Energy saving in electric resistance furnaces

Electric resistance furnaces (**ERF**), based on the release of heat in the conductors during the passage of electric current through them - a very common type of **electrical load** and are of particular interest to **energy auditors**.

First, the technical characteristics of **ERF** during operation can change significantly due to aging of electric heaters and linings, as well as when using materials that differ in properties during repair work.

Secondly, the **specific consumption of electricity** in **ERF** depends on the schedule of their operation. Many furnaces were once designed for three-shift modes of operation in terms of serial production, and now they are used in other modes.

Thirdly, new heat-insulating and heat-resistant materials have appeared and become available, which allow to modernize **ERF** and make them more energy-efficient.

The purpose of **ERF** energy inspections is to determine the compliance of technical characteristics to their passport data and to assess the correctness of their modes of operation. In case of identification of reserves to **increase the efficiency** of the surveyed **ERF**, the result should be recommendations for **organizational and technical measures to reduce the specific consumption of electricity**, and should be calculated **economic effect and payback period of capital costs**.

ERF are divided into furnaces of periodic action and continuous action.

Periodic action **ERF** on type of a design happen: chamber, mine, cap, elevator, crucible, etc.

ERF of continuous action are intended for heat treatment of details in serial type of production. There are quite a lot of them by type of construction. The name of the type of furnace is based on the type of mechanism used to move the workpieces through the furnace. **ERF** of continuous action are: conveyor, roller conveyor, drum, pusher, etc.

At longer lengths of the working space of the **furnace**, **ERF** is divided into several thermal zones. Each zone has an independent power supply, its own thermocouple and temperature controller. Two-position temperature control is most often used in **ERF**. The operating temperature of the heating zone is set on the controller setpoint, after reaching this temperature the electric heaters of the zone are switched off, the zone begins to cool down and, after reaching the lower insensitivity temperature, the heaters are switched on again.

The assessment of the technical condition of the **ERF** usually begins with an inspection of the furnaces: whether the furnace doors fit tightly, whether the heat shields are in good working order, whether the seals are not damaged, or whether the quality of painting the casings is satisfactory.

All kinds of leaks and holes in the lining cause a significant increase in heat loss. The loading and unloading openings of the oven should not be left open unnecessarily, the oven door should be well sealed. In continuous furnaces in which the loading or unloading openings are open during operation, care must be taken to ensure that their dimensions correspond to the dimensions of the parts included in the furnace and to arrange screens, such as asbestos, in these openings.

When painting the furnace casing with aluminum paint, **heat losses** are reduced by 2 - 3% by reducing the radiation coefficient of the furnace casing. Therefore, painting the furnace with aluminum paint must be carried out.

At inspection of furnaces it is necessary to reveal **ERF** with the raised temperature of a casing. Most likely, this can be done with a thermal imaging scanner. It is convenient to determine the temperature of the casing with an infrared thermometer for non-contact temperature measurement. More precisely, the temperature of the casing can be measured using a surface thermocouple. The temperature of the outer surface of the casing should be not higher than 30-40 °C at the operating temperature of the furnace 700-800 °C and not higher than 40-50 °C at the operating temperature of 800-1200 °C. Such furnace casing temperatures provide good conditions for service personnel and relatively small **heat losses** (not more than 300 ÷ 400 W / m2).

If the surface of the casing has a high temperature, it indicates an unsatisfactory condition of the furnace lining. Sometimes during the repair of the lining use the available materials, which may differ in properties from the design materials for the worse. There are even cases of using a brick battle to repair the lining, when the brickwork was replaced by backfilling. This is due to the desire to save money on overhaul of the furnace. However, in the future you have to pay for increased **electricity consumption**. Therefore it is not necessary to save on the cost of thermal insulation. On the contrary, if possible, when repairing **ERF**, it is desirable to replace the existing thermal insulation with a more perfect one. Recently, you can order almost any of the most effective insulation materials. On average, it can be assumed that each cubic meter of high-quality thermal insulation in **ERF** gives from 5000 to 10000 kWh of **electricity** savings per year. The cost of this **electricity** saved per year will be higher than the cost of high-quality insulation, and the latter will pay for itself in less than 1 year.

Do not try to reduce the temperature of the casing by excessively increasing the thickness of the lining, as this increases the **loss of electricity** for heat accumulation and increases the heating and cooling time of the **furnace**.

