Smart optimization control system for energy-intensive equipments

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ABSTRACT

China has abundance of mineral resources such as magnesite, hematite and bauxite, which constitute a key component of its economy. The relatively low grade, and the widely varying and complex compositions of the raw extracts, however, pose difficult processing challenges including specialized equipment with excessive energy demands. The energy intensive furnaces together with widely uncertain features of the extracts form hybrid complexities of the system, where the existing modeling, optimization and control methods have met only limited success. Currently, the mineral processing plants generally employ manual control and are known to impose greater demands on the energy, while yielding unreasonable waste and poor operational efficiency. The key way to solve these problems is to make the control systems of energy intensive equipment become CPS. CPS for energy intensive equipment is a smart optimal control system.

This talk presents syntheses and implementations of a smart optimal control system for the energy intensive processing equipment. The talk will focus on three main functions of the proposed smart optimal control system: (i) process control; (ii) operational optimization control; and (ii) operational conditions diagnostics and self-healing control. The design of a novel data-driven dual closed-loop intelligent optimal operational control will be described for realizing these primary functions.

The data-driven dual closed-loop control employs a two-layered structure: (i) an intelligent optimal control layer for identification of optimal set points of control loops which takes functions of target indices associated with energy saving, product yield, product quality and efficiency as optimization index, and the set points as the decision variables; and (ii) a set points tracking intelligent control layer focusing on virtual unmodeled dynamics compensation based controller.

This talk introduces a hybrid simulation system for operational optimization and control of complex industrial processes developed by our team. Simulations to electric magnesium melting

furnace for magnesia production industry are used to demonstrate the effectiveness of the proposed method.

This talk also introduces the smart embedding control system of electric magnesium melting furnace developed by our team adopting the novel data-driven dual closed-loop intelligent optimal operational control algorithm proposed. It has been successfully applied to the largest magnesia production enterprise in China, resulting in great returns. `Issues for future research on the smart optimization control system are outlined in the final section.

Tianyou Chai was born in Lanzhou, Gansu Province, China. He received the B.A. degree in automation from Northeastern University of Electric Power, Jilin, China in 1980, the M.S. and Ph.D. degrees in control theory and engineering in 1983 and 1985, respectively, from Northeastern University, China.

Since 1985, he has been with the Center of Automation at Northeastern University, where he became a Professor in 1988. He serves as a director of The National Engineering and Technology Research Center of Metallurgical Automation since 1997; director of Key Laboratory of Integrated Automation of Process Industry, Ministry of Education since 2003; director of Department of Information and Science of National Natural Science Foundation of China since 2010; director of The State Key Laboratory of Synthetical Automation for Process Industries since 2011; and Chair of Academic committee of Northeastern University since 2011. In 2003, he was elected as a member of Chinese Academy of Engineering.

He is a Fellow of IFAC and IEEE. He has served as Member of Technical Board of IFAC and Chairman of Coordinating Committee on Manufacturing and Instrumentation of IFAC from 1996 to 1999, a member of Chinese National Disciplinary Appraisal Grou since 1992, and a Vice-Director of Committee of Experts of Advanced Manufacturing and Automation in National 863 High-Tech Program from 2001-2006.

His main research interests are in modeling, control, optimization and integrated automation of complex industrial processes. He has served extentively as a consultant to industry and government. He has authored or coauthored 3 books, more than 450 technical articles including 176 international journal papers and 280 international conference papers, and holds 14 patents. He has been invited to deliver 41 plenary speeches on international conferences including 21 in IFAC and IEEE hosted conferences.

For his contributions, he has won 4 prestigious awards of National Science and Technology Progress and National Technological Innovation from China, the 2002 Technological Science Progress Award from Ho Leung Ho Lee Foundation, the 2007 Industry Award for Excellence in Transitional Control Research from IEEE Multiple-conference on Systems and Control and the 2010 Yang Jia-Chi Science and Technology Award from Chinese Association of Automation. He received several best paper awards, including Best Paper Award for 2011-2013 from Control Engineering Practice in 2014.