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jmr&t Journal of Materials Research and Technology
www.jmrt.com.br

Original Article

EOF cold model-study of bath behavior

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ARTICLE INFO

Article history:
Received 25 August 2015
Accepted 22 October 2015
Available online 4 December 2015

Keywords:
EOF
Supersonic lances
Injector
Tuyere
Cold model

ABSTRACT

The EOF reactor was developed in Brazil in the eighties with unique features. The pre-heating of scrap and distribution of injection points oxidizing gases and fuels make up these features. This paper aims to reproduce the behavior of the metal bath an EOF of 45 tons comparing their top three gas injection equipment: supersonic lances, atmospheric injectors and tuyeres. The lances and tuyeres promoted greater agitation of the bath with atmospheric injectors a great opportunity for improvement.

1. Introduction

According to KORTEC (1986) [1] manual, the traditional "Open Hearth Furnace", depending exclusively on the fuel used to produce heating energy, had their limit prospected. The process then called "KORF – KORF OXI-REFINING FUEL" was an integrated system involving changes in the Siemens-Martin (Open Hearth) structure, changes in the coating of furnaces and changes in the methods and practices operation through a combination of regenerative processes and pneumatics. One of the key parameters was increased hourly productivity, approximately double, as a result of the reduction of cycle time. With the shortening of tap to tap, heat loss was reduced as well as the need for fuel, helping to increase the competitiveness of steel with reduced operating costs. With the fundamental principles of KORF, new developments have been made in Pains's plant, resulting in EOF ("Energy Optimizing Furnace"), an oven with great flexibility in the process. Fig. 1 shows a schematic view of the first EOF.

In Fig. 1, according with the Catálogo da Companhia Siderúrgia Pains [2], it can be seen that the EOF originally had stages of preheating scrap indicated by numbers 1–3. Each step of preheating is a heat to be processed in the primary refining. In the design, the EOF had a system to pre-heat the air (N°. 10), helping the afterburner injectors (N°. 5) that could also be enriched with oxygen blow (N°. 9). It was possible to recarburate the bath by injection of carbon (N°. 8), or

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http://dx.doi.org/10.1016/j.jmrt.2015.10.001

