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EAF optimal managing elements

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Abstract. Electric Arc Furnaces (EAF) is an important and complex aggregate. We present elements of EAF operating efficiency. The reliability of the EAF is mainly determined by electric circuit reliability and especially of the transformator of the furnace. This due to the fact that, in an electric steel plant, the objective „24 tapping/day" involves. Due to the complexity of the process, the EAF operation needs a computer usage and, in his componence, it must have two independent calculation units (UC1) and (UC2). Based on these two input sets ($\sum i_1$) and (($\sum i_2$), the calculation unit (UC1) builds the general operation procedure based on mathematical methods. For that purpose, there are used the results of the 5 mathematical methods: the mathematical model to write-off the function objective (M.F.O.); the mathematical model of calculating the charge (M.C.C.); the mathematical model of conducting the effective melt (M.C.M.); the mathematical model of reheating the charge (M.R.C.); the mathematical model of blasting the reactive dusts (M.B.R.D.).

1. Introduction

The changing of the electric energy into heat takes place mostly inside of the Electric Arc Furnace (EAF), where the temperature goes above 2500^{0}C. The heat transfer from the electric arc to the charge in the furnace it is done through conduction and radiation [1], [2].

One of the main advantages of the EAF is also the possibility of using scrap iron as a main charge to obtain the steel. This allowed the EAF development and affirmation as a steel melting assembly [3].

The main parts of the direct action EAF are:

- refractory masonry;
- steel construction;
- electrical equipment.

The refractory masonry of the direct action EAF consists of: the hearth furnace masonry, the side walls masonry and the roof. In Figure 1 we present the scheme of EAF shell with a capacity of 10t [5], [6].

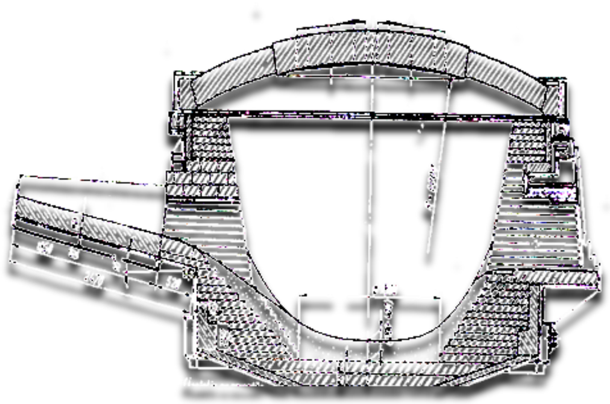

Figure 1. The EAF masonry (10t capacity)

Metallic construction of direct action EAF consists of:
- the furnace bowl (borders the bedstone - which can have a cone head or spherical shape)
- the furnace work door;
- the molten steel outlet and spout;
- vault ring;
- the tilting mechanism;
- the supporting - coupling and handling electrodes devices.

The EAF tilting mechanism has a great importance for its efficiency. It must comply with the following tasks [4]:

- to ensure the fine tilting of the furnace (without any bumps) with 40...50° towards the outlet spout and with 10...20° towards the work furnace door;
- to allow changing the tilting speed according to necessities (emergencies); the tilting speed is 1,5°/s for small furnaces and 0,4...0,8°/s for big furnaces;
- to be located so that it will not be damaged in case of hearth boring.

For this purpose the tilting mechanism is to be located to the bottom of the furnace and it consists of two runners (sledge) which the furnace is built on. The tilting force applies in a point between the two sledge runners (for small furnaces) or it applies to the two runners (for large furnaces) and it is realized hydraulic (with water or oil) or electro mechanic [7], [8].

2. Elements of EAF Optimal Managing

The work power (Pt) at EAF is calculated with the ratio (1):

$$P_t = \frac{W}{t \cdot \eta \cdot \cos\varphi} \quad [\text{KVA}] \tag{1}$$

where :
W – is the total electrical consumption in the melting time period (kWh);
t – is the melting time (h);
η – is the efficiency (0.8...0.9);
cosφ – is the power factor (about 0.85).

The electrodes serve to conduct the current from cathead to the metal charge and to ensure the electric arcs forming. The EAF most often uses the graphite electrodes.

The diameter of the electrode (d) is calculated with the ratio (2):

$$\mathrm{d} = \sqrt{\frac{4 \cdot \mathrm{I}}{\pi \cdot \Delta}} \quad [\text{cm}] \tag{2}$$

where:

I - is the phase current, [A];
Δ - is the current density [A/cm^2]

In Table 1 are synthetically presented the main constructive and functional characteristics of EAF.

Table 1. Constructive and functional characteristics of an EAF

Nr Crt	**EAF type Parameters**	**DSN-3**	**DSP-6**	**DSP-12**	**DSP-25**	**DSP-50**
1	Charge capacity [t]	3	6	12	25	50
2	Working Power [kVA]	2000	4000	8000	12500	25000
3	The specific melting electrical consumption [kWh/t]	500	500	470	460	440
4	The graphite electrode diameter [mm]	200	300	350	400	500
5	The inner diameter of the coat [mm]	2764	3190 ... 3500	3760 ... 4260	4450 ... 4950	5800 ... 6050
6	The bath diameter at the limit level [mm]	-	2230	2740	3540	4500
7	The depth of the bath at the limit level, in mm	400	425	555	775	890
8	The height of the melting space from the border to the vault [mm]	1050	1110	1365	1500	1950
9	The work door size [mm]	650X500	750X500	980X680	1000X800	1200X570
	The angles:					
10	-the rotation angle of the vault to the spout [degrees]	-	61	70	75	70
11	-the tilting angle of the furnace to the spout [degrees]	-	40	45	45	45
12	- the tilting angle of the furnace to the working door [degrees]	-	15	15	15	15
13	The steel construction mass, in t	35.5	45	80	140	235
	The power in kW:	-		-	-	-
14	- the lifting mechanism of the furnace working door		1,0			
15	- The oil pump	-	10X4	10X4	10X4	10X4
16	- The vault rotation mechanism	-	-	-	3.2	3.5

