Abstract

In order to improve upon the productivity and reduce the cost of production in Indian iron and steel making units operated with minimal instrumentation and probes, several prediction and optimization models are developed based on the data-driven modelling (DDM) techniques. Various DDM techniques, viz., Artificial Neural Network (ANN), Fuzzy Logic (FL), Genetic Algorithm (GA) and their hybrid variants like ANN-GA, Adaptive Neuro-Fuzzy Inference System (ANFIS), Nonlinear Auto-Regressive eXogenous models (NARX) have been used for modelling sponge iron rotary kiln, iron blast furnace and LD converter steel making .

On a minimal instrumented sponge iron rotary kiln, oxygen enrichment condition is modelled using Artificial Neural Network (ANN) coupled with Multi-Objective optimization using Genetic Algorithm (MOGA). The model predicted that, in order to maintain a relatively low bed temperature at the end zone of the sponge iron rotary kiln (say, 1080 ^{o}C), the specific oxygen enrichment needs to be maintained at < 10 Nm^3/t (typically 8 Nm^3/t in a plant practice). Specific air volume and quantity of coal fines injection need to be reduced. Using the guidelines of the present model, it is reported that in an industrial practice the campaign life of kiln is doubled (typically100 d) compared to kiln's normal campaign life under air-based operation (typically 50 d) along with a 6 % improvement in the production and a 6 % decrease in the coal consumption.

Iron making blast furnace operated with minimal instrumentation and probes is modelled for prediction of hot metal silicon, hot metal temperature, and optimization of pulverized coal injection (PCI). Feed forward neural network (FFNN) is used for prediction of hot metal silicon. ANN, ERNN and ANFIS are used for prediction of hot metal temperature model. ANN has given the best results for the prediction of hot metal temperature. Sensitivity analysis yields the most important variable affecting the hot metal temperature and hot metal silicon, in order of diminishing importance, as the hot blast temperature, oxygen enrichment, quantity of steam and PCI. When the hot blast temperature is > 1050 ^{o}C and oxygen availability is > 7000 Nm^3/h, the present model predicts that coal dust injection can be increased to 80 g/Nm^3 without affecting the hot metal temperature. ANN-GA is used to model the conditions required for optimization of PCI. By maintaining the optimized conditions predicted by the model, PCI quantity can be enhanced by 23 % from the present level of operation.

End blow oxygen requirement of Bhilai steel plant LD converter (of original LD design commissioned in 1984) is predicted using data driven models through a two step process. In the first step, the intermediate stoppage temperature is predicted using an ANN model, and in the second step the end blow oxygen quantity is predicted using a NARX model. The end blow oxygen quantity varied from converter to converter depending on its campaign life. End blow temperature of the steel is the most significant parameter for the converters at their beginning and middle of their campaign life, and intermediate stoppage temperature is the most significant parameter for the converter at its end of the campaign life.

The present study indicates that the formulation of the data driven models for iron and steel making operations should be customized for a particular production unit, and the models need to be dynamically updated using the current plant data.

Keywords: Blast Furnace; LD Converter; Sponge Iron Rotary kiln; Data Driven Model; Artificial neural network; Genetic algorithm; Fuzzy logic