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Detailed Modeling of Radiative Heat Transfer in Electric Arc Furnaces Using Monte Carlo Techniques

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INTRODUCTION

In an Electric Arc Furnace (EAF), the energy transfer from the arc to the surroundings occurs via three mechanisms: the flow of electrons, radiation and convection. Energy due to the flow of electrons is small (lower than 3%) and usually neglected . In the other hand, the contributions of the convective and radiative mechanisms of heat transfer are less clear, and the topic is yet mater of discussion in the metallurgical community.

Given the uncertainty about these phenomena, existing EAF models are built on either:

- arbitrary assumptions on how the energy of the arc is distributed between convection and radiation mechanisms ,
- the energy distributions reported by the British Steel Corporation ,
- parameter-estimation techniques that calculate heat transfer coefficients and the energy distribution between convection and radiation.

Well known EAF models that considered radiation mechanisms are . In these works, the cone-frustum geometry was used to model the solid scrap. The main advantage of using this geometry is that the view factors describing the radiative exchanges can be calculated using standard view factor formulas and view factors algebra.

After a series of observations of the process in our plant, we noticed that the cone-frustum geometry fails to describe the real shape of the scrap during the melting process. For example, it fails at describing the changes in height of the scrap during the initial and intermediate stages of each melting stage, and assumes that most of the melting process occurs during the initial minutes after each charge. For these reasons, we propose to model the solid scrap as a hollowed cylinder that decreases in height and that increases its internal radius as the batch time progresses. See Figure 1.

The main challenge of using this geometry is that blockages and shadings in view lines must be considered. From the various techniques that allow the calculation of complex view factors, we focus on the Monte Carlo algorithm due to its accuracy, simplicity, and easy implementation. The radiative heat exchanges are calculated by remodelling the heat transfer phenomena as a DC circuit that changes dynamically in topology, as the solid mass of scrap melts. The model here presented assumes that the only mechanism of heat transfer between the arc and the rest of the surfaces is radiation.

