Material devoted to use of computer techniques in the theory and practical application of heat treatment (HT) and casehardening (CH) is placed in the collection published below. Basic trends in the introduction of the computer to HT and CH practice are direct control over production processes and the model design of the technology. The widespread use of powerful computers and, as a result, the elimination of computer difficulties have promoted the broader use of computational methods in the analysis and design of multifactor HT and CH processes. Use of the computer in the theory and practical application of HT and CH has made it possible to reduce the time and outlays required for the development and investigation of new production regimes, and also to increase the efficiency of production by creating automated production assemblies with a computer in the control circuit.

PROSPECTS FOR COMPUTER USAGE IN HEAT TREATMENT AND CASEHARDENING

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Use of electronic computer techniques in the practical application of heat treatment (HT) and casehardening (CH) has evolved in two basic directions.

1. Use of the computer for direct control over the production process of heat treatment.

2. Computer modeling of the processes that take place during heat treatment to predict production regimes.

At the present time, the basic tendency in the evolution of modern forms of HT and CT is the expansion of programmed computer-assisted control of the production process [1]; this is governed primarily by economic reasons.

Micro- and minicomputers and microprocessor systems, which are distinguished from main-frame computers by a comparatively small memory (operational) and by the deployment of a system of devices to interface the computer assemblies with the object being controlled, are used primarily for computer-assisted control [10].

Use of the computer in heat treatment makes it possible to improve its quality due to more accurate observance of production regimes, to select more rational regimes that ensure energy savings, and to use operational solutions to control the process on the basis of data acquired and processed by the computer.

The basic parameters that must be controlled during HT or CH are as follows:

- the temperature regime of the process;
- the composition of the atmosphere being controlled;
- the pressure and degree of vacuum in the furnace muffle.

It is precisely these parameters that are regulated by microprocessor-based control systems.

Use of the equipment for vacuum heat treatment makes it possible to generate a substantial saving after microprocessor installation as a result of increased productivity and significant improvement in production quality [2]. Work on the development of HT segments
that are fully computer-controlled is underway, although basic attention is still focused on computer techniques to control individual furnaces and units.

Use of the computer also makes it possible to solve problems associated with reduction of air pollution. Automated computerized monitoring and regulating of the composition of the gaseous atmosphere are used to reduce the content of harmful components in the gases discharged from the thermal furnaces.

Mathematical models of the heat transfer and adaptive control of furnace operation, which are run through the controlling computer, make it possible to determine the optimum effects on the actuation units. For example, use of a microcomputer to control high-velocity, pulsed, gas burners in heat-treatment furnaces permits the precise distribution of heat not only as a function of the specific heat-treatment regime, but also the shape and thickness of the component being treated, providing, in turn, for reduced outlays of heat and electric energy.

Use of minicomputers is also effective for control of the cooling time during hardening: The rate of heat transfer from the component can be calculated by the computer for specific cooling conditions from its surface temperature as measured by a thermocouple, the cooling system selected (air or air + water), and the performance of the systems that regulate the water and air feed controlled as a function of the results of the computations.

The simplest type of control is to conduct the process in accordance with a rigid prescribed program.

The technological program (production regime) is assigned using a special programmed unit prior to the start of the treatment cycle, while the technological parameters are maintained at the required level by local regulators, which are constructed on the basis of microprocessor facilities or which are computer-controlled [3].

At the present time, the effectiveness of computerized control of CH processes depends primarily on the level of instrumentation used to monitor and regulate furnace atmospheres.

Infrared gas analyzers (IR analyzers), which continuously monitor the content of CO, CO₂, and CH₄ in the gaseous atmosphere, have come into widespread use in carburizing furnaces [4].

An oxygen sensor with a solid electrolyte, which measures the partial pressure of oxygen in the gas mixture, is a promising means of determining the carbon potential of the atmosphere.

The interfacing of the gas-analysis system with a computer makes it possible to calculate the carbon potential during carburizing, and also the difference between its assigned and current values.

Regulation is accomplished by control signals from the computer using an actuation mechanism that corrects the feed of natural gas and air. A uniform concentration of carbon is attained in the carburized articles when this apparatus is used.

In the absence of reliable sensors for the thickness and phase composition of the diffusion layer during CH, good results are achieved with adaptive control of the production process through its mathematical model, which is run in real time on the controlling computer [5].

Calculation of the equilibrium composition of the carburizing atmosphere and the distribution of carbon in an article on the basis of measured parameters of the process makes it possible to increase the productivity and the accuracy of its regulation, to exclude operator error in controlling the process, to increase the stability of results for the heat treatment, to improve diagnostic control of equipment, and to simplify the task of acquiring operational data on the process.

There already exist heat-treatment shops that are wholly controlled by a computer — central minicomputer — with a fully automated continuous carburizing cycle. The sequence of mechanical operations (charging, discharging, displacement of the charge in a furnace with a built-in quenching tank) is performed by an industrial robot [6, 9]. The technological parameters — the carbon potential of the atmosphere, the quenching and tempering temperatures, the temperature of the quenching oil and wash water, the circulation rate of the oil — are all controlled in each unit by a microprocessor linked to the central computer.