OPTIMAL MANAGEMENT OF MELTING IN ARC FURNACES FOR STEEL DEVELOPMENT

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Abstract. *Early seventies with the start of the energy crisis, electric arc furnaces had a outstanding growth in metallic materials industry. Among the developed procedures, with a major contribution in reducing specific consumption of electricity, include use of oxy-fuel burners and mathematical modeling of the melting process using capability indices*

Keywords: *electric furnace, oxy-fuel burner, capability indices.*

1. INTRODUCTION

Manufacturing a product requires process optimization of obtaining from multiple reasons (safety, economic), so that the process in satisfying the highest customer requirements. The concept of capability certification of a process includes: the state of statistical control of the process; some convenient value of process capability index . Thus, the concept of state of statistical control - namely the state of statistical stability as system parameters vary within reasonable limits ± is a prerequisite for approval of any process.
As has been already mentioned, The statistical control is a set of actions designed to diagnose and reduce the processes variability, validation actions is reflected in the recorded values of statistical control indices (CP and CPK).

The processes diagnosis involves the parameters criticality and their hierarchy according to the impact they have on the process economy

Stages to provide data for subsequent analysis are:
- Criticality establishment of the processes and hierarchy according to purpose (work environment, opeatorilor protection, productivity, consumption, etc.);
- Setting parameters determining for the processes to be followed;
- Data collection and preparation of statistical control charts.
- Interpretation of data by capability indices (Cp and CPK).
- Establish action plan and its implementation;
- Verify whether the measures taken by monitoring the evolution of capability indices.

Develop steel in electric furnaces involves several processes:
- Electric arc furnace load;
- Melting of metal;
- Steel - refining;
- Evacuation of steel;
- Preparing the next batch.

The article presents a theoretical and experimental analysis of optimal management procedures of melting metal in electric arc furnaces (EAF) using statistical control indices.
The melting of the metal loads is the longest period with the highest energy consumption (60 ... 80% of the total energy required for the elaboration of a batch).

Melting duration varies depending on:
- conditions of adjustment of the oven;
- chemical load composition;
- readiness of cargo;
- compactness of the metal load and loading sequence;
- preheated load use (it is appropriate the charge to be warm up to 500-800^{0}C);
- using oxygen in the development process;
- use of oxy-fuel burners in the process of developing

2. Determination requires the use of external energy source.

Power requirements for getting a ton of atomized steel (powder metal) includes the energy needed to bring liquid metal charge, steel refineries and energy to heating energy required during the operation of casting steel (atomization).

If necessary energies for reffining and steel casting are constant and can not be used in fusion energy significantly influenfluentate can be reduced by using external energy sources (burning flame).
While reducing the electrical energy required is reduced during melting and increases productivity.

2.1. **The energy required steel melting and overheating**

$W_{u_{top}} =$

$G_{otel}\,[c_{p_{otel}}$

$\cdot t_{top} + q_{top\cdot otel} + c_{ps_{otel}}(t_s - t_{top})]/860$ [kWh/to]

$G_{otel} = 8500kg$; - mass of the charge

$c_{p_{otel}} = 0.167 kcal/kg\cdot{}^0C$ - specific heat of melting steel;

$c_{ps_{otel}} = 0.2 kcal/kg\cdot{}^0C$ - latent heat of molten steel overheating;

$q_{Top_{otel}} = 65 kcal/kg$ - latent heat of melting;

t_{top} = 1495 ^0C - Melting temperature of steel (0.1% carbon in the first sample).

ts =1560 ^0C - temperature of overheating of steel;

$W_{u_{top}} = 394 kWh/t$ - amount of heat necessary theoretical melting.

2.2 The amount of energy required for melting plus the amount of energy necessary to train slag, elimination of water (physically and chemically related inoxides), energy due to loads, fumes, energy lost in masonry and water cooling this energy is about 18% of the energy developed by the arc. Detailed calculation is not the subject of this article.

$$W_{endoterma} = 71 kWh/t$$

2. 3. The amount of exothermic energy from burning on the load oxidizing elements and the electrodes is about 4% of the energy developed by the arc. Detailed calculation is not the subject of this article.

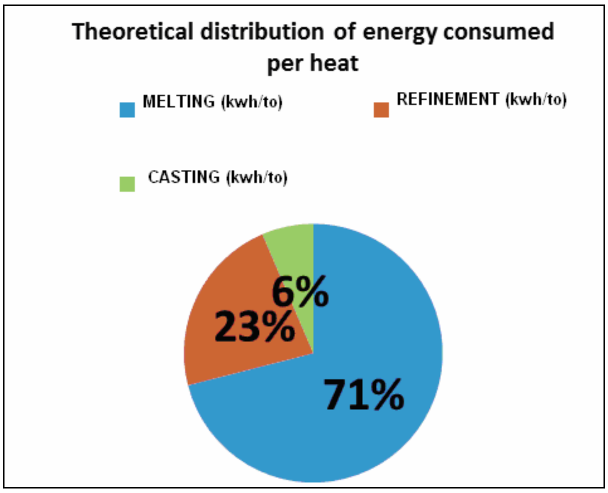
$$W_{exoterma} = 15.7 kWh/t$$

The melting heat required per tonne of material is:

$W = Wutop + Wendoterma - Wexoterma = 448$ KWh/to.

