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Burners in the steel industry: utilization of by-product combustion gases in reheating furnaces and annealing lines

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Abstract

The steel industry demands large quantities of raw material and energy to produce iron and steel. During the overall process, parts of the generated by-products are combustible gases, which can be valorized in different equipment of integrated steel mills. After a description of the by-product combustible gases: coke oven gas (COG), blast furnace gas (BFG) and basic oxygen furnace gas (BOFG), a focus is given on the constraints of their usage, in particular due to the constantly fluctuating composition and physical characteristics. Examples of usages in two steel mills energy intensive equipment are given: reheating furnaces comprising dozens of several MW burners and annealing lines equipped with hundreds of burners under 200 kW power output.

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Keywords: Burners, reheating furnaces, annealing lines, COG, BFG, BOFG.

1. Introduction

Different operations are needed to produce iron and steel [1]. These steps are intensive in raw material and energy, and generate important quantity of by-products, including combustible gases such as coke oven gas, blast furnace gas and basic oxygen furnace gas [2]. In integrated steel mills, equipment providers and plant owners put many efforts to valorize this yield of energy in different parts of the process. The main motivations are energy and operational cost savings, but also to lower the environmental footprint of iron and steel production. Here we will focus on the utilization of by-product gazes as fuel in two energy intensive components. The first component is the

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reheating furnace, where hundreds of tons per hour of steel products (slabs, billets and blooms) are heated up to 1250 °C. The second component is the annealing line, where strips from coils follow different temperature paths, from ambient temperature up to 950 °C. The by-product fuels characteristics will impose specific constrains to the furnaces and burners operation and control.

2. Overview of the steel making process

An overview of the steelmaking process in an integrated steelwork is summarized Fig. 1. In short, from iron ore, limestone and other elements, using energy from coal or natural gas, blast furnace is used to produce iron and subsequently steel after lowering the carbon excess in the basic oxygen furnace. Then, through the continuous casting, several items can be generated and transformed, immediately or later: slabs are transformed into either plates or hot-rolled / cold-rolled strips (coils), billets into hot-rolled bars, rods or tube rounds, and boom into structural shapes or rails.

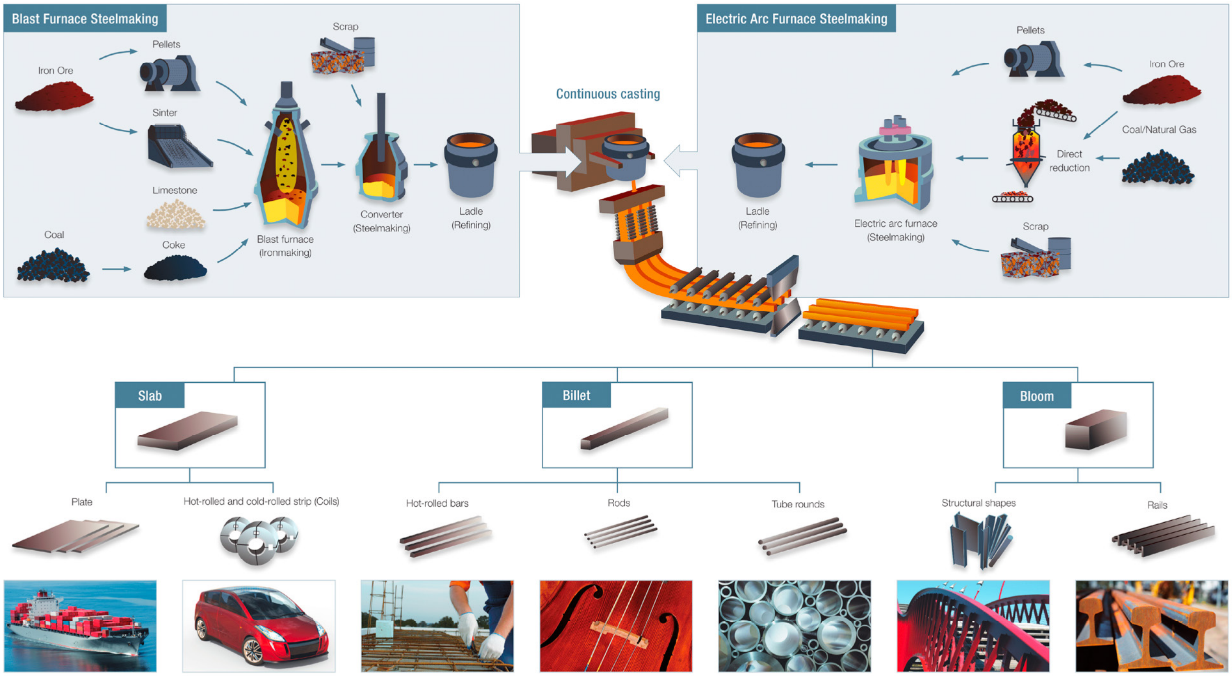

Fig. 1. Overview of the steelmaking process (source: World Steel Association [1]).

Different process inputs are needed for the iron and steel production, and subsequent waste materials are generated all along the route, as represented in Fig. 2. Among the by-products, important quantities of combustible gases are available: Coke oven gas (COG) from the metallurgical coke production, Blast furnace gas (BFG) from the blast furnace, and Basic Oxygen Furnace Gas (BOFG) when the liquid iron is refined in a basic oxygen furnace, where decarburization of the iron leads to steel [3].

These fuels constitute the basis of the energy system in integrated steelworks. The quality (composition, calorific value and cleanliness) and volume of the different gases may vary significantly, e.g. a typical blast furnace produces around 1320 to 2210 Nm^3 of BFG per ton of pig iron, and these factors have an impact on where the fuels can be exploited. When possible, most of the energy demand is satisfied by these gases; the remaining part must be balanced with purchased energy, such as electrical power and Natural Gas (NG). A high share of steelwork (e.g. in Brazil, India or China) are not using NG, in certain cases fuel oil is used as backup fuel. In other cases (e.g. in the USA) coke can be imported on-site, therefore COG will not be locally available. When available, NG will preferably