

A statistical and post-mortem study of wear and performance of MgO-C resin bonded refractories used on the slag line ladle of a basic oxygen steelmaking plant

Ronaldo Adriano Alvarenga Borges, Guilherme Frederico Bernardo Lenz e Silva *

University of São Paulo, Department of Metallurgy and Materials, São Paulo, Brazil

ARTICLE INFO

Article history:

Received 13 July 2016

Received in revised form 24 March 2017

Accepted 26 March 2017

Available online 28 March 2017

Keywords:

MgO-C refractories

Wear mechanism

Steelmaking ladle

Post-mortem analysis

ABSTRACT

Refractories are essential materials used in steelmaking equipment. Understanding their wear mechanisms is important to promote safe, low-cost and high-performance steel processing. In the present work, a wear and performance evaluation of MgO-C refractories from steelmaking ladles was performed using statistical and post-mortem analyses to identify the main causes of degradation and failure. The post-mortem analysis showed that the main wear mechanism involved in the degradation process was the chemical corrosion of magnesia grains facilitated by the addition of nepheline fluxing, which is linked to the production method of steel grades with low sulfur content. Chemical corrosion of magnesia grains in the refractories used for ladle slag lines was intensified by the sodium-rich calcium-aluminum silicate slag reactions that dissolve magnesium, decreasing life of the equipment. A statistical evaluation of steelmaking shop ladles during 2015 (approximately 6700 heats) showed the main cause of degradation of the refractory ladle to be totally linked to the manufacturing process of low-grade sulfur steels.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Among the various types of materials used in the steel industry, we can highlight refractory materials, which are widely used as coating equipment and as pig iron and steel transport/treatment vessels in steelmaking plants around the world. The intensive use of refractories in steelmaking plants is due to the properties these compounds exhibit such as high starting melting point, high structural strength at high temperatures and in highly corrosive environments, and an intensive stability in temperature variations [1–5]. Virtually all major industries producing materials such as iron and steel, cement, glass, chemicals and petrochemicals use some sort of refractory ceramic material in the coating of its reactors for protection and wear, as working temperatures (some above 1000 °C) are high [1]. Refractories are responsible for limiting the wear corrosion and reducing heat losses from the molten steel reactors and, in general, it would be virtually impossible to manufacture such materials without the use of any type of refractory ceramic material that can withstand the extreme conditions that the reactors are subjected to in terms of temperature, pressure and aggressive chemicals [1].

In general, coating wear is caused by various factors that may act in independent or combined ways. Corrosion by liquid metal and slag, metal and slag infiltration, sudden changes in temperature (thermal shock), excessive compression of the structure,

* Corresponding author.

E-mail address: guilhermelenz@usp.br (G.F.B. Lenz e Silva).

Table 1

Refractory structure composition of the steel treatment ladles in accordance with the chemical specifications.

Slag line		Metal line		Bottom ladle		Bottom ladle (jet's impact region)	
Substance	Wt. (%)	Substance	Wt. (%)	Substance	Wt. (%)	Substance	Wt. (%)
MgO	85–90	MgO	75–80	Al ₂ O ₃	~79	Al ₂ O ₃	~88
C	11–13	Al ₂ O ₃	20–25	MgO	~6	MgO	~6
		C	5–8	C + others	~15	C	~6

oxidation of the carbon in refractory brick, and erosion caused by impact are the main refractory degradation factors [6,7]. Furthermore, according to [8], the wear of the refractory slag line is from chemical, thermal and mechanical events. Generally, the degradation process starts with a chemical event due to chemical potential differences between compounds of the refractory and slag and ends with thermomechanical events depending on the conditions to which the refractory is exposed and the type of reactor project.

The post-mortem analysis is one of the most useful tools for determining the root causes of the failures of coatings and for understanding the wear mechanisms involved. This technique is performed by conducting a systematic characterization of a refractory product after the end of its lifetime [9]. According to [10], the post-mortem analysis is the one of main tools to determine refractory in service and to provide information that can point the way to better service.

Through the post-mortem analysis of the refractory samples, it is possible to determine the chemical reactions that occur during the corrosion process, as evaluated by optical microscopy, X-ray diffraction (XRD), scanning electron microscopy with energy dispersive spectrometry (SEM-EDS) and cathodoluminescence (CL) microscopy [4,11]. Some works such as [4,11,12] show how post-mortem analysis can be utilized to identify the mechanisms and phenomena of the corrosion and chemical dissolution of the refractory by slag.

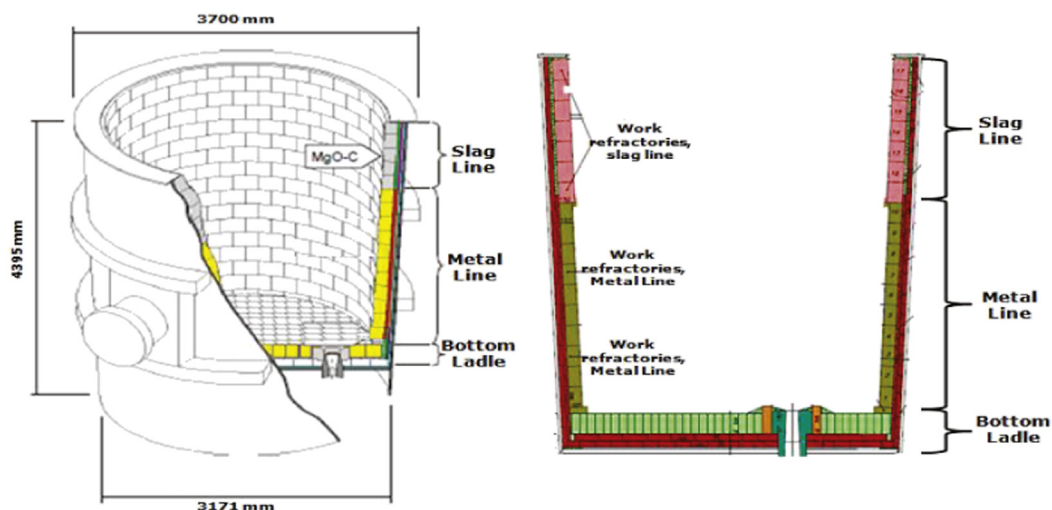
The objectives of this work are to analyze the degradation phenomena and wear mechanisms that occur in the slag line region of the steel treatment ladle (Table 1 and Fig. 1) of an oxygen steelmaking plant using the post-mortem analysis' technique. In addition, this work tries to understand if this degradation process is linked to typical metallurgical refining treatment processes that occur in the plant using a statistical process analysis of an operational database. Table 2 shows the main steps used in a typical post-mortem refractory analysis.

2. Materials and methods

For the experimental part, refractory samples from a steel treatment ladle in operation were collected after the end of its lifetime. For this study, samples were collected from only the slag line region because of the level of wear in this region. After the collection of the samples, they were prepared and analyzed by optical and electron microscopy for the post-mortem study. From the observations and chemical analyses, it was possible to identify the degradation phenomena and possible wear mechanisms that govern the performance ladle over its lifetime.

The sample collection was conducted using a hydraulic machine (known as a hydraulic remover), as illustrated in Fig. 2.

After the collection, the samples were taken to a laboratory where they were prepared for microscopic analysis. The preparation steps were sampling, cutting and mounting using epoxy resin impregnation under vacuum and after curing, sequential

**Fig. 1.** Image and structure of the steel treatment ladle with different regions.

Download English Version:

<https://daneshyari.com/en/article/5013630>

Download Persian Version:

<https://daneshyari.com/article/5013630>

[Daneshyari.com](https://daneshyari.com)