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Theoretical Foundations of Energy Saving

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Abstract — *This article analyzes the theoretical basis of energy saving measures in enterprises.*

Keywords — consumption of energy, energy conversion, energy resources, heat of the system , enterprises.

Introduction

The final consumption of energy by a person, society or industrial production (heat, light, electricity, sound, movement, etc.) has always corresponded to the level of development of civilization. At the same time, the extraction and production of energy resources significantly, several times, exceeds the final energy consumption. This is explained not so much by the shortcomings of existing energy technologies as by fundamental limitations associated with the very nature of energy conversion processes. The main stages of converting fossil fuel energy into electricity are as follows. The chemical energy of the fuel in the combustion process is converted into the internal energy of water vapor, then in the process of steam expansion, its internal energy is converted into mechanical energy of the turbine generator rotor rotation. Further, the electrical energy received in the turbine generator after transformation and transmission through the networks will be consumed by the consumer.

Materials and methods

Such stages are present in many types of power plants. The laws of energy conversion are the subject of thermodynamics. This area of science developed back in the 19th century. But its basic laws constitute the fundamental foundations of modern scientific knowledge. For a quantitative comparison of various methods of energy conversion, the simplest criterion is the efficiency, calculated by the formula

$$\eta = \frac{W}{E} 100\%,$$

where W is the useful work being performed;
E - expended energy.

The efficiency of existing power plants differs quite significantly. So the efficiency of a thermal condensing power plant (IES) is about 40%, a combined heat and power plant (CHP) - 60%, and a diesel power plant DES - 20%.

The simplest model of a power plant can be the diagram shown in Fig. 1.

In such a simple system, three main processes are performed over the working fluid: evaporation, expansion, condensation.

The arrows connecting these three processes show the direction of movement of the working fluid. The energy supplied to the system in the form of combusted fuel is spent on the evaporation of the working fluid (water). At point B, the working fluid is steam with high temperature and pressure. Then the working fluid expands, causing the rotor of the turbine generator to rotate, producing electrical energy.

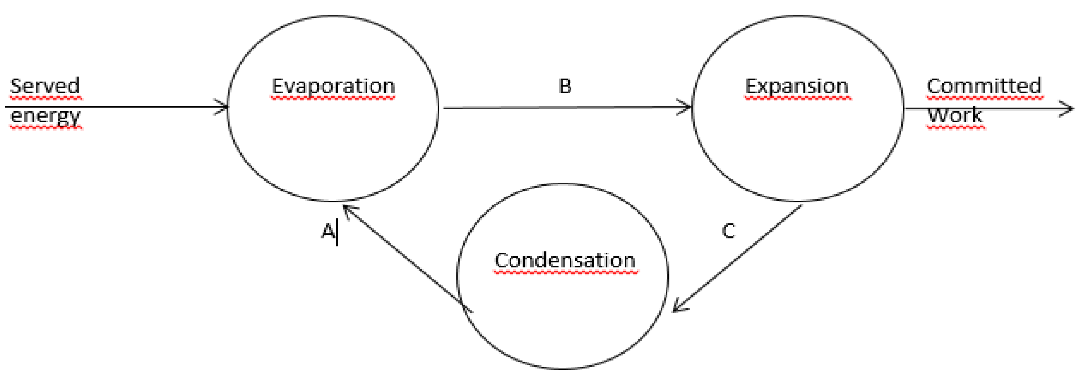

Fig. 1. The simplest model of a power plant

At point C, the working fluid is steam, which has a low temperature and very low pressure. In the condenser, the working fluid is again transferred to a liquid state. The energy that needs to be removed from the system to condense the steam is usually taken away by the cooling circulating water. The working fluid is returned to the steam generator by a feed pump. The amount of energy supplied to the system in total is equal to the amount of energy removed and the work performed. To change the state of aggregation of the working fluid, its evaporation or condensation, it is necessary to supply or withdraw a certain amount of energy. And the working body has the ability to store energy. If the change in the internal state of the working fluid is characterized by the amount of energy stored by it ΔE, then the mathematical expression of the first principle of thermodynamics - the law of conservation of energy for a system that exchanges energy with the external environment in the form of heat and work W, is expressed as follows:

$$Q = \Delta E + W,$$

where Q is the heat of the system.

