NSERC INDUSTRIAL RESEARCH CHAIR *Control of Oilsands Processes*

NEWS LETTER, IRC AND RELATED R&D ACTIVITIES, ISSUE 8, MARCH 2016

We are committed to the continuous research and thrive for the innovative solutions to the economical and sustainable development of the oil sands process while ensuring safety by combining various aspects of process systems engineering including control, optimization, and data mining.

CSChE Bantrel Award ceremony Calgary, October 6, 2015. Amarjeet Bassi, CSChE President (right)

Top News

IRC is currently in the process of being renewed and expanded with additional industrial partners

Success Stories

Ruomu Tan

An emulsion flow rate soft sensor has been successfully implemented in a well pad of SAGD site for the purpose of monitoring and control. The aim is to estimate the emulsion flow rate for all well pairs in the well pad of interest. The soft sensor has been developed based on historical data. Further, data reconciliation strategy with a robust layer was developed to improve the soft sensor's performance. The developed solution helps to obtain fast-rate estimations of the emulsion flow and makes real-time closed-loop control possible.

Shekhar Sharma, Ming Ma, Yaojie Lu, Yu Miao, and Ruben Gonzalez

A data reconciliation method based on mass balance has been proposed to match the daily feed rate provided by a weightometer consistent with that of the WENCO system in an oil sand operation site. To improve the performance further, bias between the reconciled weightometer and the WENCO system is reduced by a moving window bias correction method. The proposed solution has been implemented online and evaluated through extensive field tests. Online monitoring results show that the corrected weightometer performs significantly better than the original weightometer. Future work is to develop closed-loop control applications based on the corrected weightometer predictions.

2016 IRC Workshop's presentations

Steam Generation Network Optimization, by Rishik Ranjan

SAGD operation consists of several water processing and steam generation plants. Steam production rates across different plants may not be well coordinated due to plant outage or slowdown. The objective of this project is to find an economically optimal distribution of water flow rate across the site in the presence of changes in operating constraints by utilizing tanks as buffers. This problem was solved by constructing mass balance models for all process units. Data reconciliation and optimization were performed using these models. The solution has been developed in the form of a GUI-based Excel application that interfaces with GAMS optimization software. Operators may use this GUI as a decision-making tool on a daily basis. It can also be used to close the mass balance across the site and estimate missing flow rate measurements. The performance of the tool is found to be adequate on historical data and is currently being evaluated by process engineers. Future work involves making the tool more generic and applicable to a wide range of utility optimization problems.

Emulsion Flow Rate and Water Content Soft Sensor by Ruomu Tan and Yanjun Ma

In a typical well pair of the Steam Assisted Gravity Drainage (SAGD) process for producing bitumen, hot and high-pressure steam is injected through the injection well into the oil sands reservoir. As the viscosity of bitumen is reduced by the injected steam, an emulsion of bitumen and water is pumped out through the production well. The flow rate and water content of the produced emulsion are key variables for control and optimization. However, fast-rate sensors for measuring these variables are expensive and difficult to implement. Therefore, soft sensors for predicting both the emulsion flow rate and its water content are built using measured process variables. The soft sensors are trained and validated on historical data sets collected from different well pairs. Further, using the overall flow rate measurements, an online data reconciliation strategy is applied to improve the performance of the developed flow rate soft sensor. Currently, this emulsion flow rate soft sensor with a robust layer has already been used on-line for model predictive control. While off-line analysis and validation is in progress for the water content soft sensor.

2016 IRC Workshop's presentations (cont'd)

Sulfur Content Soft Sensor with Application, by Hariprasad Kodamana

Sulphur content is an important quality variable in the Heavy Gas Oil (HGO) hydrotreator plants in the Oil Sands upgrading process. However, the lab measurement of Sulphur content is usually infrequent, which is undesirable and more frequent data are required for online-control. Therefore, we propose a soft sensor to provide continuous estimation of the Sulphur content. Based on an extensive study of upstream processes, possible process variables which may have direct impact on the Sulphur content are selected and used for the development of the proposed soft sensor. The testing results demonstrated that the proposed solution has significant improvement in its performance in comparison with an existing soft-sensor.

N2B Soft Sensor with on-line Inferential Control, by, Shekhar Sharma, Ming Ma, and Yi Zheng

Naphtha is added to the IPS (Inclined plate separator) feed to enhance the density difference between the feed components and aid in the separation process. The naphtha to bitumen (N:B) ratio is a key quality variable, the measurement of which is not available on demand and is determined through laboratory analysis. Therefore, this soft sensor provides reliable and accurate fast-rate prediction of N:B to be used for closed-loop control. Grey box modeling strategy was used to develop the soft sensor and after offline testing and validation, it was implemented online. As online performances was fulfilled, the soft sensor has now been implemented in DCS for closed-loop control of N:B ratio and improved operation performance has been observed.

