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Abstract. The role of the solar energy as a natural energy source for the synthesis of electric heaters is discussed in this article. The work of famous scientists on the development of the field of using energy devices based on solar energy in heat supply systems is presented. In addition, you will get acquainted with the most popular and probably unfamiliar electric heaters, their types, and modes of operation. You will also learn about the process of making electric heaters imported to date based on solar energy. Where and why electric heaters are used, their functions, you will be able to use a local product that completely replaces the imported product.

Key words: solar energy, electric heaters, silicon carbide, chrome lanthanum, humidity conditions, resistance heating, oven.

INTRODUCTION

The problems discussed in this article lead to the problems of ensuring a stable mode of operation of electric heaters, increasing the speed of production and reducing power losses, thermal engineering processes, the relationship between the parameters of the base area. In this article, based on a review of the ability of electric heaters to heat up to 17000C, the dynamics of temperature change and the maximum operating temperature in each part of the electric heater are determined, depending on their duration. The characteristics of the obtained results and the optimized state of their application in high-temperature electric furnaces are of interest. This article will help to expand the concepts in distinguishing the types of the electric heaters from each other. The famous scientists as Strebkov D.S., Kharchenko V.V., Alekseev V.V., Vissarionov V.I., Kazanyan B.I., Tarnievsky S.N., Andersen B., Beckman U., Duffy J., Klein S., McVeig D., Khrustov B.N. and Uzbek scientists as Zakhidov R.A., Avezov R.R., Klychev Sh.I., Abbasov E.S., Abdurakhmonov A. Mamatkosimov made a great contribution. In particular, they conducted the research on the development of energy-efficient technologies for using the solar energy in the production of ceramic materials, improving the temperature and humidity conditions and modeling heat and mass transfer processes for optimal control of technological processes. Although the use of solar energy for ceramic materials is widely used in foreign countries (Russia, Ukraine, etc.). The insufficient attention is paid to solving the complex requirements for the parameters of high-temperature electric heaters using renewable energy sources, especially solar energy. [1-4].By converting the solar energy into heat, the use of a set of the solar energy devices can increase the productivity by up to 50% by automatically adjusting energy consumption in the production of high-temperature electric heaters, as a result of which these designs can reduce capital costs by 60-70%.

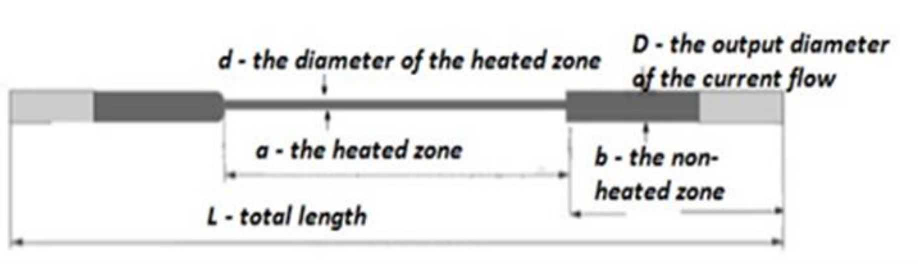
METHODS AND MATERIALS

Particular attention is paid to the development of new types of high-temperature electric heaters, which is one of the most promising directions in the rapidly developing ceramics industry in the world today, as well as the improvement of high-temperature electric heaters based on carbide silicon and chrome-lanthanum. A distinctive feature of electric heaters is their electrical resistance. It is much higher at room temperature, but drops to a minimum as the temperature rises to 800°C. When the temperature limit exceeds 800°C, the resistance of the heater increases by about 5% every 100°C between 1000 and

