graphite crucible is heated unevenly in an uneven electromagnetic field, although the temperature differential within the crucible decreases, evidently due to the high thermal conductivity of graphite. With the optimal spacing and diameter of the inductor coils the unevenness of the temperature field in the depth of the ISB drops to 4–7°C. The hardness and metallographic data for samples heated in the ISB indicate high quality of the heat treatment throughout the length of the sample. For deep ISB it is also possible to use standard graphite–carborundum muffles (GOST 3782-54). By combining the B muffle with the MA muffle (Fig. 2) it is possible to obtain a crucible of almost any length. In this case it is necessary to increase the power of the high-frequency generator.

CONCLUSIONS

1. Induction salt baths of large depth ensure more even heating than ESB and make it possible to improve the quality of heat treatment of long parts made of steel R6M5.

2. Induction salt baths of any depth can be made by using standard graphite–carborundum muffles for this process.

3. Induction salt baths are more economical than ESB, since startup is very rapid, they are easily overhauled, and the lining is made of readily available and cheap materials.

LITERATURE CITED


USE OF BLIND RADIANT TUBES IN EQUIPMENT FOR CHEMICOTHERMAL TREATMENT

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The Bryansk Automobile Plant employs automatic apparatus for chemicothermal treatment of both domestic and foreign design that use gas radiant tubes of various types (straight through, U-shaped, and blind).

For one- and two-row apparatus for chemicothermal treatment it is efficient to use blind radiant tubes in the machine construction industry. They are characterized by fairly even heating (±25°C) of the radiating surface, high efficiency (70–80%), are easy to maintain, and can easily be replaced when they go out of commission. Furthermore, these radiant tubes can be manufactured from less highly alloyed scale-resistant materials.

Blind radiant tubes have been used at the Bryansk Automobile Plant since 1969, with testing of five different types during this period.

Tests of blind radiant tubes of the ZIL-VNIIPromgaz design were begun in 1969 in chemicothermal treatment of gears made of Cr–Ni steels. The operating principle of the radiant tube (Fig. 1a) is the gradual combustion of natural gas in air streams. This makes it possible to control the temperature along the length of the radiating tube and avoid overheating of internal elements. The temperature of the gas tube is 950–1000°C; the natural gas (91.8% CH₄, 5.4% CnH₂n+2, 1.2% CO₂, 1.6% N₂) dissociates with precipitation of free carbon (in the form of soot) in the bulk and on the inner surface of the tube (in the form of pyrocarbon). To reduce the rate of deposition of pyrocarbon, the gas is mixed with a portion of air (α₁ = 0.1). This leads to additional...
local heat liberation in the tube due to the low-oxidation pyrolysis of natural gas (above all, the higher homologs of methane).

The service life of radiant tubes made of steel Kh23N18 does not exceed 6–8 months and maintenance is difficult due to the necessity of controlling the deposition of soot.

It should be noted that these drawbacks do not occur when the operating temperatures are below 850°. Thus, the furnace for low-temperature tempering in chemicothermal treatment has been in operation for many years; it requires no inspection or maintenance of the radiant tubes.

The All-Union Scientific-Research Institute of the Gas Industry in collaboration with the Bryansk Automobile Plant has perfected the design of blind radiant tubes with combustion of the gas in air streams. In contrast to the first design (Fig. 1b), there is no multiple head and between the gas and air tubes there are tubular screens that change the direction of air movements. All the air entering the regulator flows over the gas tube and then passes through the opening of the air tube. In this design the air improves the cooling of the gas tube but also reduces its heating due to screening of the air tube against radiation.

It was found that with radiant tube temperatures not over 850–870° the natural gas hardly dissociates. Therefore, with low heat output of the radiant tube a substantial quantity of excess air is required for reliable cooling of the gas tube ($\alpha = 2.0$).

The automatic chemicothermal treatment line for parts made of Cr-Ni steels has been improved by means of blind radiant tubes 102 mm in diameter and 1100 mm long operating with a gas input of 1.0–0.5 m³/h and $\alpha = 1.05–2.0$, with an efficiency of 60–77%. The primary gas–air mixture ($\alpha_1 = 0.1$) is prepared for all apparatus. The service life of radiant tubes of steel Kh23N18 is approximately 1.5 years. The gas tubes are blown through periodically to remove soot (once or twice every three months, but not all tubes).

A 21-tray muffle-free apparatus with blind radiant tubes employs natural gas without preliminary mixing with air; the gas input is 1.2–0.5 m³/h. The burner of the radiant tube is designed so as to permit removal of the gas tube from the burner. After 12 months in operation a layer of solid pyrocarbon about 1 mm thick was found in the gas tube. The service life of the burner can be increased by changing the gas tube. Operating tests of a modernized unit confirmed the expediency of replacing straight through radiant tubes with recuperative blind tubes. The gas input was cut in half and the productivity increased 25% due to the more efficient zone of heating.

In an automated electric chemicothermal treatment apparatus (STTsA) converted to gas heating, 19 radiant tubes 121 mm in diameter and 1230 mm long with combustion of the gas in air streams were placed in the first zone of the carburizing furnace (operating temperature 920–930°) and in the solutioning furnace (850–870°). The burners operate with pure gas (1.3–1.0 m³/h). The surface temperature of the radiant tube is 950–1000°.