hot vapor by drawing heat from the environment. It allows the heat to be withdrawn from the desired environment by evaporating the refrigerant fluid (Figure 2.19). In short, it is the part where cooling is done. In air conditioning and refrigeration systems, the evaporator is usually placed in a cooled environment.

When the liquid refrigerant enters the evaporator, it absorbs heat from the substance in the environment (air, liquid or solid). While absorbing the heat, it also begins to boil and evaporates. Thus, the evaporator realizes the general purpose of the system, that is, the cooling process. Evaporator in a cooling circuit; expansion element (capillary tube, TGV, automatic expansion valve, etc.) is located between the compressor and the Deceleration line.

12. Structure of the Evaporator

Evaporator; it will ensure the good and quick evaporation of the refrigerant, the cooled substance (air, water, brine, etc.) should be designed in such a way that it will receive its heat with a high efficiency by providing a good heat transfer and will keep the pressure difference (losses) at the inlet and outlet of the refrigerant to a minimum. However, the last of these is usually in conflict with the first two. That is, a good heat transfer and good the conditions necessary for evaporation increase pressure losses because they require the inner and outer surfaces to be more indented and easier to get wet (too capillary). For this reason, evaporator design requires a way of working that requires extensive experience and attention, as well as frequent reference to experiments. The most important factor in directing these studies is the type and location of the substance to be cooled (liquid, solid, gas). In addition, the state of the volume in which the refrigerant is located and moves while exchanging heat also makes significant changes in the evaporator design. Here, the refrigerant is allowed to move inside a pipe coil. It is the case that the substance to be cooled passes outside the pipes or vice versa, the first of which is usually applied in dry-type direct expansion evaporators, and the second in liquid-carrying type evaporators.

Plate Type Evaporators

After the cavities are opened on the two plates mutually by press pressure, these plates are boiled on top of each other. Thus, an evaporator serpentine is formed with the Decoupling grooves remaining in between (Figure 21). It is used in refrigerator and showcase type coolers

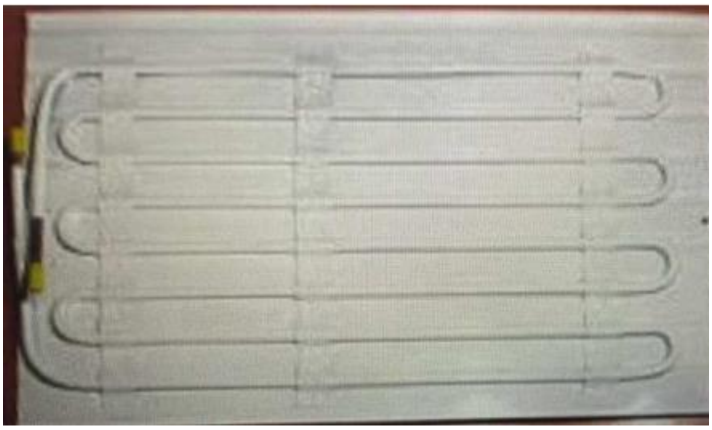


Figure 21 Plate Type Evaporators

Finned Evaporators

It is a type of evaporator used for cooling air (Figure 22).

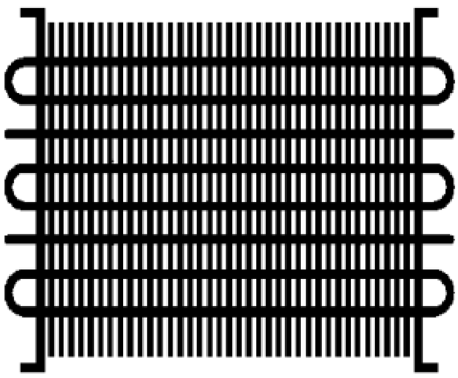


Figure 22 Finned Evaporators

Lamellar Evaporators

To increase the surface, fin rods are used instead of wings on the serpentine curved pipes to increase the surface (Figure 23). Rather, it is produced for small cooling loads.

Figure 23 Lamellar Evaporators

Body Tube Type Evaporators

The housing has the same structure as the tubular condenser. It is used in water cooling. Such evaporators are used to produce cold water for fancoils (fensolir) in large cooling capacity chiller (çilir) groups where cold water is needed (Figure 24). For an effective cooling, all the couplings should definitely be touched with fluid. Their low space occupation, high capacity and easy maintenance are their main advantages.

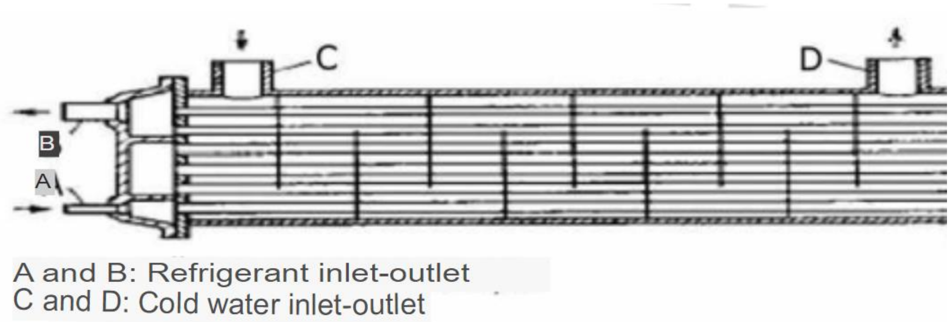


Figure 24 Lamellar Evaporators

Immersion Type Evaporators

It is formed by dipping a serpentine-shaped copper tube into the liquid to be cooled. It is mainly used for cooling drinking water or other types of beverages (Figure 25). The evaporator temperatures are above the freezing point (0 ºC).