1500°C. Therefore, by measuring the resistance at room temperature, note that these values do not correspond to resistance values at operating temperature of the same heater. This should be taken into account when choosing heaters and connecting them to groups. The resistance of a high-temperature electric heater is measured in an open field at a constant temperature of 1000-1500°C in a steady state of the working part, and its value is calculated by dividing the supply voltage by the current flowing through the heater. In this regard, the principle of operation of electric heaters is one of the important tasks in creating a new type of improved requirements for the strength of external influences on heat, maintaining its condition and varying levels of color. In the world of ceramics today, great importance is attached to determining the role of their parameters in the formation of the physical properties of electric heaters. In this regard, the implementation of targeted research, including scientific research in the following areas, is an important task, which includes: a thorough study of physical processes occurring in the structures under study and identification of mechanisms for the formation of resistant characteristics; improvement of technological methods of production of all-round convenient heat-resistant electric heaters; to determine the spectral characteristics of hetero-structured electric heaters based on carbide silicon and serpentine in relation to hetero boundary processes; search for ways to optimize their functional parameters, and improving the technology of their preparation. According to the Action Strategy for the further development of the Republic of Uzbekistan, special attention is taken to the creation of effective mechanisms for the implementation of scientific and innovative achievements. In particular, one of the important tasks is to study in practice the ability to control the various processes and spectral characteristics of electric heaters in hetero-structures. It is noteworthy that the Year of Active Entrepreneurship, Innovative Ideas and Technology Support brings the scientific results to a level that meets modern requirements. At that point, it is important to increase their efficiency by optimizing the functional characteristics of hetero-structure electric heaters for different spectral ranges. Methods have been developed to reduce the effects of radiation and ultrasound on the internal effects of electric heaters. In this regard, it is important to determine the processes that explain the formation of spectral characteristics, dynamic and static characteristics of hetero-structural ceramic plates based on carbide silicon and chrome-lanthanum, increase the efficiency of technical parameters and develop new technologies for their creation. The Chromite lanthanum-based ($LaCrO^3$) electric agitators have different properties and configurations in high-temperature industrial and laboratory electric furnaces. In room-temperature electric ovens, they provide a temperature of 1700-1800°C. [1-3].

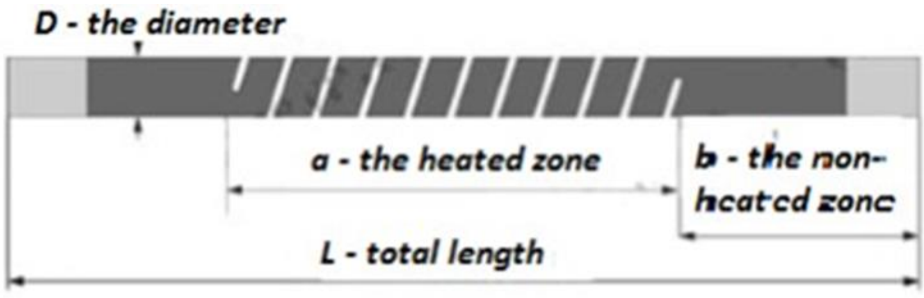
The results of our research based on a large solar oven in collaboration with the Institute of Materials Science of the Physics-Sun Research and Production Association of the Academy of Sciences of Uzbekistan and "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" The National Research University. The following types of electric screwdrivers are manufactured and sold. Electric agitators can also be used in other environments. The Chromite is the least aggressive substance compared to lanthanum, inert gases (argon, helium), nitrogen, carbon dioxide when the atmosphere is heated to 1200°C. When the reduced oxygen pressure is less than 100 Pa, it is possible to work in this atmosphere at a temperature of 1400°C. [4-5] [5-6].

Conveniences: easy and quick replacement;
L-continuous and cyclic operation;
heating up to 1800°C in an oxidizing atmosphere;
stability of electrical properties during operation (no aging) - old and new heating elements can be used together;
the ability to work in the entire temperature range (from room to maximum).
Types of high-temperature electric heaters based on lanthanum chromite:

1 

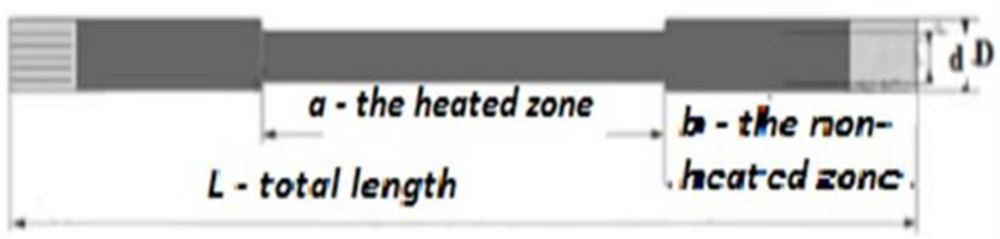
(a)

Type - K lanthanum chromite electromagnet - in the form of a dumbbell, a-working area, L- total length, d-diameter of the working part, D-diameter of the contact part, b-part of the cold contact, the maximum operating temperature of type K-type electric heaters reaches 17500 ° C. [7].



