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Automation on thermal control of blast furnace

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To realize efficient and stable operation of a blast furnace, accurate process control through automation is crucial. In this study, we developed an automatic control system for hot metal temperature (HMT). To cope with the slow and complex process dynamics of the blast furnace, we first built a two-dimensional (2D) transient model that can simulate the chemical reactions and the heat transfer phenomena in real time. The estimation accuracy of HMT improved significantly by reproducing a chemical reserve zone where the gas reduction of iron oxides is close to the chemical equilibrium. To use the 2D transient model persistently in the process control, the estimation error caused by unmeasurable disturbances, such as the change of material characteristics, is an issue. We successfully incorporated the effect of disturbances into the model calculation and maintained the estimation accuracy by adopting moving horizon estimation (MHE) algorithm which successively correct the model parameters online. Subsequently, we constructed a control algorithm that calculates the optimal target pulverized coal ratio (PCR) to control HMT using nonlinear model predictive control (NMPC) based on the eight-hour-ahead HMT predictions by the 2D transient model. Finally, we developed a control system that automatically adjusts the target PCR and pulverized coal flow rate. Evaluation in an actual plant showed that the developed control system successfully suppressed the effects of disturbances such as changes in the coke ratio and blast volume, reducing the average control error of HMT by 4.6℃ compared to the conventional manual operation. The developed control system has been applied to multiple blast furnaces at JFE Steel Corporation, contributing to the reduction of the reducing agent ratio (RAR) and CO2 emissions.

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