

Dynamic EAF Energy and Material Balance Model for On-Line Process Optimization

Sunday Abraham, Yufeng Wang, Randy Petty, Tim Sprague, Tony Franks and Eric Brown

SSAB Americas
1770 Bill Sharp Boulevard
Muscatine, IA 52761

E-mail: Sunday.Abraham@ssab.com; Yufeng.Wang@ssab.com; Randy.Petty@ssab.com; Tim.Sprague@ssab.com;
Tony.Franks@ssab.com; Eric.Brown@ssab.com
Tel.: (563) 381-5774

ABSTRACT

A comprehensive and dynamic model has been developed for predicting key melting parameters. The model predicts temperature, carbon, oxygen, slag composition and offgas composition during the melting process. The temperature module is based on energies from electricity and chemical reactions. The carbon and oxygen module is based on scrap chemistry and supplied carbon and oxygen. The slag module is based on flux additions and oxidation reactions. From an established oxidation reaction hierarchy, the offgas module computes the volumes of CO and CO₂. This paper discusses the implementation of the model for on-line process control and optimization at SSAB Americas.

Keywords: EAF, melting, energy, scrap, slag, foaming, off-gases.

INTRODUCTION

The discovery of electric arc by Sir Humphry Davy, a British chemist, in 1800 led to the invention of the electric arc furnace¹. In 1853, primitive forms of electric arc furnace were developed in France and England. In 1878, Sir William Siemens patented an electric arc furnace, which operated using dynamo as a source of current. Initially, electric arc furnaces were used for the production of alkali metals, phosphorus, graphite, calcium carbides, and metallic calcium. In 1886, Paul Héroult of France was granted a patent for the electric arc furnace used for the production of aluminum. In 1896, Major Stassano of Italy began making electric arc furnaces for smelting iron ores. At this time, the prices of electricity were prohibitive, and the production of iron using Stassano's electric arc furnace did not amount to any degree of commercial success, as it could not compete with the blast furnace and open-hearth processes. A breakthrough in the commercialization of electric arc furnace for steelmaking occurred in 1906. During this time, the Canadian government collaborated with Paul Héroult of France to conduct a series of experiments at Sault Ste. Marie to smelt Canadian iron ore in Héroult's electric arc furnace. The success of this collaboration set the stage for the rapid growth of using electric arc furnaces for the production of pig iron. However, the tonnage from the electric arc furnaces was very low (typically, 1 to 15 tons), and therefore, their use was reserved for producing special steels because it was not economical for bulk steel production. The output from the electric arc furnace steelmaking process was limited because significant aspects of the operation were conducted manually. In 1950s, however, technological advancements in furnace designs and improved electrode controls increased the efficiency of the electric arc furnace steelmaking process. This resulted in the continued expansion of the use of the electric arc furnace for steelmaking^{2,3}.

The electric arc steelmaking process is particularly attractive due to its low capital cost compared to the traditional (blast furnace) route of steelmaking. Other advantages of electric arc furnace route of steelmaking are: a) simplicity of the plant operation; b) flexibility to produce a variety of grades; c) better environmental impact; and d) possibility of using local energy sources. These benefits are the reasons for the emergence of the electric arc furnace as the dominant steelmaking route today. Table I provides a summary of the technological advancements that contributed to the success of electric arc furnace steelmaking process.⁴ Although significant improvement in operational efficiency of electric arc furnace has been achieved over the last few decades thanks to the automation of the control systems⁵⁻¹², the control of the metallurgical aspects of the process are still based on the judgement of individual operators. One area that can be beneficial to the operation of the EAF is