(b)

The electric submersibles made of lanthanum chromite, type C - are tubular elements with a spiral working part. Due to its geometric properties, the resistance of the central spiral part is much higher than that of the edge - this provides the most efficient redistribution of the generated heat along the length of the element. The working temperature of type-C of the electric stirrers is 1700 ° C.



(c)

FIGURE 1. Technological scheme of electric heater.

The working area of the Chromite Lanlan T-type heater is slightly thicker than that of the K-type, so the maximum operating temperature is 1800°C. [8]

Element installation and operation.

1. For each element, a certain resistance must be selected before installation to maintain the oven temperature and the mounting device. The value deviation should not exceed ± 10% of the resistance of the electric heaters in the kit.

2. As the element is very delicate, be careful during installation and use to avoid damage.

3. When starting the oven, increase the voltage slowly and gradually, never fully load at once, otherwise the heating element will be damaged.

4. Silicon carbide electric heater works with both alternating current and direct current, adjusting transformer or silicon control transformer, voltmeter, ammeter, automatic control thermometer and so on to use the element. During operation, the voltage must be increased to maintain the normal temperature of the furnace, as the resistance value gradually increases due to the oxidation of the element. When the voltage reaches the extreme point of the transformer and the temperature is still lower than required, the furnace must be stopped, the method of connecting the heaters (in parallel, in series or in series - in parallel) and then continue to operate.

5. During long operation of the oven, if for some reason any individual element is damaged, it should be replaced with a heater whose resistance value corresponds to the old one, never use a new heating element accidentally. If the heating element is severely damaged or its resistance value is too high and cannot reach the oven temperature, then it is better to replace all heating elements with new ones. Measure the resistance value of the old elements (they will be replaced) and place them in a lower temperature area.

6. Before using a new oven or an oven that has not been used for a long time, it should be dried before starting work. You can use old elements or other heat sources to dry.

7. When switching on the appliance (oven) or material, if water leaks, the oven should have holes for the release of water vapor or other unwanted gases, to protect the heating elements and to increase the service life.

Results. High-temperature electric heating elements based on chromite and lanthanum are made of ceramic material, are conductive and allow resistance heating directly from room temperature. Structurally, these heaters made of chromite and lanthanum are made in the form of wires and pipes of various cross-sections and configurations, which have a metal coating at the ends for connecting electrical contacts. Heaters based on chromite and lanthanum are used in air-driven electric resistance furnaces and provide thermal processes at temperatures up to 1700 ° C, in some cases up to 1800 ° C. The heaters can be used continuously and intermittently with full cooling between cycles. Heating elements based on chromite and lanthanum are easy to replace, which reduces production losses.

In the industrial production of this type of heaters, the following technologies are used:

- large and small functions of the ceramic mass are synthesized by the addition of lanthanum and chromium oxide, followed by the addition of calcium. All these chemical elements are brought into the same state;
- then from the prepared fractional mass, ceramic pipes with a flowing wire are formed;
- the pipes are heated in a high-temperature industrial electric furnace, which allows the heater to be one unit.

This product has a length of up to 1500 mm and more. The voltage in the supply network can be used for any network, but mainly 220, 380 volts. The maximum temperature of such elements is up to 1800 degrees. Determination of material density and porosity. The density and porosity of the coated ceramic materials were determined using hydrostatic gravity according to the following expression:

$$\rho = m_н \, \rho_{сув.} / (m_н - m_{сув.}), \qquad (1)$$

where p - is the density of the sample, kg / m^3; mн is the mass of the sample, kg; $p_{сув.}$ - density of the liquid, kg / m^3; $m_{сув.}$ is the mass of the sample in liquid, kg.