Figure 25 Immersion Type Evaporators

CAPILLARY PIPES AND EXPANSION VALVES

These materials, which are one of the main elements of the cooling circuit, reduce the pressure by allowing the liquid refrigerant from the condenser to expand, and cooling begins from this region. The areas of use of these materials, which are the absence of cooling systems, differ according to the system capacity. According to its capacity, capillary pipe is used in small systems and expansion valves are used in large systems.

Capillary Tube

It is a very small diameter pipe placed between the condenser and the evaporator, the inner diameter and length are selected according to the capacity of the cooling system, mostly ranging from 0.76 to 2.16 mm in diameter. Decoupling Decoupling is a very small diameter pipe. Because the inner diameter is very small, it is called a capillary pipe (capillary pipe).
It is placed between the condenser and the evaporator. Decongestant. Capillary pipes should be cut using capillary pipe scissors because they are very thin pipes.

Figure 26 Capillary Tube

Expansion Valve (Throttling Valve)

Throttling valves are the element that serves to reduce the pressure of the refrigerant to the desired evaporator pressure (Figure 27). The expansion process takes place at approximately constant enthalpy. Expansion valves are pressure reducing elements. With the pressure drop, the refrigerant is reduced to low temperatures. In order to make efficient use of the expansion valves, the system must be protected from foreign substances, excessive humidity and corrosion. In order to protect the valve from such effects, a dirt holder, filter and dryer should be added to the system. It is used in the field of industrial and commercial air conditioning and refrigeration.

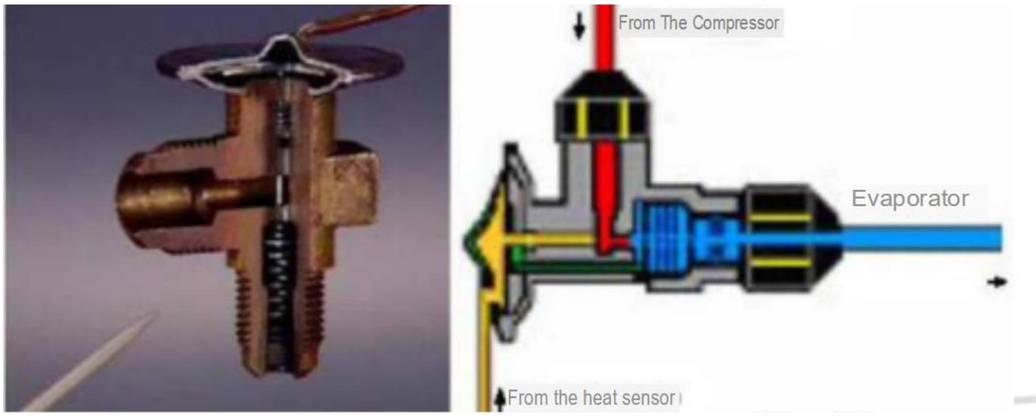


Figure 27 Capillary Tube

Types of Expansion Valve (Throttling Valve)

Automatic Expansion Valve

This expansion valve, used in refrigeration applications where the cooling load does not change much, tries to provide a constant evaporation temperature as well as provide a constant evaporation pressure. In these valves, the desired pressure can be obtained by changing the upper spring voltage with a set screw. Since this type of expansion valves only keep a certain set evaporation pressure constant, they are not suitable for large installations and cannot respond to sudden load changes. For this reason, it is used for constant cooling loads and medium-sized refrigerants.

Thermostatic Expansion Valve

The main function of thermostatic expansion valves is to ensure the most efficient use of the evaporator and to prevent the refrigerant from reaching the compressor in the liquid phase (Figure 2.28). In thermostatic expansion valves, the amount of heat absorbed in the evaporator and the amount of refrigerant that can be evaporated are allowed to enter the evaporator. Valve; although it works according to the degree of heating of the refrigerant and its changes in this degree, it also uses part of the evaporator to heat the refrigerant. Thermostatic expansion valves are of two types according to the way of pressure balancing.

Internal Balanced Thermostatic Expansion Valve: In this type of valves, the valve outlet pressure is transmitted under the diaphragm of the thermostatic element through a channel inside the housing. Internally balanced valves are used in refrigeration systems with a compressor and an evaporator, where the temperature drop corresponding to the pressure loss in the evaporator does not exceed 1 K.

Externally Balanced Thermostatic Expansion Valve: In cooling systems where the pressure loss in the evaporator and /or distributor is high, externally balanced valves are used to improve performance. The pressure at the evaporator outlet is transmitted just below the diaphragm of the thermostatic element through the external balance line.

Elektronik Genleşme Valf

Electronic expansion valves are widely used. Electronic expansion valves can be classified into four ways according to the control types:

- Heat-engine controlled
- Electromagnetically modulated
- Pulse modulated (on-off)
- Step-motor controlled

COOLING AUXILIARY ELEMENTS

Apart from the main elements, they are the elements used for the regular and safe operation of the system. Whether auxiliary elements are used or not may vary depending on the system and operating condition. A part of the cooling system can be disabled with auxiliary elements and a service or repair operation can be performed.

Visual monitoring of the refrigerant is provided, ensures the use of refrigerant and lubricating oil for a long time and without damage, performs take-off and automatic defrosting operations on large-capacity compressors.