The reliability of the EAF is mainly determined by its electric circuit reliability and especially of the transformator of the furnace. This due to the fact that, in an electric steel plant, the objective „24 tapping/day" involves:
- 150.000 adjusting charge manoeuvre/year;
- 50.000 closing – opening;

And therefore:
- 45% of the incidents destroy the transformer coil;
- 40% of the incidents affect the short power supply of the furnace;
- 15% of the incidents are related to the voltage adjustment.

In Figure 2 is presented the basic diagram for computer assisted EAF operation.

Due to the complexity of the process, the EAF operation needs a computer usage and, in his componence, it must have two independent calculation units (UC1) and (UC2). Furthermore, considering that the most EAF's in the country don't have AMCR (automatic model charge reheating) to work in a continuous mode and in real time, the operator presence is requested.

For the proper operation of an EAF it is required to ensure two inputs sets for the calculation unit (UC1):

- $\sum i_1$ – inputs obtained from the outputs of the process $\sum y_1$, possible to be quantified through direct measurements - ensured by the measuring elements ($\sum$EM).
- $\sum i_2$ – inputs ensured by the operator (these are the values that cannot be measured continuously and in real time).

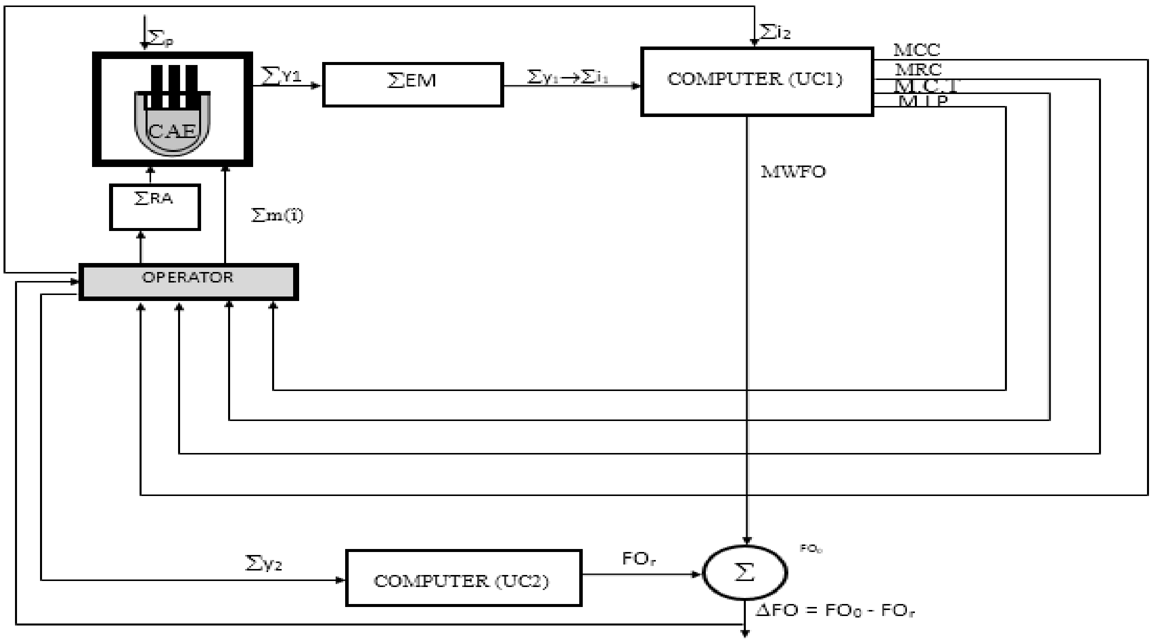

Figure 2. Basic diagram for computer assisted EAF operation

Based on these two input sets ($\sum i_1$) and ($\sum i_2$), the calculation unit (UC1) builds the general operation procedure based on mathematical methods. For that purpose, there are used the results of the 5 mathematical methods:

- The mathematical model to write-off the function objective (MWFO);
- The mathematical model of calculating the charge (MCC);
- The mathematical model of conducting the effective melt (MCT);
- The mathematical model of reheating the charge (MRC);
- The mathematical model of blasting the reactive dusts (MIP).

3. Results and conclusions

The operator takes over the general operating procedure parameters of EAF and, for some categories, it launches tasks to the line of automated regulators ($\sum$RA) which ensures the guidance of the whole process, and for other parameters it acts directly in the process through the execution extensions as it is the case for ensuring the right dosage of the charge when manual operating.

Simultaneously, the calculation unit (UC1) elaborates the prescript level of the function objective (FO_0).

When the process is done (in our case it is considered the elaboration ending), the operator takes over all the outputs of the process ($\sum y_2$) which couldn't be ensured through the continuous measurements and in real time. These data are provided to a second calculation unit (UC2) which, along with the calculation unit (UC1), elaborates the accomplished level of the function objective (FO_r).

According to the level of this deflection value, the operator decides to modify the general procedure of operating the EAF and through these two calculating units, he elaborates a new operating procedure.

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