Improving the efficiency of the **furnace** can sometimes be provided by increasing its productivity. This is possible if there is some power reserve. If in the second half of heating (for the furnace of periodic action) in the furnace there are frequent shutdowns and the period of the disconnected condition is big (50-70% of the general time), the furnace is used insufficiently and its productivity can be increased.

You can increase the productivity of the **furnace** by raising the operating temperature (by changing the setpoint of the thermostat). This is possible provided that the heating elements allow their operation at elevated temperatures. With increasing temperature in periodic **furnaces**, the heating time will decrease, and in continuous furnaces, simultaneously with the increase in the operating temperature of the **furnace**, it is necessary to increase the speed of movement of products in the **furnace**. When heating massive products, the temperature differences with increasing furnace temperature must be calculated and agreed with the technologists. The final temperature differences can be reduced by reducing the temperature of the thermostat at the end of heating to the original. At the same time in **furnaces** of periodic action it is necessary to change temperature settings of a temperature regulator twice during a cycle. In methodical multi-zone furnaces this can be achieved by setting the regulator in the first zones at the maximum allowable temperature of the heaters, and in the last zone - at the temperature set by the technological process.

When the productivity of the **furnace** corresponds to its power and it is fully used, the question may arise about the feasibility of increasing the power of the furnace. This increase in power can be effective for products that do not require long exposure, ie during hardening, normalization and tempering, as well as when heating workpieces for forging and stamping. At the same time for **furnaces** of periodic action increase in productivity and decrease in specific consumption of the **electric power** will take place also at the expense of reduction of time of warming up of the **furnace**.

The power of the **furnace** can be increased by recalculation and processing of heating elements. At the same time power cables and switching equipment should be checked also. In some cases, it is possible to increase the capacity because many **ERF**s have insufficient power.

ERFs often have a power factor equal to one. Sometimes **ERF**s are provided with step-down transformers and control transformers, which leads to a decrease in power factor.

The power of individual **furnaces** ranges from fractions of a kilowatt to several megawatts. At a power of 20 kW and above **furnaces** are usually three-phase, so ERF, as a rule, are symmetrical loads.

In some cases, **ERF**s are very sensitive to voltage changes. The mode of operation of **ERF** at voltage decrease essentially worsens, duration of technological process and, consequently, production cost increases. Thus, when the supply voltage is reduced by 7% in the resistance **furnace** for annealing of non-ferrous metal blanks (**furnace** power 675 kW), the duration of the technological process increases from 3 to 5 hours. And when the supply voltage is reduced by 10%, annealing becomes impossible. High-temperature and low-power **ERF** are especially sensitive to voltage changes. In some cases, in order to prevent a massive shortage of products, it is necessary to feed the **furnace** through voltage stabilizers maintained with an accuracy of ±1%.

Resistance **furnaces** are often placed in groups, forming thermal sections and shops. In these cases, the schedule of their **electricity consumption** is almost completely uniform, because the time of switching on and off the **furnaces** and zones of each furnace do not coincide.

Measures to save electricity in ERF

As a result of the survey it can be found that the **furnace** has an increased **specific consumption of electricity**, which can be reduced without large capital costs, carrying out only low-cost and (or) organizational measures, such as:

- Changing the mode of operation of the **furnace** (for example, switching the furnace from one-shift operation to three-shift operation, etc.);
- Increasing the productivity of the **furnace** by increasing its operating temperature;
- Timely repair work (replacement of heating elements, linings, seals, painting the furnace casing with aluminum paint, etc.);
- Proper operation of the **oven** (make sure that the loading and unloading openings are not open unnecessarily, so that the heated products are correctly placed in the oven during loading, etc.).

The average cost measures to reduce the **specific consumption of electricity** include the following:

- Replacement of the thermal insulation available on the **furnace** with a more efficient one;
- Increasing the power of the **furnace** by replacing the existing heating elements with more powerful heaters with simultaneous replacement (if necessary) of power cables and switching equipment;
- Use of heat of cooling products to preheat other products before loading them into the **oven;**
- Reduction of loading and unloading time due to improvement or replacement of appropriate **furnace** mechanisms.

High-cost measures include:

- Replacement of a **furnaces** of periodic action with a continuous **furnace** (in series production), or vice versa, when mass production has become virtually individual;

Replacement of a furnace with a longer heating time with a furnace made of better thermal insulation materials and with less **energy loss** for heat accumulation and time heating (this measure is especially effective when from serial production pass to individual and instead of the furnace of continuous action it is necessary to establish the furnace of periodic action).