Drayer (Dirt Holder and Dryer)

During installation, the moisture remaining in the refrigerant circuits is placed on the liquid circuit in order to prevent blockages and corrosion effects caused by icing at low temperatures (Figure 28). Dryers also have the ability to filter foreign substances on the refrigerant circuit (filtration). The function of the dryer (drayer and strainer) placed at the condenser outlet is to absorb water and acids and keep small solids (dust, etc.).) is to filter.

Figure 28 Drayer (Dirt Holder and Dryer)

SIGHT GLASS

It is usually found in large systems. It is placed at the condenser outlet and immediately after the filter. It is used to monitor whether the refrigerant is saturated liquid or not and to see the liquid level (Figure 29). It also gives information about the humidity in the system. It has been prepared in order to be able to observe the flow status of cooling and to control the moisture content of the cooling system.

Figure 29 SIGHT GLASS

Liquid Tank

It is the tank that discharges the liquid refrigerant from the condenser, relieves the condenser, and serves as a tank for the liquid in case of maintenance and repair (Figure 30). It is located after the condenser and is large enough to take all the liquid (refrigerant)

Figure 30 Liquid Tank

Oil Separator

The task of the oil separator is to reduce the amount of oil circulating in the system and therefore increase the efficiency of the system (Figure 31). The general purpose of the oil separators is to separate the oil discharge gases and to ensure the regular and accurate recycling of the oil into the compressor crankcase. The oil separator is used in the compressor pressing line in cooling systems.

Figure 31 Oil Separator

Accumulator

In some evaporators, the refrigerant inlet setting may not be fast enough to keep the cooling load changes at the same setting. In other words, it may be possible for some more liquid to flow through the expansion element by entering the evaporator. In the same way, the capillary tube as an expansion element has no such condition as closing under light evaporator loads, and the capillary tube can somehow cause liquid overflow (Fıgure 32).

Figure 32 Accumulator

Manometer

A measuring instrument that serves to measure the pressure of a gas or liquid fluid is called a pressure gauge. The manometers used in the refrigeration sector are mostly used in two units as the “high pressure side” after the compressor and the “low pressure side” before the compressor. The high pressure manometer is usually red in color, while the low pressure manometer is blue in color (Figure 33).

Figure 33 Accumulator

Pressure Switch (Prosestat)

The pressure switch continuously controls the pressures in the low pressure (suction) line and high pressure (pressure) line in the cooling system during operation, stops the compressor to prevent it from exceeding the set low and high pressure values (Figure 34).

Figure 34 Pressure Switch (Prosestat)

It ensures that the low and high pressures on the suction and compression sides of the compressor always remain within the safety limits by preventing them from going outside the desired lower and upper limits Jul. During normal operation, the contacts are closed and current passes through the circuit. When the upper and lower pressure limits set by the manufacturing company are exceeded, the low-high pressure process stops the compressor electric motor. Low and high pressure processes can be applied together or separately. The place of use in the cooling circuit is the compressor pressure line and evaporator return line.

Check Valve

It is designed to ensure that liquid or gas flows in only one direction (Image 35). The check valve is opened by the pressure difference that occurs between the inlet and outlet Decals of the valve during the flow in the normal direction. This closes when the pressure decreases or increases on the outlet side compared to the inlet side.

Figure 35 Pressure Switch (Prosestat)

Solenoid Valve

It is an on-off valve controlled by electric current. According to the function or purpose of operation of the plant, the refrigerant is mounted on liquid or gas circuits. It opens or closes the liquid or gas circuit according to the warning it will receive from the thermostat or prosestat (Figure 36). Usually, the solenoid valve is closed when the electrical current is cut off. It is used before the expansion valve. It depends on the compressor. Prevents flow by turning off when the compressor stops.

Figure 36 Solenoid Valve

CLEANING THE CIRCUIT WITH NITROGEN GAS AND PRESSURE TESTING

The Process of Pressurizing the Refrigerant Circuit with Nitrogen

After the installation of the cooling circuit materials, nitrogen pressurization should be performed to test whether there are leaks at the connection points.

The main elements used in the cooling circuit are pressure tested with nitrogen when the production phase ends. Because oxy-gas welded and gland connections made in cooling circuits are places that can cause leakage on the system. Pressurization with nitrogen in the cooling circuit allows the detection of leaks that may occur at the copper pipe joints. The reasons for performing a pressurization test before vacuuming and charging the refrigerant in the cooling circuit are as follows: • Detecting leaks in the connections made • Removing moisture and dirt from the system • Preventing fluid consumption by preventing the formation of refrigerant leaks • Preventing damage caused by working without oil and refrigerant in the cooling circuit, especially in high-pressure sections, leakage may occur in the circuit, so more attention should be paid to the use of refrigerant in these regions. In order to perform pressurization with nitrogen, care should be taken that the regulator is connected on the nitrogen tube. The pressure contained in the tube should be controlled with a regulator.

If the nitrogen tube, which is not connected to the regulator, is tried to be opened, it may cause work accidents that may result in death. In addition, when the accidents caused by the nitrogen tube were examined on Earth, it was found that the accidents caused by trying to pressurize with the manifold connection without a regulator. While the regulator is the material that can adjust the nitrogen at high pressure in the tube to the desired pressure; the manifold is the element that provides the transfer of substances such as predetermined pressure, nitrogen and refrigerant into the cooling circuit. Therefore, attention should be paid to its use. For connection construction, the service end of the manifold is connected to the nitrogen tube, and the high pressure valve is connected to the compressor service end, and the cooling circuit is pressurized with nitrogen until it reaches the desired pressure.