New Development in Steam Quality Soft Sensor for Steam Generators, by Yanjun Ma and Yaojie Lu

The need to ensure safety and economical energy consumption in SAGD process, requires appropriate control of steam quality produced from steam generators. Consequentially, in our previous work, steam quality soft-sensors for individual passes as well as recombined pass of the steam generators were successfully developed and implemented. However, measurements of certain variables may not always be available across all sites. To address this problem, two solutions are developed: first one uses a data-driven algorithm to estimate the missing measurements, and the second one estimates the individual pass steam qualities directly without relying on the missing measurements. Both of these solutions have been implemented in real-time and provided significantly improved steam quality estimations compared to the existing sensors.

Plant-wide Optimality and Safety Assessment, by Shabnam Sedghi

Operating performance of industrial processes may deviate from the initial target over time due to variations in process characteristics and in product demands. Such changed conditions will reduce the profits and may affect safety and optimality. Thus, it is necessary to develop an effective method for online operating performance assessment, which takes both safety and optimality into considerations. As a solution, we propose a probabilistic framework for online operating performance assessment. The proposed method is tested on a water treatment network plant in SAGD process and results show that this approach has a potential to detect the operating status, predict performance degradation in real-time, and helps in troubleshooting process abnormality.

News and Events

Aug. 6, 2015: Mr. Peter Read, Syncrude Canada Vice President - Strategic Planning visited the University of Alberta, met Dean of Engineering and attended an update meeting.

Aug. 14, 2015: Mr. Chris Wolfe, Syncrude Canada Vice President - Technical Operations Support visited the University of Alberta, met Dean of Engineering and attended an update meeting.

IRC workshop was held on Feb 25, 2016 at the University of Alberta under the name*: 2016 Spring Workshop on Process System Engineering and Control.*

Introducing researchers

Ruomu Tan

had joined Prof. Huang's research group in 2013, she completed her MSc degree and currently works as a research assistant. Her research focuses mostly on data-driven modelling approaches and statistical approximation of non-Gaussian distributions. She also contributed to soft sensor developments among which, the emulsion flow rate soft sensor for SAGD process. This work has been successfully implemented for monitoring and control.

Shekhar Sharma

has a BSc in chemical engineering from IIT Roorkee, India. He began his Masters degree in Process Control in September 2013 under Prof. Huang's supervision. His thesis was focused on developing soft sensors for industrial applications based on the Just-In-Time modeling framework. He published his work in the Journal of Chemometrics and presented it at the 65th Canadian Chemical Engineering Conference. Moreover, Shekhar is experienced in troubleshooting of soft sensors for the oilsands industry.

Rishik Ranjan

joined Prof. Huang's group to pursue his Master's degree in Process Control after receiving a Bachelors of Technology in Chemical Engineering from the Indian Institute of Technology, Bombay (India). His research interests is in process modeling, control, and optimization. Besides working on theoretical topics such as robust process modeling using non-parametric data-based approaches, he has developed an application which can be used to perform data reconciliation and optimization for steam generation networks in industry.

Ouyang Wu

joined Prof. Huang's research group to pursue his M.Sc. in 2013. His research interests include multi-model approaches, state estimation, and electricity price prediction. His works are submitted to reputed journals, including IEEE Transactions on Industrial Electronics. In addition, he is involved in industrial projects such as development of soft sensors for oilsands upgrading. Ouyang obtained his M.Sc. in Process Control in 2015.

Recent Sample Journal Publications

S. Zhao, Y.S. Shmaliy, B. Huang, and F. Liu, Minimum variance unbiased FIR filter for discrete time-variant systems, *Automatica, 53, 355-361, March 2015.*

S. Zhao, B. Huang, F. Liu, Fault Detection and Diagnosis of Multiple-Model Systems with Mismodeled Transition Probabilities, *IEEE Transactions on Industrial Electronics, 62, 8, 5063-507,1 August 2015.*

J. Zheng and B. Huang, A Bayesian sparse reconstruction method for fault detection and isolation, *Journal of Chemometrics, 29, 6, 349 – 360, June 2015.*

Y. Shardt, B. Huang, and S. Ding, Minimal required excitation for closed-loop identification: Some implications for data-driven, system identification, *Journal of Process Control, 27, 22-35, 2015.*

Y. Guo and B. Huang, State estimation incorporating infrequent, delayed and integral measurements, *Automatica, 58, 32-38, August 2015.*

Y. Yuan, S. Khatibisepehr, B. Huang, and Z. Li, Bayesian Method for Simultaneous Gross Error Detection and Data Reconciliation, *AIChE J., 61, 3232-3248, October 2015.*

R. Gonzalez and B. Huang, Process monitoring using kernel density estimation and Bayesian networking with an industrial case study, *ISA Transactions, 58, 330-347, September 2015.*

L. Chen, S. Khatibisepehr, B. Huang, F. Liu, and Y. Ding, Nonlinear process identification in the presence of multiple correlated hidden scheduling variables with missing data, *AIChE J., 61,3270-3287, October 2015.*

C. Shang, B. Huang, D.X. Huang, and F. Yang, Probabilistic Slow Feature Analysis-Based Representation Learning from Massive Process Data for Soft Sensor Modeling, *AIChE J., 61, 4126-4139, December 2015.*

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