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Analysis of the effect of heating a container for chemical-thermal treatment of titanium in a carbon-containing environment, depending on the geometry and current strength of the inductor

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Introduction

In modern industry, various methods of heat treatment of workpieces made of metals and alloys using electric energy are widely used. These methods include: 1) heating in resistance furnaces; 2) heating in electric arc furnaces; 3) electrical contact heating; 4) radiation heating; 5) electron beam heating; 6) induction heating.

Each of the heating methods has advantages and disadvantages. The most promising method of non-contact electric heating of metal products is the use of high-frequency technologies, in particular, induction heating. The widespread use of heating by high-frequency currents (HFC) is explained by the speed and locality of heating, the possibility of automating the process, as well as high efficiency in comparison with indirect heating installations. When HFC of metals and alloys are heated, complex processes occur, which are both stationary and non-stationary. Temperature and heating rate control is important in induction heating due to factors such as oxides that interfere with the determination of the metal surface temperature.

One of the options for determining the temperature can be the use of numerical methods for solving problems of heat conduction. When considering distributed systems containing several elements and interfaces, the finite element method (FEM) is often used. The purpose of the work is to determine the temperature fields during the process of chemical-thermal treatment.

Methodology

The heated system "container - working environment - sample" consisted of a sealed container (4) and a lid (1), made of refractory metal. The container contained a titanium sample (2) and a carbon-containing medium (3) in the form of graphite powder. The container with the load was located in the inductor (6), which was cooled with water (7). Between the container and the inductor there was a quartz tube 5, which served as thermal and electrical insulation, (8) - the atmosphere (Figure 1).

The choice of the geometry of the inductors for modeling was carried out on the basis of the condition of providing heating in the zone of the location of the carbon-containing medium and the titanium sample. For this, the container, in the zone of which the load is contained, was located opposite the central coil of the inductor. In the first geometric model, the inductor was a two-turn spiral, in the second case, a three-turn one. Numerical modeling was carried out using the “Elcut” software.

Results

The simulation results showed that the temperature field in the carburizing containers was fairly uniform in the heated system. The maximum temperature was 1000 ºC. However, different inductor currents were used to achieve equal temperature values. The inductor current for the first model was 3.2 kA (Figure 1, *a*), for the second it was 3.7 kA (Figure 1, *b*).

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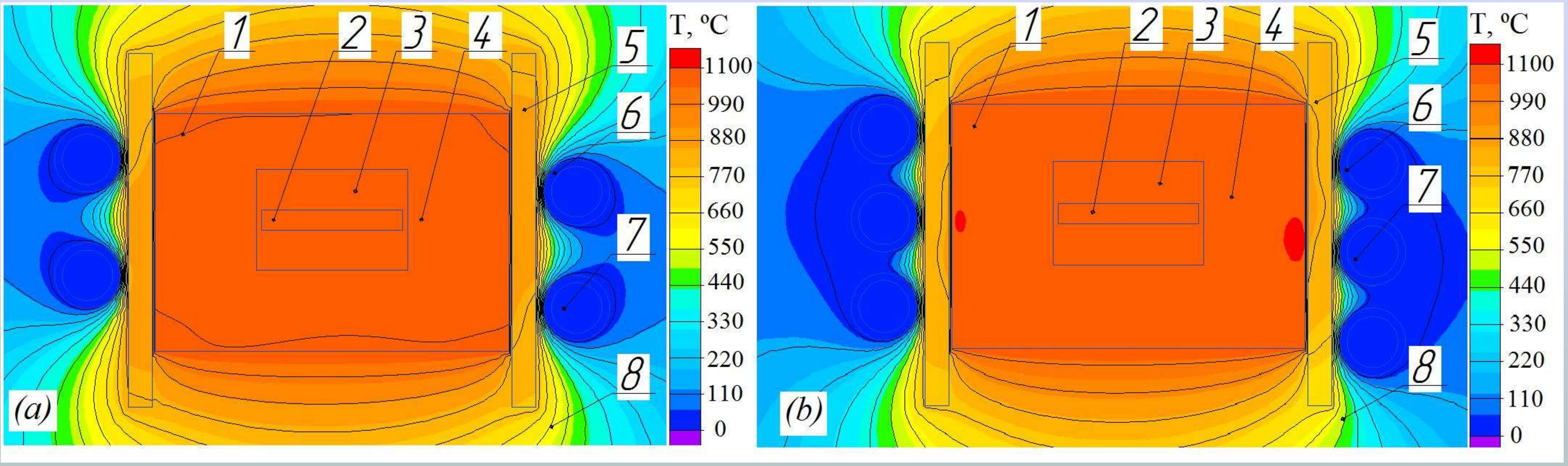

Figure 1. *a* - model of temperature fields for a two-turn inductor; *b* - model of temperature fields for a three-turn inductor

Conclusions

Thus, the simulation showed that the temperature field in the heated system is uniform and reaches a temperature of 1000 ºC. The efficiency of a two-turn inductor is higher since it requires a much lower inductor current. And the number of turns does not affect the heating intensity.

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