After pressurization is performed for leak control, the pressure value on the manifold high pressure gauge must be recorded. Then, the connection points should be checked first by eye and then by foam test or leakage control devices. If there is no leak detected after the checks, it should be ensured that the manifold valve is closed. Then, at least 12 hours should be waited for the change in the pressure value on the high pressure gauge. If there is a detected leakage, the gland should be tightened again for the gland connection leakage and leakage control should be performed again. If a welding leak has been detected, a leakage sound may occur due to high pressure.

This makes it easier to detect the fugitive. In order to eliminate the leakage from the source, the nitrogen must first be discharged through the circuit. After the welding process is performed, the pressurization process should be performed again, it should be observed that the pressure of the cooling circuit does not decrease for at least 12 hours after pressurization.

Vacuuming Process

The non-condensing gases such as nitrogen, air and carbon dioxide remaining in the cooling circuit interact with the oil in the circuit and begin to leave residues in the compressor over time. In addition, these residues cause some temperature values of the air contained in the pipes in the cooling circuit to turn into moisture. In this case, moisture can enter the section of the cooling circuit below 0 degrees and turn into ice, leaving permanent damage to the circuit. Therefore, vacuuming is important for the cooling circuit (Figure 37).

Figure 37 Vacuuming Process

The characteristics required in a vacuum cooling circuit

they are:

- Not being a fugitive
- To be clean Jul
- It should be dry
- To be free from air
- To be free from nitrogen, refrigerant and carbon dioxide

STRUCTURE AND TYPES OF REFRIGERANTS

13. Refrigerants

Refrigerants used as intermediates in sending heat from one medium to another during a cooling cycle usually provide heat exchange by Decaying from a liquid state to a vapor state and from a vapor state to a liquid state. This is especially true for the steam compression cycle. Refrigerants must have certain physical and chemical properties in order to perform the above tasks, that is, for the system to work efficiently and safely.

Chlorofluorocarbons (CFCs)

Chlorofluorocarbons are the refrigerants that cause the most damage to the ozone layer. In addition, the global warming potentials are quite high. Therefore, various measures are being taken for the use of

CFCs by imposing some bans worldwide. Its chemical structure can remain intact in the atmosphere for between 75-120 years. Dec. Their potential to penetrate the ozone layer is high. The most commonly used ones in practice are: R 11, R 12 and R 114.

Hydrochlorofluorocarbon (HCFC)

Hydrochlorofluorocarbons react with the ozone layer because they contain chlorine atoms. Despite this, HCFCs have very poor chemical stability due to the presence of hydrogen in their structure. As HCFCs rise into the atmosphere, the hydrogen in their structure reacts with water molecules in the air and therefore their structure deteriorates. HCFCs have little ozone depletion potential. Another important feature is that they do not stay in the atmosphere for a long time without their chemical structure being disturbed (15-20 years). The most commonly used HCFCs in practice are: R 22, R 124 and R 123.

Hydrofluorocarbon (HFC)

Since there are no chlorine atoms in the structure of hydrofluorocarbons, they do not have the potential to pierce ozone. In other words, there are no negative effects on the ozone layer. Despite this, they have some impact on global warming. In Table 5.1, refrigerants that occur as a result of mixing with each other are classified.

Refrigerant	Chemical Description	Chemical Formula
R 11 (CFC 11)	Triclormethane	CFC13
R 12 (CFC 12)	Dichlorflormethane	CF2C2
R 13 (CFC 13)	Chlortriflormethane	CCIF3
R 13B1 (BFC 13)	Bromtriflormethane	CBrF3
R 22 (HCFC 22)	Chlordiflormethane	CHF2CI
R 23 (HCF 23)	Triflormethane	CHF3
R 32 (HCF 32)	Diflormethane	CH2F2
R 113 (CFC 113)	Trichlordrifluorethane	C2F3C13
R 114 (CFC 114)	Dichlortetrafluorethane	C2F4C12
R 115 (CFC 115)	Chlorpentafluorethane	C2F5CI
R 123 (HCFC 123)	Dichlortrifluorethane	C2HF3C12
R 125 (HFC 125)	Pentafluorethane	CF3CHF2
R 134a (HCF 134a)	Tetrafluoroethane	C2H2F4
R141b (HCFC141b)	Fluorodichloroethane	C2C12FH3
R 143a (HFC 143a)	Trichlorethane	CF3CH3
R152a (HCF152a)	Dichlorethane	C2H4F2
R 290 (HC 290)	Propane	C3H8
R 600 (HC 600)	Butane	CH3CH2CH2CH3
R 600a (HC 600a)	Isobutane	CH(CH3) 3
R 717	Ammonia	NH3
R 718	Water	H20
R 744	Carbon Dioxide	CO2
R 764	Sulfurdioxide	SO2