Pure purity was determined by the following expression:

$$П = (m_{т.\ сув.} – m_{н.})\cdot 100\% / (m_{т.\ сув.} – m_{сув.}), \qquad (2)$$

where П- is the purity of the samples,%; $m_{т.\ сув.}$ - is the mass of the sample saturated with liquid, kg.

Determination of linear shrinkage. Recovery of samples during synthesis was determined by the following expression:

$$У = ((l_0 – l_1) / l_0)\ 100\ \%, \qquad (3)$$

where Y - shrinkage of samples during synthesis, %; l_0 — length of samples taken before synthesis, m; l_1 is the length of the samples taken after synthesis, m.

Determination of the weight loss of a sample during synthesis. The weight loss of the sample during synthesis was determined by the following expression:

$$\Delta m = ((m_0 – m_1) / m_0)\ 100\ \%, \qquad (4)$$

where Δm - is the mass loss of the sample during synthesis,%; m_0 - is the mass of the sample before synthesis, kg; m_1 - is the mass of the sample after synthesis, kg.

Determination of the modulus of elasticity. The modulus of elasticity was determined by the resonance method on polished samples 5x5x45 mm using the resonance characteristics of the "ZVUK-230". The resonance frequencies are known, the elasticity of the constant materials is calculated. Measurement error is 1-2%.

Determination of bending and compression pressure of the transverse shell. The pressure in the casing was determined on a Shimadzu AG-300kNX volt-ampere machine on 5x5x45 mm samples according to the following expression:

$$\sigma_{эгилиш} = 3/2\ P\ K / (b\ h^2) \qquad (5)$$

where $\sigma_{эгилиш}$ - is the bending pressure, MPa; P - bending force, H; K - is the coefficient of the test base; b - is the width of the sample, m; h - sample height, m.

Compressive strength was determined on a Shimadzu AG-300kNX machine in 10x10x10 mm samples in accordance with the following expression:

$$\sigma_{сиқиш} = P / (b\ h) \qquad (6)$$

where $\sigma_{сиқиш}$ - is the compression pressure, МПа; P - compressive force, H; b - is the width of the sample, m; h - sample height, m.

Determination of the crack resistance coefficient. The fracture toughness coefficient (K_{1C}) was determined by the entrance to the Vickers pyramid. Cracks were detected using a TP-7p-1 optical hardness tester up to 10 μm in length. The K_{1C} values are determined by the following expression:

$$K_{1C} = 0{,}018\ (P/c^{1{,}5})\ (E_{упр}/HV)^{0{,}5} \quad (7)$$

where K_{1C} - crack resistance coefficient, MPa • m1 $^{/2}$; c - crack length, m.

The thermal stability of silicon carbide SiC, like all other polycrystalline ceramic materials, extends to brittle materials; therefore, all laws related to the movement of ceramics under the influence of thermal stresses arising from temperature changes can be applied to it. The main properties that determine the resistance of materials to thermal and thermal shock loads are strength, modulus of elasticity, coefficient of thermal expansion, thermal conductivity and heat dissipation. The study of the thermal resistance of many ceramic materials shows that an increase in mechanical strength, a decrease in the elastic modulus, an increase in the coefficient of thermal expansion and an increase in thermal conductivity always contribute to an increase in the thermal resistance of ceramic materials. Silicon carbide is characterized by high thermal conductivity, reaching values in the range of 50-150 W/m° K for products based on SiC, a relatively low coefficient of thermal expansion (4.5-5). 10-6 1/k. These properties mainly determine the high heat resistance of ceramic products made of silicon carbide [9 - 10]. Aluminum oxide - 20-79.5%, silicon carbide - 20-75 and ceramic products with a hardening additive during combustion of the product are characterized by a porosity of 30-40%, flexibility up to 80 MPa and practically unlimited heat resistance. Up to 1200° C. This material was named Tecor [11-13]. Tecor material has been used to make small tube glass bead sintering crucibles that can be used as a water filter at home. When firing crucibles with glass beads, the heating temperature reached 850° C, the heating time was 2 hours, followed by sharp cooling. Crucibles made from the specified material can be stored for up to 1500 cycles. It should be noted that the inclusion of silicon carbide, which is sufficiently resistant to oxidation up to 1500° C, into the composition of charged ceramic products up to ~ 100-200 μm, significantly increases thermal stability. Ceramic products with a SiC content of more than 50% can withstand instant heating up to 1500° C. [14-16].

