Elements of EAF automation processes

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Abstract. Our article presents elements of Electric Arc Furnace (EAF) automation. So, we present and analyze detailed two automation schemes: the scheme of electrical EAF automation system; the scheme of thermic EAF automation system. The application results of these scheme of automation consists in: the sensitive reduction of specific consummation of electrical energy of Electric Arc Furnace, increasing the productivity of Electric Arc Furnace, increase the quality of the developed steel, increasing the durability of the building elements of Electric Arc Furnace.

1. Introduction

Considering the great complexity of the specific procedures for steelmaking in an Electric Arc Furnace (EAF), the complex operation of this technological aggregate implies the systematically covering of the following steps [1], [2]:

- Quantifying and maintaining a certain prescript technological state (state of inertia) for the aggregate – achievable through conventional usual automation;
- Complex automation of EAF, which relies on the controlling of the processes for obtaining the maximum criteria function (objective) FO - prescript according to the mathematical model.

The conventional automation of EAF mainly targets [3], [4]:
- the automation of the electric regimen;
- the automation of the thermic regimen.

The characteristics of the performant level furnaces from the world ferrous metallurgy is the electro-hydraulic positioning and actioning system, at 15-20 MPa pressures. The type of electromechanical actioning and positioning of the EAF electrodes, used at the furnaces in our country, which had developed optimal operating procedures validation experiments (furnace 9 – OE 2 – COS Târgoviște and furnaces 1 and 2 – OE – SIDERCA Călărași) is based on an inductance coupling and electromagnetic brake. The electro-hydraulic adjustment system of the EAF electrodes is much more performant. In the Table 1 there are presented, by comparison, the performances of two actioning and positioning systems of the EAF electrodes [5-7].

Table 1. The performances of the actioning and positioning systems of EAF’ electrodes

| Nr. crt. | Actioning and positioning of the EAF electrodes | System type | Speed transit of the electrodes (mm/s) | Reaction time (s) |
|---------|-----------------------------------------------|-------------|----------------------------------------|-------------------|
| 1.      | Electro mechanic                               |             | 70                                     | 0,2               |
| 2.      | Electro hydraulic                              |             | 90                                     | max 0,01          |
2. Elements of EAF Automation

The main objective of the EAF automation electric regime consists of adjusting the electric power absorbed from the system on each phase (associated with each electrode). For this purpose, the algebraic composition through algebraic summing (SA) of the signals offered by the current transformer (TRI) and voltage transformer (TRU) constitute inputs for the driver of the action motor (DMA).

The adjustment of the electrodes of EAF, which has as a criterion to maintain constant of the impedance of the electric arc \( (Z_a = ct) \), is ensured by the action motor (MA) through the position of the electrodes adjustment device (DRPE).

There can also be used position regulators of the electrodes based on the following adjustment algorithms:

- the adjustment at a constant voltage of the electric arc \( (U_a = ct) \);
- the adjustment at a constant current in the electric arc \( (I_a = ct) \).

In Figure 1 we shown the basic diagram of automation (adjustment) of the EAF electrical regimen.

![Figure 1. The basic diagram of automation of the EAF electrical regimen](image)

EAF – Electric Arc Furnace; CT – Current Transformer; VT – Voltage Transformer; CD – Command Device; SD – Separation Device; \( R_I, R_U \) – Additional Resistances; AS – Algebraic Sumator; DMA – Driver of the Motor Action; MA – Motor Action; DRPE – Position Adjustment of the Electrodes Device

The analysis of the opportunity of replacing the electro mechanic system of actioning and positioning the electrodes with an electro hydraulic one, for a 100t EAF, reveals the high level of investment and determines the obtaining of a pay off time for about 2-3 years by a level of steel production of minimum 250 000 t/year.

The automation of thermic regime of EAF is based on the basic diagram shown in Figure 2. The thermic regime of EAF is defined by a lot of technological parameters, of which has been chosen as main parameters:

- The temperature of the shell masonry of EAF, \( t_{ZP} \);
- The temperature of the hearth furnace masonry of EAF, \( t_{ZV} \);
- The temperature of the molten steel, \( t_o \).
All of these basic parameters - technological and functional - can be determined through direct thermo-technological measurements.

The adjustment loop of the EAF thermic regime has, as a central element, the temperature regulator (RT) which, based on the input signals offered by measurements of the base parameters ($t_{ZP}$, $t_{ZV}$, $t_o$), launches switching actions of the furnace transformer on a new voltage bench – through the voltage bench control unit (BCTU) – and/or respectively modifying (including limitation) of absorbed electrical power – through the power regulator (RP).

Figure 2. The basic diagram of the EAF thermal condition automation

EAF – Electric Arc Furnace; CT – Current Transformer; VT – Voltage Transformer; CD – Command Devices; SD – Separation Devices; $R_I$, $R_U$ – additional resistances; $t_{SM}$ – Temperature of the Shell Masonry of EAF; $t_{HM}$ – Temperature of the EAF Hearth Masonry; $t_o$ – Temperature of the Molten Steel; TR – Temperature Regulator; VBCU – Voltage Bench Control Unit; PR – Power Regulator

3. Conclusions
The two schemes of EAF process automation, presented and analyzed in our article are particularly important for increasing the efficiency of production of steel.

The electrical automation system of EAF is particularly important on one hand, on reducing specific consumption of electricity of EAF, and on the other hand, on increasing productivity of EAF.

Automating the thermal regime of the EAF has a great importance not only on the quality of produced steel, but on the sustainability of the parts of EAF.

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