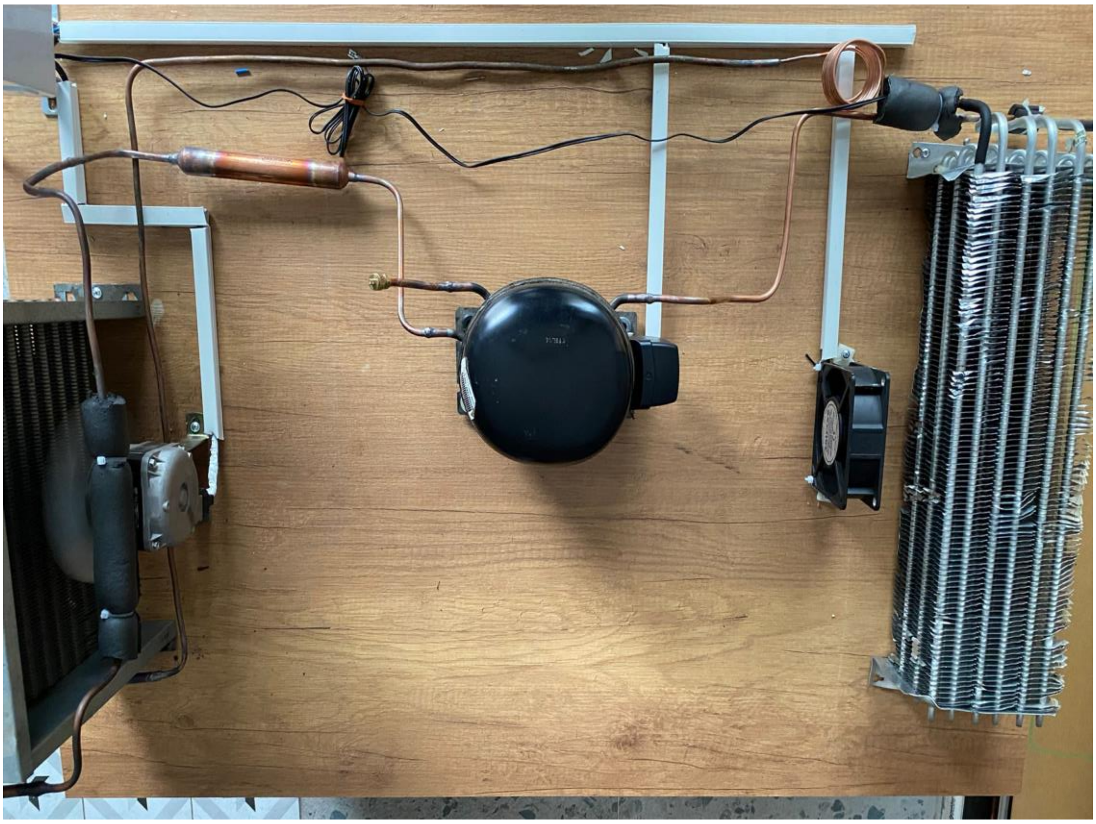
Refrigerants are stored in a pressurized tube. In addition to having the fluid name on such tubes, the colors of each refrigerant tube can also indicate which fluid is contained in the tubes (Table 5.4).

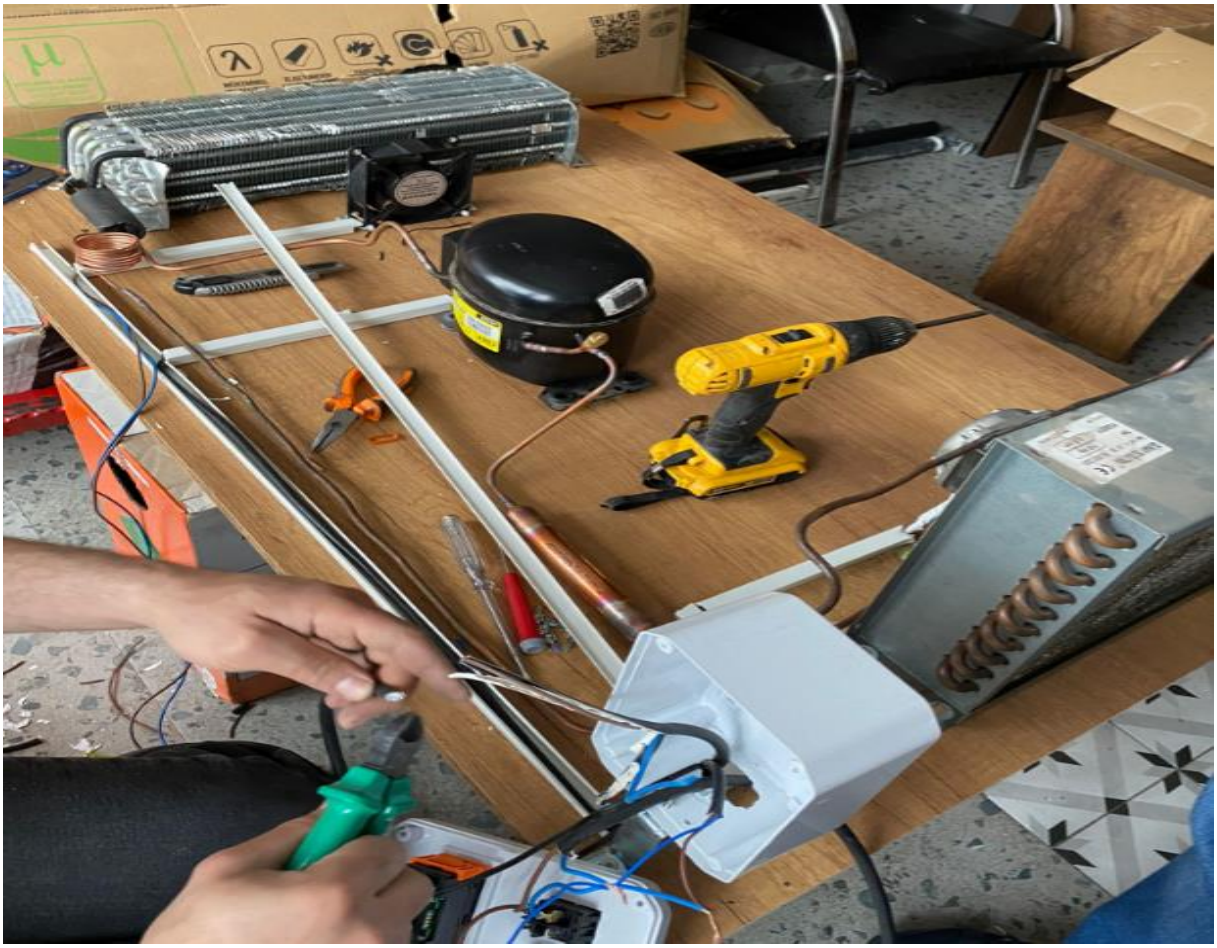
Refrigerant	
R 12	R 502
R 134A	R 404A (HP62)
R 401A	R 507
R 409A	R 402A (HP80)
R 500	R 408A
R 401B (MP66)	R 402B (HP81)
R 13	R 22
R 503	R 407C
R 23	R 410A
R 508B	