Discussion

The efficiency of a power plant is always less than one. When $\eta = 1$, all the energy supplied to the system is converted into work. In practice, such a coefficient of efficiency can be obtained, but not in a cyclic process. An example is the isothermal expansion of a gas. It can only go until the moment when the pressure becomes equal to the atmosphere. But the cyclic sequence of processes for which Q = W, ΔE = O is impossible to implement, although this does not contradict the first law of thermodynamics. This contradicts the second law of thermodynamics: it is impossible to build a periodically operating machine, the whole action of which would be reduced only to converting the heat received from the source into work.

Removal of a certain amount of heat from the working fluid to the cold source is a prerequisite for the implementation of the heat engine cycle. The work in the cycle is equal to the difference between the supplied and removed amount of heat:,

$$W = Q_1 - Q_2,$$

$$\eta = \frac{Q_1 - Q_2}{Q_1}.$$

where is the time of maximum losses.

The maximum possible efficiency of the cycle of a power plant in the idealized case is determined by the ratio of the temperatures of hot T_1 and cold T_2 sources:

$$\eta = 1 - \frac{T_2}{T_1}.$$

Such an ideal power plant is called the Karnot heat engine. This machine works as follows:

- the working fluid is adiabatically compressed, the temperature rises to T_1;
- the working fluid expands isothermally, performing work W;
- the working fluid expands adiabatically until the temperature drops to T_2;
- the working fluid is isothermally compressed until its internal energy assumes its initial value, dumping it into a cold source ΔE.

It is known that no other machine can achieve greater efficiency over the same temperature ranges. The value $\eta = 100\%$ corresponds to the condition: $T_2 = 0$, which in principle cannot be achieved.

Real thermodynamic cycles used in real heat engines - internal combustion engines (Otto, Diesel, Wankel cycles), steam and gas turbines (Rankine, Brayton cycles), refrigeration machines and heat pumps can differ quite significantly in their weight and size characteristics. , ecological and other quality properties. However, economic characteristics show the degree of their approach to the ideal.

Thus, the processes of energy conversion are always associated with its losses. At the same time, a significant part of the losses is determined by the fundamental laws of nature and, in fact, determines the technological consumption of energy in the processes of its transformation. Another part of energy losses is associated with deviations of real technological processes from the ideal. Finally, the remaining part of the loss is determined by improper operation of technological installations, incorrect setting of the technological mode, idle runs of equipment, uneconomical loading or poor insulation. It is in this last part that one should first of all look for the most effective energy saving solutions.

$$\Delta A = \frac{P^2 + Q^2}{U^2} R \tau ,$$

With regard to the electrical part of a power plant, complex or system, improving the efficiency of energy use most often consists in reducing electricity losses. If on the network section voltage U with active resistance R active power P and reactive Q flow, then electricity losses ΔA are determined as follows:

where is the time of maximum losses.

Measures to reduce losses in networks immediately become obvious:

• reactive power compensation;
• increasing the voltage level of the network;
• increasing the cross-section of wires to reduce resistance;
• reduction of transmission distance - reduction of resistance;
• reducing the time of losses;
• reduction of the maximum load.

Conclusion

The most complete picture of the state of extraction, production, transmission and consumption of energy resources is provided by the analysis of the balance of energy resources. The balance can be drawn up for any energy-using installation, enterprise, territory, region, country. Energy balancing consists in measuring and calculating energy flows by sources and areas of use. Balance analysis allows you to compare the useful use of energy resources and losses. The structuring of the balance is usually carried out by the types of energy resources used, by energy-using equipment, by workshops, buildings, production facilities, areas, types of converted energy, types of products, etc.

The balance of energy resources in this case allows you to get a clear idea of the efficiency of their use. So, the full coefficient of efficient use of energy resources is

$$k_и = 1 - 0.66 = 0.34$$

The utilization rate of energy resources in the consumer complex (industry, transport, agroindustry, commerce) is equal to

$$k_{иП} = \frac{34+7.3+3.8+2.9-24}{34+7.3+3.8+2.9} = \frac{24}{48} = 50\% .$$

The coefficient of efficient use of energy in the energy complex of the region (power plants and boiler houses) is

$$k_{иЭ} = \frac{40+38-34}{40+38} = 0.56\%$$

Energy balancing is based on the reliable collection of information about energy flows and their measurements.

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