ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889,
2024-6.875 ResearchBib IF: 8.848 / 2024

THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-4, ISSUE-3

WORKING PRINCIPLE OF A HEAT PUMP

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Abstract. *The article provides information about the operating principle of a heat pump. The heat pump stands as a remarkable technology for heating and cooling spaces efficiently, offering a sustainable alternative to traditional heating systems. This abstract delves into the intricate working principle of heat pumps, elucidating the mechanisms underlying their operation and their pivotal role in energy conservation. At its core, a heat pump operates on the principle of transferring thermal energy from a low-temperature source to a higher-temperature reservoir. This process is orchestrated through a cyclic sequence of phases, encompassing compression, condensation, expansion, and evaporation of a refrigerant fluid.*

Keywords. *Heat pump, Carnot cycle, evaporation, refrigerant, compression, expansion, condensation*

Аннотация. *В статье представлена информация о принципе работы теплового насоса. Тепловой насос представляет собой замечательную технологию эффективного обогрева и охлаждения помещений, предлагая устойчивую альтернативу традиционным системам отопления. В этом реферате рассматривается сложный принцип работы тепловых насосов, объясняются механизмы, лежащие в основе их работы, и их ключевая роль в энергосбережении. По своей сути тепловой насос работает по принципу передачи тепловой энергии от источника с низкой температурой к резервуару с более высокой температурой. Этот процесс осуществляется посредством циклической последовательности фаз, включающих сжатие, конденсацию, расширение и испарение хладагента.*

Ключевые слова. *Тепловой насос, цикла Карно, испарение, хладагент, сжатие, расширение, конденсация*

Introduction:

It has long been known that heat is transferred spontaneously from a hotter object to something colder. This was enshrined in one of the formulations of the second law of thermodynamics. In order to transfer heat in the opposite direction, work is required. A heat pump is used for these purposes. It requires energy to operate. The greater the temperature difference between the media that participate in this process, the greater the amount of energy expended.

Heat pumps - heat engines that are designed to produce heat using a reverse thermodynamic cycle.Heat pumpstransfer thermal energy from a low temperature source to a higher temperature heating system. During the operation of a heat pump, energy costs occur that do not exceed the amount of energy produced.

The operation of a heat pump is based on a reverse thermodynamic cycle (reverse Carnot cycle), consisting of two isotherms and two adiabats, but unlike the direct thermodynamic cycle (direct Carnot cycle), the process proceeds in the opposite direction: counterclockwise.

A heat pump can also be called a “refrigerator in reverse”, since a heat pump is the same refrigeration machine, only unlike a refrigerator, a heat pump takes heat from outside and transfers it into the room, that is, it heats the room (a refrigerator cools by taking heat from the refrigeration chamber and throws it out through the capacitor).

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1. Evaporation (heat gain): A heat pump draws heat from a heat source (such as air, water or soil) by evaporating a working fluid (usually freon or a similar refrigerant) in an evaporator. During the process of evaporation, thermal energy from the environment is transferred to the refrigerant, which turns from a liquid to a gaseous state.
2. Compression (increase in pressure and temperature): The refrigerant gas is then compressed by the compressor, causing its pressure and temperature to increase. In this case, the thermal energy received from the heat source is concentrated in the refrigerant.
3. Condensation (heat loss): The compressed refrigerant gas transfers its thermal energy to the heating system or hot water in the condenser. In this case, the refrigerant condenses back into a liquid state, releasing its heat to the environment.
4. Expansion (pressure and temperature reduction): Liquid refrigerant passes through an expansion valve where its pressure is reduced, causing its temperature to decrease. The refrigerant prepared in this way is again sent to the evaporator to begin a new cycle.

The design of the simplest heat pump

The design of the simplest heat pump includes 2 heat exchangers. One of them is called an evaporator, and the second is a condenser. The evaporator maintains a temperature below the medium from which heat is removed. Such a medium can be water, soil, air, etc. As a result, heat transfers to the refrigerant, which has a lower temperature. The capacitor has a temperature higher than the temperature of the medium to which heat must be transferred. This medium, or rather the body, is the heating system. The temperature difference between the evaporator and the condenser is ensured by the refrigerant that circulates between them. It can change its phase state, pass from a liquid to a gaseous state, depending on the pressure level.

Low-boiling chemicals are used as refrigerants, which at a certain pressure in the compressor change from liquid to gaseous state and vice versa. The compressor as part of a heat pump is the main consumer of electrical energy. If we delve a little deeper into the theory, we can say the following. The movement of molecules in any substance stops only at absolute zero. But if the temperature is different from this value, then the molecules move and heat can be taken from this medium and moved to another body or medium.

Most heat pumps used today are vapor compression.