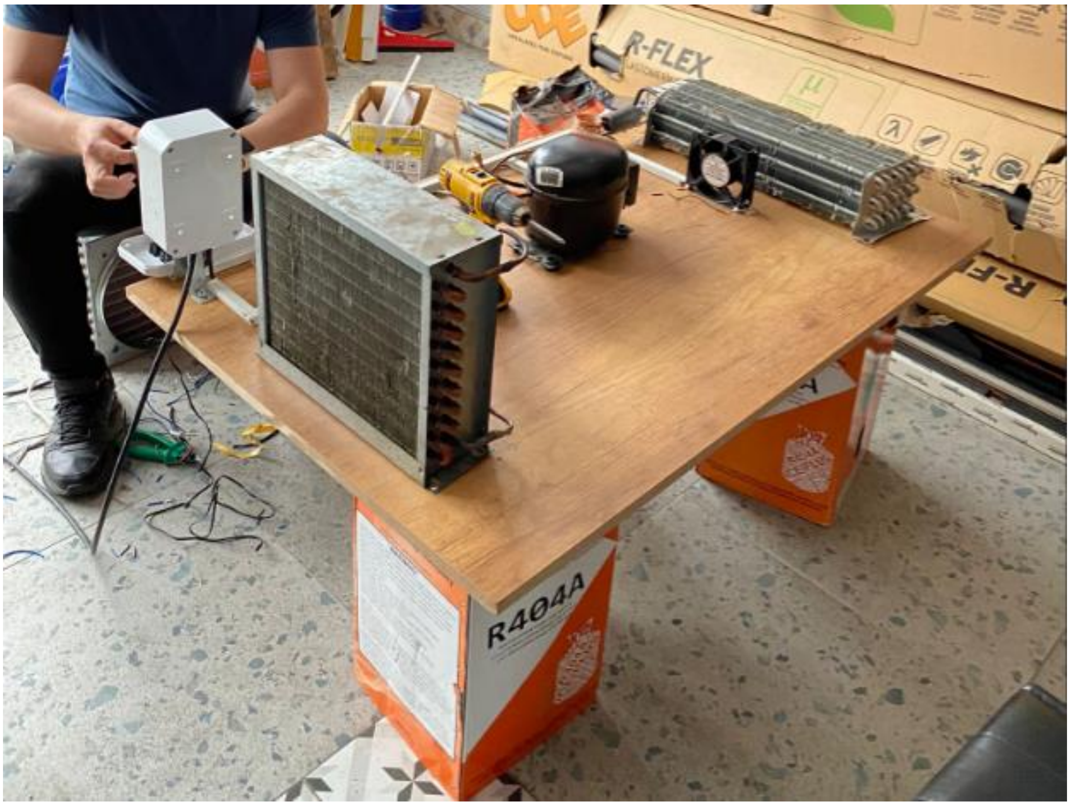
REFRIGERATOR SYSTEM WITH AUXILIARY CIRCUIT ELEMENT

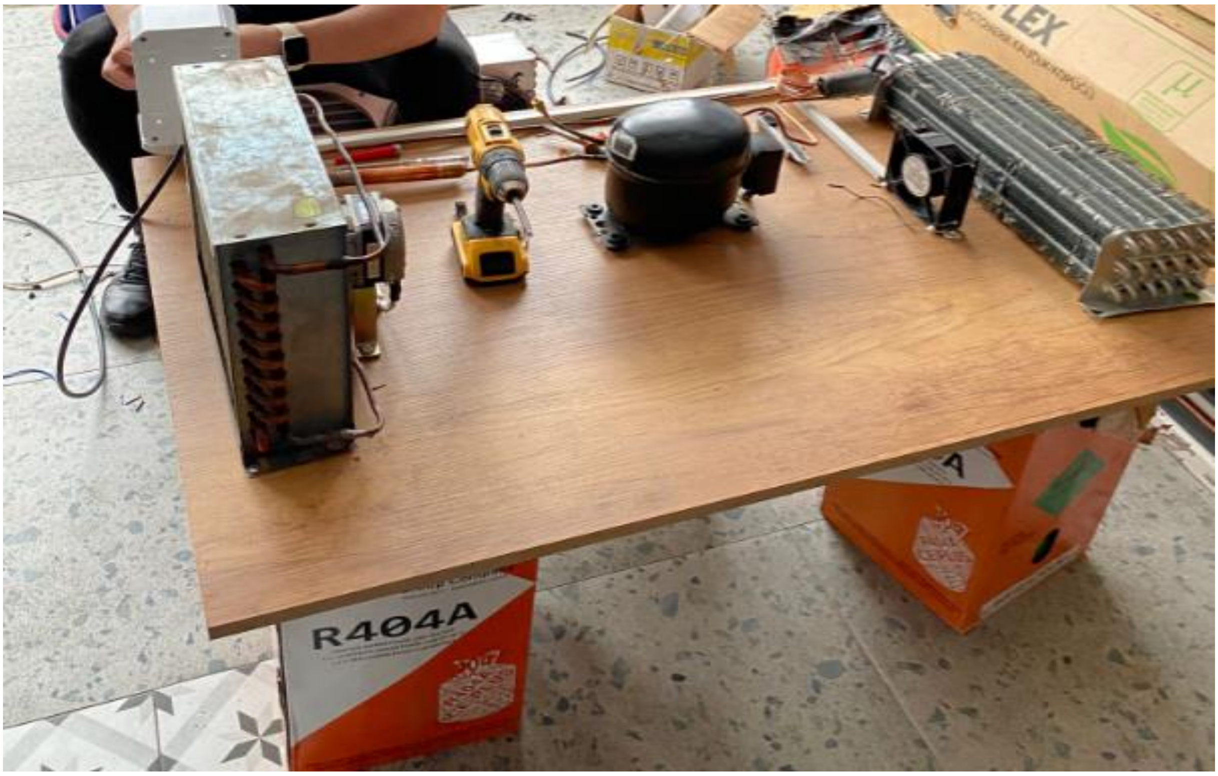
- Start by taking the necessary occupational safety measures.
- Determine the places where the main elements will settle on the coffee table (Figure 2.42).
- Fix the main elements with the help of a handbrake.
- Measure the distances Decoupled between the elements.
- Cut the copper pipe according to the size with pipe cutting scissors.
- Ream the cut places with the help of a reamer.
- Open the muf to the required ends of the pipes with the muf opening apparatus.

- Open the auxiliary circuit elements connection, and the welded connection is the muf. With Rack if the connection is, open the countersink.
- Solder the welding points with the help of oxy-gas welding kit.
- Check the soldering process you are doing by eye.
- While performing the installation process, work with your friends in a group, coordinated and cooperative.
- Clean the environment in which you work and separate the resulting waste properly.
