Artificial Intelligence-Based Computer Modeling Tools for Controlling Slag Foaming in Electric Furnaces

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Abstract

Due to increased competition in a world economy, steel companies are currently interested in developing techniques that will allow for the improvement of the steelmaking process, either by increasing output efficiency or by improving the quality of their product, or both. Slag foaming is one practice that has been shown to contribute to both these goals. This paper describes an effort in progress to both model and control the slag foaming process using neural networks in tandem with genetic algorithms and fuzzy logic.

Introduction

Slag foaming is a common process used within the steel industry to improve steel production. It involves the injection of oxygen and carbon into a molten steel bath. Carbon monoxide bubbles are formed, which rise and begin to foam the surface of the steel bath. This process results in less energy consumption, less refractory wear, and improved quality of the steel produced.

Overall, slag foaming has greatly improved the efficiency of steel production in electric arc furnaces. However, slag foaming is a highly dynamic process, which makes it difficult to model and control. Several different artificial intelligence-based tools exist for creating models of such complex systems. Two approaches have been found to be particularly effective in developing data-driven computer models: (1) neural networks and (2) fuzzy mathematics with genetic algorithms.

The project discussed in this paper proposes a dual approach to modeling the slag foaming process. Two computer models of the slag foaming process will be developed: (1) a neural network model and (2) a geno-fuzzy model. Both computer models will be data-driven; they will use data obtained from an industrial electric arc furnace operation. The data will consist of input/output pairs. Once developed, these models will be connected with genetic algorithm / fuzzy logic controllers that will be trained to maximize the quality of the foamy slag being modeled. These controllers would then be installed into steel plants, where final adjustments would occur.

Results

Progress has already been made towards developing a slag foaming model. Specifically, two different models have been developed. One of these models (developed in conjunction with Martin Marietta) predicts slag composition at various times during a steel heat. Results show that the neural network model makes accurate predictions (within five percent error) on eighty-five percent of the slag composition data. The second model (developed in conjunction with Georgetown Steel and Albany Research Center) takes data given on the amount of raw material and energy coming into the refractory, and predicts slag height in the refractory at every two to three seconds. Figure 1 shows how closely the neural network models the actual slag height over time.

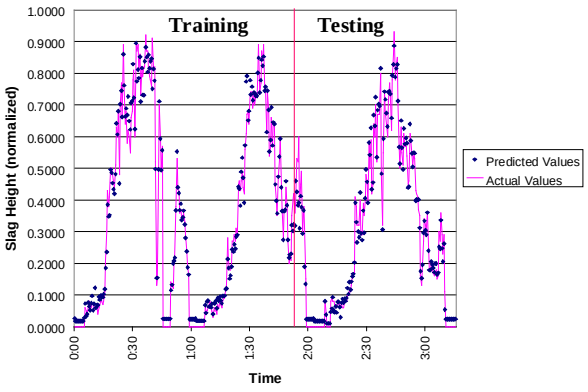

Figure 1 — Neural Network Prediction of Slag Height

Future work will include the development of a slag foaming controller using genetic algorithms and fuzzy logic in conjunction with the neural network slag foaming models already developed. This controller will then be installed, tested, and refined at Georgetown Steel. Completion of this project should occur in May 2001.