Thermal conductivity of SiC (silicon carbide).

This property mainly determines the performance of silicon carbide materials at high temperatures. Heat in silicon carbide is transferred mainly by phonons. Thermal conductivity (λ) of SiC single crystals is close to the thermal conductivity of diamond, silicon and other covalent crystals. The thermal conductivity of SiC-based ceramics depends on many factors - the amount of porosity, the residual carbon and silicon content, and temperature. Porosity always significantly affects the value of thermal conductivity of all ceramic materials, including SiC materials. Thermal conductivity of dense materials made of SiC has high l products, reaching 120-150 W/m.K. As the porosity increases, the thermal conductivity decreases significantly, but still remains at a porosity level of 20-30% at 40-50 W/m.C. As the porosity increases, the thermal conductivity decreases significantly, but still remains at a porosity level of 20-30% at 40-50 W / m.C.

In the middle part of the solar oven, the temperature reaches its maximum value (about 2050° C) in about 10 minutes, and then is maintained at 1700-1800° C for 17 minutes after the start of the test (thermocouple № 1). The drop in temperature after 17-17.5 minutes can be explained by the deposition of electric heating material and the corresponding redistribution of heat. The change in the amount of heat supplied to the sample is noticeable, especially in the area adjacent to the electric heater (thermocouple № 1), and practically imperceptible at large distances (thermocouple № 4). At a distance of 200 mm from the sample (furnace center), the temperature (thermocouple № 3) reaches 1250° C in about 9-10 minutes, and at a distance of 300 mm (thermocouple № 4) in about 23 minutes.

Figure 1. Shows time plots of temperature values obtained from the improved models above. In the course of the experiment, the temperature was measured at

four points (thermocouples of the chromel-alumel type were used): thermocouples №. 1 and 4 were located at a distance of 20 mm from the sample surface, №. 2. - the ambient temperature was measured at a distance of 180 mm from the sample surface in thermocouple №. 3.

An experiment was carried out in which the temperature was measured at four points (chromel-alumel thermocouples were used): thermocouples № 1 and 4 were located at a distance of 20 mm from the core surface, № 2. - the ambient temperature was measured at a distance of 180 mm from the surface of the core and in thermocouple №. 3. The location of the thermocouples is shown in Figure 2. The dynamics of measurements in Figure 3.

Thermocouple № 1 showed a sharp rise in temperature, which began after 8.5 hours and did not exceed 1350° C. Thermocouple № 2 showed a maximum temperature of 1200° C. Thermocouple showed the ambient temperature № 3, which by the end of the campaign did not exceed 150° C. Thermocouple № 4 showed that a maximum temperature of 1000° C was reached at the end of the run. It should be noted that the power consumption shown in the experiment was 103,000 kW/h. According to experimental data, it can be argued that at a distance of 0 ÷ 30 cm.

The process of forming silicon carbide from the core in the industrial furnace continues. The experimental results also suggest that the mode of power supply for heating the furnace has a significant effect on the mass yield of silicon carbide. It should be noted that the process of obtaining silicon carbide is affected by the uneven heating of the core and the deposition of the charge.

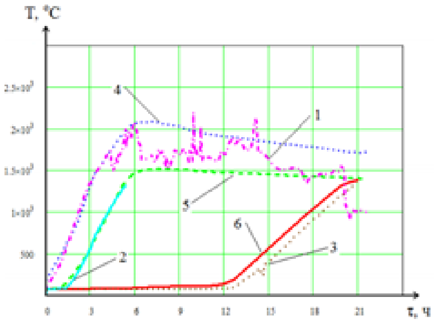


Figure 1. Experimental and calculated values of temperature dependence on time when the oven is running.

The numbers from 1 to 6 correspond to the thermocouple numbers.

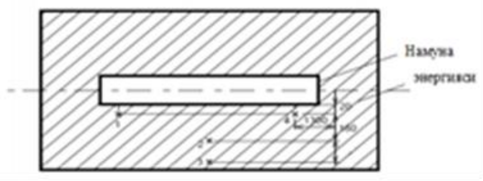


Figure 2. Installation diagram of thermocouples in the cross section of the furnace.