- Please deliver the hand tools you use to the tool shop.






R-FLEX
R404A


R404A

14. Idealized log p-h diagram of an evaporator

If an evaporator is operated alone at a certain evaporation pressure, a simplified log p-h diagram can be drawn as follows.

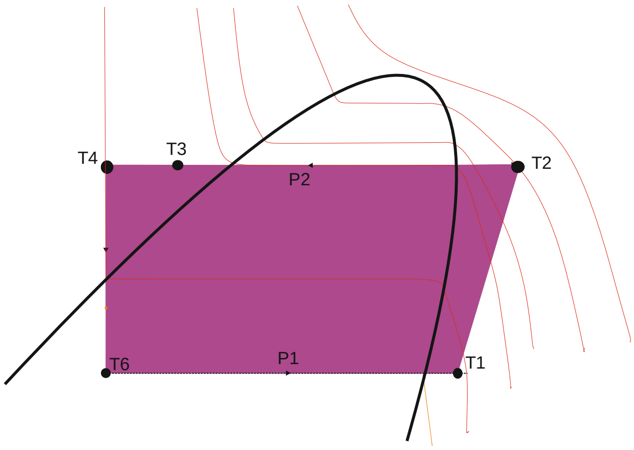


Figure 7. Thermodynamic cycle for the evaporator at a given pressure

15. Capacity calculation

Cooling capacity

By operating the evaporators, their capacity can be calculated

The cooling capacity is shown in Fig. 7 For independent operation with a single evaporator, the thermodynamic cycle can always be determined by the same process. You can also use the example calculation below.

$$Q_0 = m_r.(h_1 - h_6)$$

Since the volume flow is calculated in the system, this should be used to calculate the mass.

Flow:

$$m_r = V_r.\rho_r$$

Condenser capacity:

The operating mode of the system is not important in the measurements to be used to calculate the condenser capacity. The capacity should always be determined according to the following.

$$Q_{kon} = m_r.(h_2 - h_4)$$

Mass flow formula:

