A Global Initiative of Academic Networks (GIAN) Course on

ECONOMIC PLANTWIDE CONTROL OF INTEGRATED CHEMICAL PROCESSES

16th to 20th December 2019, National Institute of Technology, Tiruchirappalli

Overview

The imperatives of fierce market competition and ever increasing sustainability concerns reflected in increasingly stringent product quality norms as well as pollution/emission norms and carbon tax has driven the chemical process industry towards greater material and energy integration (recycle). Modern plants are thus highly energy efficient producing only the desired high-quality product with zero waste/by-product discharge. The several material and energy recycle loops significantly improve the process material and energy efficiency, and hence its overall economics. However, the recycle loops also result in a highly non-linear and interacting system with multiple paths for disturbance propagation. We thus have the non-linear phenomena of the snowball effect, multiple steady states and infeasible steady states in even the simplest of process systems with material/energy recycle. The overall plantwide dynamics also slows down significantly as variability propagates through the various process units inside the recycle path. The safe, stable and efficient operation of such highly integrated processes then becomes the determining factor in ensuring success of the manufacturing enterprise. Indeed, depending on the control system implemented, significantly higher (~5-20%) production may be achieved from a given plant. At the other extreme, it is also possible that a poorly structured control system makes the plant vulnerable to very frequent shutdowns with extremely poor operability. While control theory and chemical engineering fundamentals of material and energy balances are well understood in isolation, their synthesis in designing a robust economic plantwide control system is quite poorly understood in current chemical engineering practice and academia, particularly in the Indian context. What are the key considerations in the design of a robust overall plantwide control system for complex integrated chemical processes? How does one systematically go about designing a robust overall plantwide control system that ensures safe, stable and economic process operation of such integrated processes? This workshop is designed to address these questions towards extracting greater economic benefits from existing and upcoming chemical processes in India, without compromising on robustness.

Objectives

The primary objectives of the course are to develop the following in/for the course participants:

i. A deep appreciation of the role of chemical engineering fundamentals (degrees of freedom analysis and independent material / energy balances) in plantwide control system design for continuous chemical plants.
ii. Essential control theory principles widely applied and useful for the practicing process engineer.
iii. An understanding of the control issues due to material and energy integration and control structure guidelines for addressing them.
iv. An understanding of the role of material/energy recycle in the dominant economic operation tradeoffs and control strategies for ensuring near economic optimum process operation.
v. A systematic procedure for plantwide control system design for safe, stable and economic operation of integrated chemical plants.
vi. The ability to synthesize economic plantwide control systems for integrated chemical plants using several example case studies and exercises.

Lecture Schedule: Dr Suraj Vasudevan (SV) and Prof Nitin Kaistha (NK)

Day	Date	Time	Topic
1	16-12-2019 (Monday)	8:30-9:30	Registration and Inauguration
		9:30-11:00	**Lecture:** Introduction to course & Essential process control basics (SV)
		11:30-12:30	**Lecture:** Process dynamics, PID feedback control, identification and tuning, advanced control structures, multivariable decentralized control and advanced model predictive control (SV)
		14:00-15:00	**Lecture:** Control and steady state degrees of freedom (DoFs) Intuitive procedure, DoFs, specs and Controlled Variables (CVs) (SV)
		15.30 - 16:30	**Tutorial:** Auto tuning a SISO PID controller. Degrees of freedom exercises (NK)
		16:30-17:00	Open Discussion - Q&A
2	17-12-2019 (Tuesday)	9:00-10:30	**Lecture:** Control of common unit operations: Distillation, reactors, heat exchangers, and miscellaneous systems (SV)
		10:45-12:30	
		14:00-15:00	**Tutorial:** Tray temperature selection in a distillation column (NK)
		15.30 - 16:30	**Tutorial:** Control configuration synthesis for standalone units (NK)
		16:30-17:00	Open Discussion - Q&A
3	18-12-2019 (Wednesday)	9:00-10:30	**Lecture:** Connecting control structures, DoFs and independent balances (NK)
		11:00-12:30	**Lecture:** Regulatory issues due to recycle Snowball effect, steady state infeasibility, slow plantwide dynamics and subtle drifting modes (NK)
		14:00-15:00	**Lecture:** Addressing regulatory issues due to recycle. Key control configuration guidelines. Throughput manipulation and inventory control (NK)
		15:30-16:30	**Tutorial:** