NSERC INDUSTRIAL RESEARCH CHAIR *Control of Oilsands Processes*

NEWS LETTER, IRC AND RELATED R&D ACTIVITIES, ISSUE 3, JULY 2013

Process System and Control Laboratory

Success Stories

Li Xie et al.

The steam quality soft sensor that was developed by Li Xie et al. has been put on-line for control of steam quality in our industrial partner's In-situ oil sands operating facility. Clear improvement of control performance has been achieved.

Mulang Chen

has developed a novel algorithm for model updating of Near Infrared Spectrometer, which enables engineers to identify important variables during the online updating phase. While testing the method using industrial diesel data from an industrial partner, it was shown that the model accuracy can be improved by 13%. The methodology and results have been published in Industrial & Engineering Chemistry Research, 52, 7886−7895, 2013.

The search for solutions to the oil sands development has typically focused on the processes that make up an oil sands operation. We take a different approach by focusing on the systems that control these processes.

SAGD R&D Subject 1) Mathematical Modeling of Steam Assisted Gravity Drainage. By Mohammad Rashedi & Dr. Amiya Jana

Steam assisted gravity drainage (SAGD) is perhaps the most promising way for reaching deep oil sand reservoirs in Alberta. The SAGD process aims at producing oil through the reduction of viscosity by injecting steam into the reservoir. Reducing the amount of steam for each barrel of oil (or steam-oil ratio) and increasing the rate of oil production are two key objectives of the process. With these goals, this research work aims to model the dynamics for state estimation and formulate a high-quality control system for this process.

The principal components of a SAGD extraction process are steam generator, steam injector, steam chamber and oil production well. In a SAGD operation, the once-through steam generator (OTSG) is commonly used to produce steam for injection through wellbores. The representative OTSG is equipped with continuously heated pipes through which the pressurized feed water flows in to generate superheated steam. Accordingly, the phase change of flow can typically divide the pipe into three continuous sections: compressed water (economizer), wet steam (evaporator) and superheated steam (superheater). The length of each section is allowed to vary with time, which leads to the change of process variables such as pressure, temperature, flow, etc. Performing overall balance on mass, energy and momentum, the steam generator model is developed. The simulated steam generator is capable of producing both the high pressure (HP) superheated and saturated steam as per the requirements. Once the steam is generated, it is injected through the wellbores into the reservoir that mainly preserves the oil-sands. In the reservoir, the steam chamber starts growing as the hot steam spreads from the injection wells. Consequently, the viscosity of oil is reduced, which in turn improves the mobility. In this way, the production wells discharge the oil for further treatment. To represent this mechanism involved in the SAGD process, a simulation algorithm using a mathematical model is being developed.

SAGD R&D Subject 2) Cogeneration HRSG Steam Quality Soft Sensor. By Chen Li

The Cogeneration in an In-situ oil sands plant consists of a Heat Recovery Steam Generator (HRSG) which provides steam for injection into the reservoirs, as well as power supply to both Firebag and sales to the grid. Along with the HRSG, the Cogeneration also includes the addition of a gas turbine. A steam quality soft sensor has been developed for the Cogeneration operation facilities. The reliability and accuracy of steam quality measurement has been significantly improved compared to the original online calculation. Thus, the development of the soft sensor makes it possible to implement steam quality control for each individual pass and the overall steam quality.

Introducing A Researcher

Tianhong Pan

***P**rior to joining Professor Huang's research group as a postdoctoral fellow in November 2011, Tianhong obtained his Ph.D. degree in April, 2007 from Shanghai Jiao Tong University, China. He then worked for 1.5 years at National Tsinghua University, Taiwan China as a postdoctoral fellow, where he gained valuable industrial experience in semiconductor manufacturing processes (Taiwan Semiconductor Manufacturing Company, TSMC) and petrochemical industry (CPC Corporation). Additionally, he published several articles in refereed journals and international conferences. In the IRC group, he has successfully collaborated with Alberta Health to develop cytotoxicity assessment methods in toxicity testing. His achievements have been highly valued by the research community. One of the methods (AUC_{50}) has been taken as a standard index for high throughput screening in toxicity testing. During his tenure at the University of Alberta, Tianhong published several articles in high quality journals.*

SAGD R&D Subject 3) History Matching of SAGD Reservoir Using Constrained Ensemble Kalman Filter (EnKF). By Abhinandhan Raghu

Properties such as porosity and permeability have a great impact on the amount of recoverable oil in In-situ oil sands operation. This heterogeneity also makes the prediction of reservoir performance extremely challenging. In this work, the future performance of the reservoir, where the oil is produced by the Steam Assisted Gravity Drainage (SAGD) process, is predicted by means of developing a history matched reservoir model. History matching is performed using a constrained Ensemble Kalman Filter (EnKF). In this method, the uncertain model parameters are refined continuously so that the reservoir simulation results match the production history of this method. The EnKF uses the reservoir model with an ensemble of initial conditions to make a prediction for each time interval, after which, in the update step, the model predictions are reconciled with data to provide updated parameter estimates. We have developed a novel algorithm to include constraints in the EnKF, which is employed in this history matching exercise. It was found that constrained EnKF results in better history match compared to unconstrained EnKF.

