Engineering Applications of Computational Methods

Volume 3

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Intelligent Optimization and Control of Complex Metallurgical Processes

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Preface

Iron and steel industry is the basis for the development of a country. Its level of development determines the economic level and comprehensive national power of a country. However, accelerated energy consumption and significant CO_2 emissions have limited the development of the iron and steel industry. Metallurgical automation technologies have been developed to yield the green manufacturing of the iron and steel industry.

The iron and steel industry involves complex processes, such as raw material proportioning, sintering, blast furnace ironmaking, steelmaking, continuous casting, and rolling. They have the common characteristics of strong nonlinearity and a large number of parameters. In order to achieve the green manufacturing of the iron and steel industry, we have to consider the problems of energy saving, emission reduction, environmental protection, etc. These problems involve the modeling, optimization, and control of complex processes. However, conventional methods of modeling, optimization, and control are not suitable for actual applications for complex processes with uncertainties. Advanced intelligent optimization and control technologies have been applied to the iron and steel industry to improve production efficiency and reduce CO_2 emissions.

We summarized our work and experience in the control of complex metallurgical processes over the last two decades in this monograph. We hope that it would be a useful reference for engineers in the field of metallurgical automation and complex process control, and for graduate students interested in computational intelligence and its applications of industrial process control.

The monograph consists of six chapters. Chapter 1 describes the current status of metallurgy processes and explains conventional intelligent algorithms in the aspects of modeling, optimization, and control. Chapter 2 describes the methods of how to optimize the proportioning of a coal blending process in an iron ore sintering process. An expert control strategy is designed based on a combination of back-propagation networks, mathematical models, and rule models to accurately determine and track the target percentages for a coal blending process. An intelligent integrated optimization system with a hierarchical configuration is devised to solve the problem of optimizing the proportioning for an iron ore sintering process.

Chapter 3 focuses on the problems of how to measure and control the coke-oven temperature. An integrated soft-sensing model of the coke-oven temperature and a hybrid hierarchical control system of a coke-oven combustion process are developed to solve these problems. Chapter 4 describes control methods of thermal state parameters in sintering process. An intelligent control of a sintering ignition process is designed to stabilize the ignition temperature. An intelligent control system for the burn-through point is designed to stabilize the point in an actual sintering process. Chapter 5 describes intelligent decoupling control methods for both the gas collection process of multiple asymmetric coke-ovens and a gas mixing-and-pressurization process in an iron and steel company. Chapter 6 focuses on the problem of how to control the rolling temperature and reduce the energy consumption of the process of a reheating furnace. An optimization and control system for the heating furnace is devised to solve this problem.

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Min Wu received his B.S. and M.S. degrees in engineering from Central South University, Changsha, China, in 1983 and 1986, respectively, and his Ph.D. degree in engineering from the Tokyo Institute of Technology, Tokyo, Japan, in 1999.

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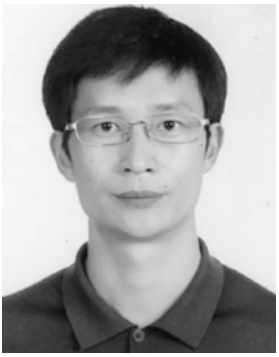

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Abbreviations

ACO	Ant colony algorithm
ADO	ActiveX data object
AI	Artificial intelligence
ANN	Artificial neural network
ATL	ActiveX template library
BIBO	Bounded-input, bounded-output
BP	Backpropagation
BPNN	Backpropagation neural network
BTP	Burn-through point
C/S	Client/server
CIQPM	Cascade integrated quality-prediction model
COT	Coke-oven temperature
COTC	Coke-oven temperature on the coke side
COTM	Coke-oven temperature on the machine side
CSP	Compact strip production
CVPD	Calorific value and pressure decoupling
DCS	Distributed control system
DDE	Dynamic data exchange
DOB	Disturbance observer
ECS	Expert control system
EGT	Exhaust gas temperature
EGTRP	Exhaust gas temperature rise point
EID	Equivalent input disturbance
ES	Expert system
FCM	Fuzzy C mean
FL	Fuzzy logic
FNNDC	Fuzzy-neural-network decoupling controller
FNNIM	Fuzzy-neural-network inference machine
GA	Genetic algorithm
GAP-EKF	Growing and pruning with an extended Kalman filter

HIC	Hierarchical intelligent control
HMI	Human–machine interface
HPSO	Hybrid particle swarm optimization
IIO	Intelligent integrated optimizer
IIOS	Intelligent integrated optimization system
JSP	Job scheduling problem
LP	Linear programming
LR	Linear regression
LTC	Longitudinal temperature on the coke side
LTM	Longitudinal temperature on the machine side
MFC	Microsoft foundation classes
MIMO	Multiple-input, multiple-output
NN	Neural network
OLEDB	Object linking and embedding database
OPC	OLE for process control
PID	Proportional–integral–differential
PLC	Programmable logic controller
PSO	Particle swarm optimization
QAP	Quadratic assignment problem
RBF	Radial basis function
RBF-RNN	Radial-base-function-based recurrent neural network
SA	Simulated annealing
SDF	Satisfactory degree function
SDNN	Supervised distributed neural network
SIP	Sintering ignition process
SSP	Satisfactory solution principle
TDF	Two-degrees-of-freedom
TSP	Traveling salesman problem
TTR	Temperature at the top of a regenerating chamber
TTRC	Temperature at the top of a regenerating chamber on the coke side
TTRM	Temperature at the top of a regenerating chamber on the machine side
VRP	Vehicle routing problem
WinCC	Windows control center