Electricity distribution necessary to make a ton of cast steel (spray) is given in the table below:

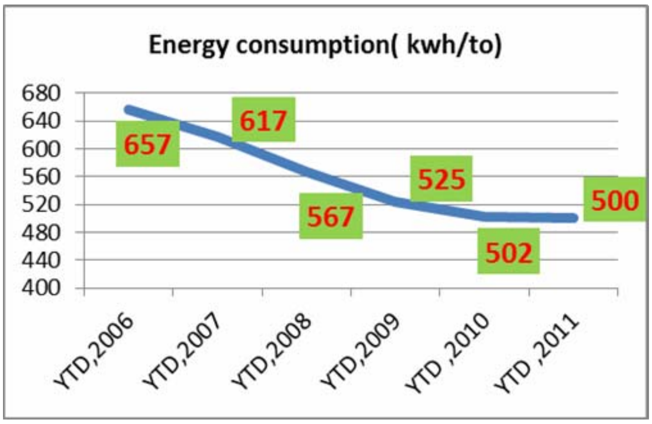
Melting (kwh/to)	Reffining (kwh/to)	atomization (kwh/to)	Total
kwh/to			
448	140	40	628

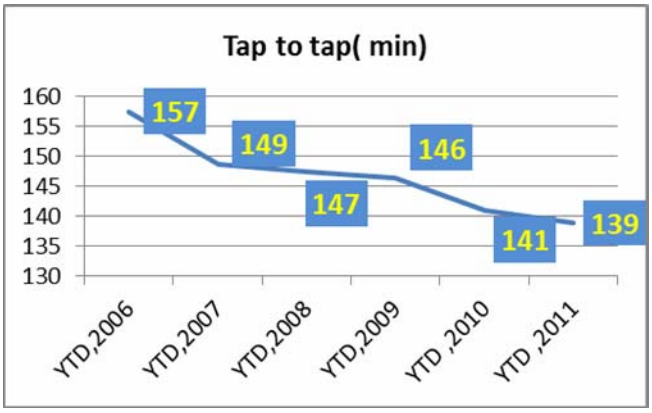


Reduction of development (reduction of melting time) in phase 1, requires the implementation of an additional melting using chemical energy (gas and oxygen). Reducing the amount of electricity consumed by 30% means introducing a flame burner with a maximum output of 1.2 MWh / batch.

The burner used is designed for use with propane and oxygen, has a great flexibility in the terms of the power cut and the oxygen – gas ratio . The burner was built in 2006 and implemented in 2007.

Oxygen and propane are circulated into the body through concentric pipes, oxygen inside and the outside propane by De Laval nozzle, which provides supersonic speeds. To protect exposed parts from the heat, flame stabilizer and combustion chamber are cooled. Flame temperature reaches values of 2300-2500 C.



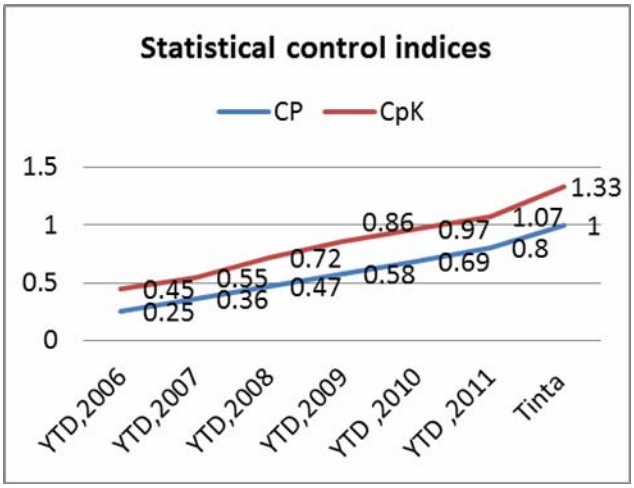


If in the first year of operation the gain was 40 kWh / t and 8 minutes per batch, using control techniques stataistic Phase 2, the 18 minutes decreased concomitantly with a decrease in total energy consumption by 27 kWh / t.

Cp = the stability of the process technology to the limits imposed.
CPK = the stability of the process adjustment to the average

Taking into account the factors that influenced the process of melting we acted to lower the dispersion values (time and use supersonic burner).

	CP	CpK
YTD,2006	0.25	0.45
YTD,2007	0.36	0.55
YTD,2008	0.47	0.72
YTD,2009	0.58	0.86
YTD ,2010	0.69	0.97



Conclusions:

Using indices of statistical control in the management the processes the brings these benefits:
- avoiding errors in production,
- reducing the variability of system parameters;
- the opportunity to detect errors that can not be shown than the final test stand;
- monitoring the manufacturing process and ensure that next steps will not contain any parameter of the charge out of specification (the following process is considered a beneficiary of the previous process client);
- detect and remove a disruptive process quantities both in terms of their magnitude and in the optimization parameters that influence such as: material, equipment performance (machine parameters).
- Early identification of problems relatied to quality, and the technological processes;
-stability of production, statistically control of all the manufacturing processes
- reduce costs, the percentage of rejects and verification costs both in terms of restricting the number and scope of verification

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