Recent Sample Journal Publications

L. Xi, Y. Zhao, D. Aziz, X. Jin, L. Geng, E. Goberdhansingh, F. Qi, B. Huang, Soft sensors for online steam quality measurements of OTSGs, **Journal of Process Control**, 23, 7, 990–1000, 2013.

J. Deng, L. Xie, L. Chen, S. Khatibisepehr, B. Huang, F. Xu, A. Espejo, Development and industrial application of soft sensors with on-line Bayesian model updating strategy, **Journal of Process Control**, 23, 317-325, 2013.

S. Khatibisepehr**,** B. Huang, E. Domlan, E. Naghoosi, Y. Zhao, Y. Miao, X. Shao, S. Khare, M. Keshavarz, E. Feng, F. Xu, A. Espejo, R. Kadali, Soft sensor solutions for control of oil sands processes, Oil Sands Special Issue in **Canadian Journal of Chemical Engineering**, DOI: 10, 1002/cjce.21833, 2013.

M. Chen, S. Khare, B. Huang, H. Zhang, E. Lau, E. Feng, A recursive wavelength selection strategy to update near infrared spectroscopy model with an industrial application**, Industrial & Engineering Chemistry Research**, 52, 7886−7895, 2013.

T. Pan, B. Huang, W. Zhang, S. Gabos, D. Huang, V. Devendran, Cytotoxicity assessment based on the AUC50 using multi-concentration time-dependent cellular response curves (TCRCs**), Analytica Chimica Acta**, 18,764,44-52, 2013.

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Visitors

Prakash Jagadeesan, *Ph.D., Professor from Anna University, India*

Amiya Jana, *Ph.D., Professor from Indian Institute of Technology*

Weili Xiong, *Ph.D., Professor from Jiangnan University, China*

Recent Graduates

Marziyeh Keshavarz, *MSc.*

Xiongtan Yang, *MSc.*

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Newsletter prepared by
Fadi Ibrahim & Chandana Somayaji

News and Events

Awards

Dr. Huang is the winner of this year DG Fisher Award, Canadian Society for Chemical Engineers (CSChE).

Conference presentations

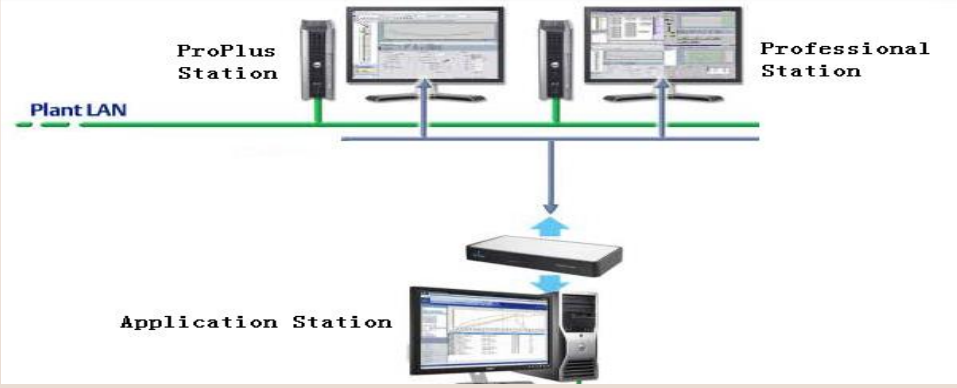
Ruben Gonzalez presented "Data-driven diagnosis with ambiguous historical data: A generalized Dempster-Shafer approach" at the 16th International Conference on Information fusion held in Istanbul, Turkey from July 9 to July 12, 2013.

Marziyeh Keshavarz presented "Expectation maximization approach to gross error and change point detection" at the 10th IEEE International conference on Control and Automation held in Hangzhou, China from June 12 to June 14, 2013.

Employment

Marziyeh Keshavarz starting job in Enbridge,
Lei Sun starting job in Suncor,
Xiongtan Yang starting job in KBR,
Janani Sridhar starting job in Pentair Valves and Control

Process Systems & Control Laboratory



In order to establish a real industrial process control system to facilitate research in the areas of process control, monitoring and optimization as well as to improve the reliability and efficiency in transforming academic achievement into industrial application, our Process System and Control Lab replaced the DeltaV Simulator with completely industry oriented DCS system composed of DeltaV ProfessionalPlus Station, Professional Station and Application Station.
The introduced DetlaV system has the ability to control multiple lab devices such as multi-tank system and hybrid tank system at the same time. Meanwhile, the communication between DeltaV system and lab devices is OPC based.
Currently, all engineering work such as control strategy design and configuration and soft sensor implementation are performed on DeltaV Professional Station. The configuration of OPC based communication between DeltaV and the lab devices is performed on the DeltaV Application Station.