There are also varieties such as

- Electrochemical.
- Thermoelectric;
- Absorption;

The operation of heat pumps is usually characterized by the energy transformation coefficient (Ctr), which is determined by the formula:

Ktr = Tout / (Tout - Tin), where

Tout – temperature at the pump outlet; Tвх – temperature at the pump inlet.

That is, Ktr is the ratio of the heat that goes into the heating system to the energy that is spent to ensure the functioning of the heat pump. In reality, the Ktr coefficient differs from what is calculated using this formula. The difference is equal to the value of the coefficient h, which takes into account energy losses and the degree of thermodynamic perfection. Energy is also spent to ensure the operation of shut-off valves, pumps, control circuits, etc.

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THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-4, ISSUE-3

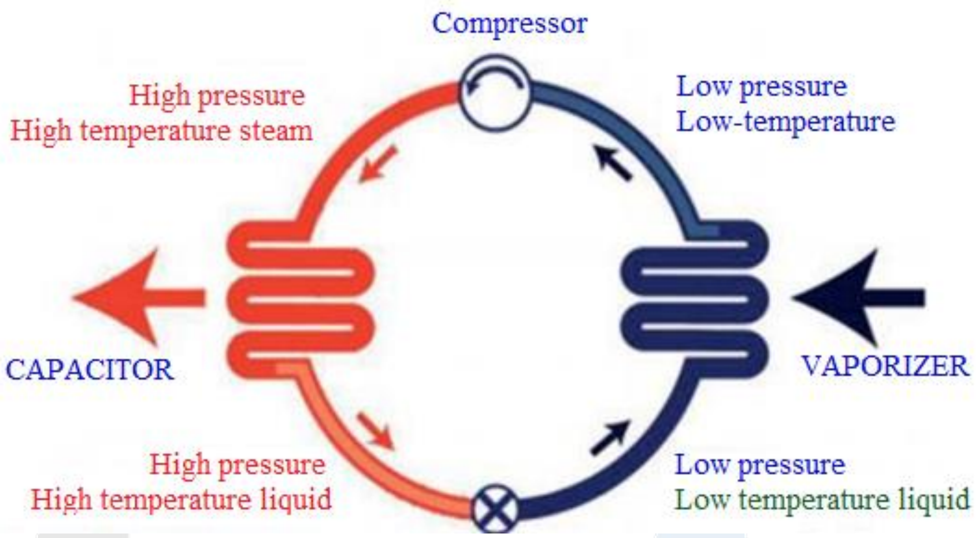

Figure 1 - Operating principle of a heat pump

The principle of operation of the HP is shown in Figure 1. After boiling, the refrigerant, moving through the pipeline, enters the compressor, which operates using 30 electric power. This device compresses the gaseous refrigerant to high pressure, causing its temperature to rise. The hot gas enters the condenser, in which the heat of the refrigerant is transferred to the coolant circulating through the internal circuit of the heating system. As it cools, the refrigerant turns into a liquid state, after which it passes through the capillary pressure reducing valve, losing pressure, and then again ends up in the evaporator. Thus, the cycle is completed and the process is ready to repeat.

A little later, the principle of the reverse Carnot cycle was discovered. When a substance evaporates, it absorbs heat, and after condensing on the surface, it releases it. It is this law that underlies refrigerators and air conditioners. A low-temperature air heat pump works like these household appliances, only in the opposite direction.

The basic principle of a heat pump is to accumulate low-temperature heat during evaporation and further release energy during subsequent condensation. This process occurs without a change in temperature, unless the working fluid is mechanically compressed, which will lead to an increase in temperature.

Conclusion:

A heat pump functions like a refrigerator, only in reverse: a refrigerator transfers heat from inside to outside, while a heat pump transfers heat from the environment to inside. The natural heat of the coolant (which is water or brine) is transferred to the evaporator. The internal circuit of the heat pump is filled with refrigerant (working substance: freon, ammonia, methane, propane, etc.), which, passing through the evaporator, turns from liquid to gaseous. From the evaporator, the refrigerant gas enters the compressor, where it is compressed to high pressure and high temperature. Next, the hot gas enters the condenser, where heat exchange occurs between the hot gas and the coolant from the return pipeline of the home heating system. The refrigerant transfers its heat to the heating system, cools and turns into a liquid again, and the heated condenser transfers heat to the heating system.

The primary circuit of a heat pump consists of elements involved in obtaining heat from an external source - for example a heat exchanger, brine circulation pump or air fan, and in a water-

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VOLUME-4, ISSUE-3

to-water heat pump also an intermediate heat exchanger. The secondary circuit includes the components necessary to convert energy and transfer it to the consumer.

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ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889,
2024-6.875 ResearchBib IF: 8.848 / 2024

THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

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