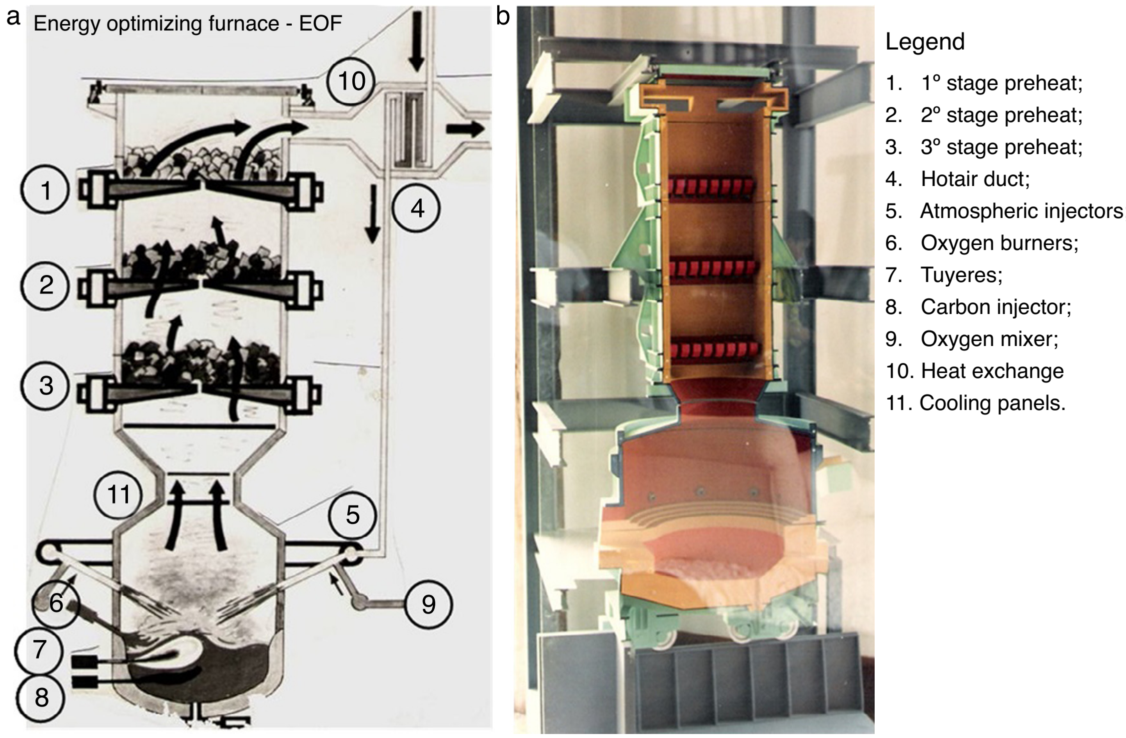

Fig. 1 – EOF conception: (a) Draft and (b) model (catalogue of Companhia Siderúrgica Pains, 1978) [2].

otherwise increase the decarburization through tuyeres (N°. 7). A major advance in the process was the inclusion of oxygen burners (N°. 6), which contributed to accelerate the oxidation reactions of the bath. Above the refractory line, all the way of the combustion gas, is contained by cooled panels (N°. 11). After recovering the energy to preheat the scrap, the remaining energy is still utilized in the heat exchange (N°. 10) to preheat the air also for post-combustion. From the original configuration to the current, many changes were made both with respect to the functionality of equipment and mainly on the concepts used face the real possibility of gain of this steel reactor, as will be explored further. The EOF – “Energy Optimizing Furnace” currently uses only one scrap preheating stage, simple and efficient with gas produced in the process through 8 injection points of oxygen in 3 different ways in the liquid pig iron with scrap [3].

2. Methodology

The experiments were conducted in the physical model of the “Laboratório de Simulação de Processos” (LaSiP) of the School of Engineering at UFMG. The cold model was made in scale 1/6 of plexiglass in comparison to 45 tons tap steel EOF furnace. The EOF geometry is complex, made for two pieces of plexiglass like showed in Fig. 2.

In Fig. 2, the crucible comprises a cylindrical base and above an inverted truncated cone. The dome also consists of a cylindrical base and above it a truncated cone. The geometry of the crucible was inserted into the slag door or “barrado” and the steel pouring channel, while the dome holes were included which represent the locations of oxygen injection and exhaustion of gases. It can be seen that the holes are located asymmetrically. This is necessary in the manufacturing process. Thus, to represent the process the arrangement of holes for insertion of the air guns in the physical model is shown in Fig. 3.

Table 1 – Dimensionless number to EOF cold model.

		Supersonic lances	Atmospheric injectors	Tuyeres
			Industrial	
Fr*	#	0.11	9.511E−05	4.56
Re*	#	2.803E+05	1.825E+05	1.879E+05
We*	#	2.028E+03	2.727E+01	2.509E+03
			Cold model	
Fr*	#	0.11	7.064E−04	4.83
Re*	#	8.419E+04	4.810E+04	6.280E+04
We*	#	1.606E+03	5.116E+01	2.573E+03

In Fig. 3, points 1, 2, 3 and 4 are the positions of atmospheric injectors. The atmospheric injectors are stationary and low penetration in the bath. Points 5 and 6 are related to supersonic lances that have movement forward and backward in addition to sufficient pressure to form a cavity in the metal bath or decarburization basin. A photo of the assembled apparatus is shown in Fig. 4.

The dimensionless numbers considered to ensure the similarity of the system are presented in Table 1 and the test matrix in Table 2 in according to the developments cited by Barbosa [4] and Carneiro [5].

According to the test matrix of EOF, the passing liquid throw slag door was collected. The volume of water, representing the metal loss in the slag door was quantified in milliliters.