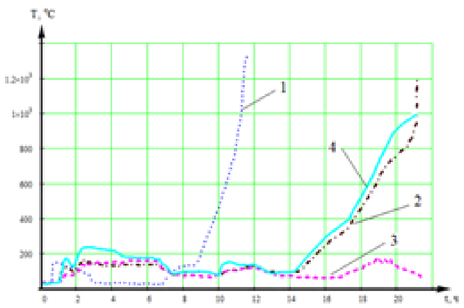


Figure 3. Experimental values of the temperature dependence of the furnace operating time. The numbers from 1 to 4 correspond to the thermocouple numbers.

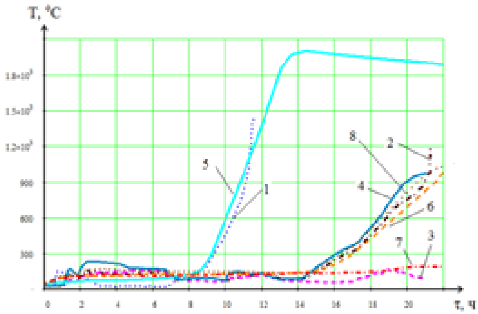


Figure 4. Experimental and calculated values of the time dependence of temperature for the period of operation of the furnace. The numbers 1 through 8 correspond to the thermocouple numbers.

In figure. 4 shows a comparison of the experimental data with the calculated values of temperatures obtained using improved models.

The S-type chromite lanthanum electric screwdriver is a tubular element with a spiral working part. Due to the geometric properties, the resistance of the central part of the spiral is much greater than that of the outer part, which ensures the most efficient redistribution of the generated heat along the length of the element.

The operating temperature of S-type electric agitators is 1700oC. The working area of the T-shaped chromite lanlan-based nagrevatell is slightly thicker than that of the K-type, so the maximum working temperature is 1800oC. Chromite lanthanum-based high-temperature electric heating elements aremade of ceramic material, conductive and resistive heating directly from room temperature. Structurally, these The Chromite lanthanum heaters are made in the form of wires and pipes of various sections and configurations, which have a metallized coating at the end to connect the electrical contacts. The Chromite lanthanum-based heaters are used in air-operated electric resistance furnaces and provide thermal processes at temperatures up to 17000C, and in some cases up to 18000C. The heaters can be used for continuous and intermittent operation, with complete cooling between cycles. The Chromite lanthanum-based heating elements can be easily replaced, which reduces production losses.

The following technologies are used in the industrial production of this type of heater:

- Large and small functions of the ceramic mass are synthesized by the addition of lanthanum oxide and chromium, followed bythe addition of calcium. All of these chemical elements are brought into the same state;
- then from the prepared fractional mass are formed ceramic pipes with flow wires;
- The pipes are heated in a high-temperature industrial electric furnace, which allows the heater to be one

unit. The length of this product is up to 1500 mm and longer. The voltage in the supply network can be used for any network, but mainly220, 380 Volts. The maximum temperature of such elements is up to 18000 Degrees.

CONCLUSION

As you can see from the pictures. Figures 1 and 4 are in good agreement between the experimental and calculated data. Taking into account the deposition and condensation of moisture in the material during the filtration process made it possible to better describe the complex technological process of silicon carbide production. The connection diagram of the heaters determines the stability of their electrical properties. When heaters are connected in parallel during operation, the differences in resistance value are reduced because heaters with lower resistance circulate with greater current. These heaters age faster and the resistance increases. Therefore, the parallel connection of the elements is preferable to the series, in which the difference in resistance values increases due to the intensive aging of the heaters with high resistance. When connected in parallel, the distribution of the resistance of the electric heaters in the set shall not exceed ± 10% of the average resistance value of the set; when connected in series, this difference should not exceed ± 5%. When designing and operating electric furnaces with silicon carbide electric heaters, the effect of the temperature control method on the cycle must be taken into account. Heater maintenance. Constant temperature control leads to an increase in the service life of the heaters compared to the position temperature at the same temperature in the electric oven, and therefore a continuous method of controlling the temperature of the electric oven is preferred. [7]

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