$$m_r = V_r.\rho_r$$

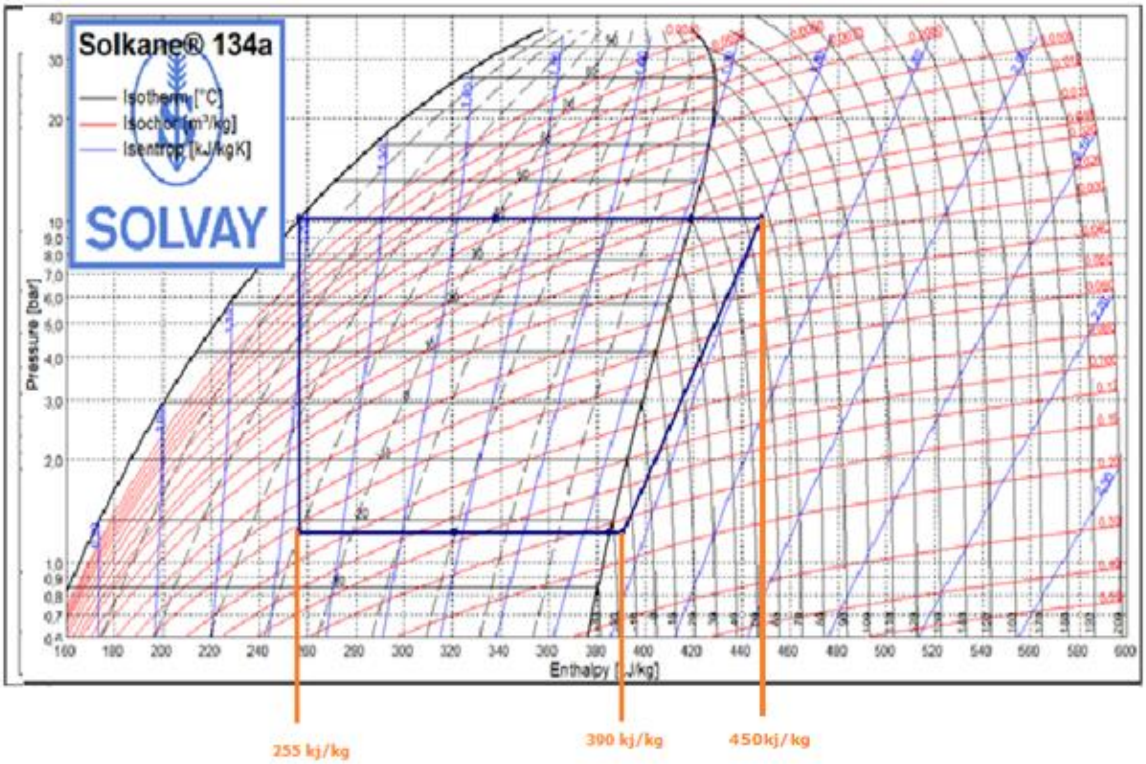
Compressor capacity:

Compressor capacity can be determined by using the enthalpy difference between the amount of refrigerant cycled in the system and compressor inputs and outputs (using refrigerant log p-h).

The method is the same as in the calculation of evaporator and condenser capacity. However, in this case, it should be remembered that the electrical energy consumption of the compressor can be quite high.

The reason for this is thermal and volumetric losses, which are estimated using the log p-h diagram.

$$Q_{komp} = m_r.(h_2 - h_1)$$



16. Calculation of system properties

Cooling capacity

The cooling capacity is calculated as follows:

$$Q_{evp=}(h_1 - h_5).m_s$$

Multiplying the difference in the enthalpy values realized in the evaporator with the mass of refrigerant entering the cooler gives the evaporator capacity. Firstly, the refrigerant mass flow should be determined by multiplying the volume flow by the density of the refrigerant R134a. Here the density (for R-134a gas) can be taken as 1.12kg /L.

$$m_s = \dot{\rho}_s . V_s$$

$$m_s = 1{,}12 \frac{kg}{lt} * 19 \frac{lt}{h} * \frac{1\,h}{3600s}$$

$$m_s = 0{,}0059\ kg/s$$

$$Q_{evp} = (390000 j/kg - 255000 j/kg). 0{,}0059$$

$$Q_{evp} = 795\ \mathrm{W}$$

17. Condenser Capacity

To calculate the condenser capacity, the enthalpy at point 2 (Compressor output) is subtracted from the enthalpy at points 3-4, the difference is taken and multiplied by the refrigerant mass flow. (Here, since the enthalpy value at points 3 and 4 is equal, any one can be taken)

$$Q_{evp=}(h_2 - h_4). m_s$$

$$Q_{con=}(450.000\mathrm{j/kg}-255.000\mathrm{j/kg}). 0{,}0059\ kg/sn$$

$$Q_{con} = 1150\ \mathrm{W}$$

18. Compressor capacity

The compressor capacity transferred to the refrigerant is equal to the difference between the condenser capacity and the evaporator capacity Decoupled. It can be calculated with two different formulas.

$$Q_{comp} = (h_2 - h_1). m_s$$

$$P_{comp} = Q_{kond} - Q_{evp}$$

$$Q_{comp} = (h_2 - h_1). m_s$$

$$Q_{komp} = (455.000\ j/kg - 390.000\ j/kg). 0{,}0059\ kg/sn$$

$$Q_{comp} = 383\ W$$

19. Technical data

1. Sizes
2. Length x Width x Height 1200 x 800 mm
3. The approximate weight is. 80 kilos
4. Power supply:
5. Voltage 230 V
6. Frequency 50 Hz
7. Rated consumption (output)1/4 hp
8. Refrigerant R134a
9. The amount of refrigerant is 1.5 kg
10. Compressor: 250V/50Hz
11. Evaporation working space: -35/+15 oC
12. Cooling capacity: (+7°C/+54°C): 840 W
13. Power consumption (+7°C/54°C): 504 W
14. Number of cylinders: 1
15. Piston diameter: 26 mm
16. Piston stroke: 21 mm
17. Piston volume: 7.95 cm3
18. Condenser (Condenser)
19. Power output (R134a) approx. 180 W
20. Fan flow rate: 80 m3/h
21. Evaporator
22. Cooling capacity (R134a) (-10°C/45) 180 W
23. Fan flow rate: 80 m3/h at 50 Hz

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