AUTOMATION OF ELECTRIC FURNACE STEEL MELTING


In recent years there has been much growth in work on the automation of electric furnace steel melting. This computer technology has found much use. This is a report on work done by the All-Union Scientific-Research Institute for Automation of Ferrous Metallurgy and Êlektrostal' Plant on the automation of electric furnace steel melting.

The type PLU-004 system for automatic control of melting heat-resistant and other types of steels in electric arc furnaces includes a number of locally built regulating devices, and makes it possible to control the electrical, temperature, and production conditions. The control system includes mechanisms for changing transformer ratio, choke drives, high voltage disconnect switches, and a regulator for the electric drive.

The PLU-004 system is made in the form of individual units placed in a cabinet. On the panel board there is a lighted display board designed to control operation of the system.

The unit for control of the electrical conditions is designed for automatic control of the furnace's electrical requirements on the basis of a specified schedule. The unit includes two sensors for electrical consumption which are connected to a normal three-phase recorder, logic elements, electric power recorders connected to the furnace during successive cycles, a power regulator, an amplifier, and a unit for changing control by the electric drive regulators.


Fig. 1. Plan of the thyatron-based regulator for electric arc melting furnaces (a) and electroslag melting equipment (b):
M—direct current motor; T—transformer; TB—tachometer bridge.

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The unit for control of temperature conditions allows automatic or manual control of metal temperature on the basis of a rational program and consists of sensors for measuring the metal temperature and recording the final temperature connected to a quick acting potentiometer and a device for the input of thermocouples and temperature regulators which corrects the power supplied to the furnace.

The unit for control of production stages contains a sensor for impulses and a regulator for the length of production stages, which, when the recorded time has reached that specified, supplies a command to the programmed control system to switch to the next stage of melting.

The unit for programmed control is designed for manual input of the required program for melting any type of steel, automatic delivery of instructions at the start of each production stage, and control commands to all units of the system.

Thyratrons, which do not require careful maintenance, are very promising as inertia-free, quick-acting, noiseless, and reliable power regulators. The plan for a thyratron based power regulation system for electric arc melting furnaces and electroslag melting equipment is shown in Fig. 1. Signals of the current and furnace voltage (for electric arc melting furnaces) or current and reference voltage (for electroslag melting equipment) are supplied to the requirement unit RU, and the signals from the requirement unit are supplied to the measuring unit MU, which includes a comparison circuit and a circuit for agreement of the comparison circuits with the input of the control unit CU, which is based on thyratron elements. The control unit CU is designed to provide the required amplification factor of the regulating system, to form and totalize control signals and feedback signals, and to control the phase shifting unit PSU. The phase shifting unit PSU controls the three phase null reversible thyratron converter TC, which consists of cathode B₁ and anode B₂ groups of thyratrons.

To improve the operation of the regulator, feedback based on the speed of the motor has been introduced.

Use of the thyratron based regulator on the DSP-5 electric arc furnaces of Elektrostal' and Novo-Lipetsk Plants has shown it to be very reliable, and to provide an increase in furnace productivity of 1%, a reduction in unit consumption of electric power of 1.2%, and an increase in the power factor of 0.02.

The production of high quality metal in electroslag melting is governed by accurately maintaining the specified electrical (current and voltage) and production conditions (slag composition, temperature, melting rate).

Rational conditions were investigated and a system of automatic control for electroslag melting based on the power in the slag bath was developed (Fig. 2). The system contains an automatic current regulator 1, an actuating mechanism 2 for moving the electrode 3 as it is melted, an automatic voltage regulator 4, a current pick-up 5, a changeover switch for voltage under the load 6, and a sensor for current and voltage 7.

The automatic current regulator compares the specified value Iₛ with the measured I, and acts through the actuating mechanism on the movement of the electrode in such a manner that Iₛ is equal to I.

The automatic voltage regulator for the slag bath compares the specified voltage in the slag Eₛ with the actual voltage in the slag bath E, measured between the bottom plate and the electrode, and acts on the voltage ratio changeover switch in such a way as to make Eₛ and E equal. The system makes it possible to maintain the specified power in the slag bath, which improves the quality of the metal and provides a uniform macrostructure and a reduced top cutback on the ingot.

In production much use is made of electric arc heating of the sinkhead, since this provides an increase in yield. To obtain sound metal in the upper portion of the ingot with a substantial decrease in cutback, it is necessary to maintain rational electrical conditions in heating, holding them constant from heat to heat.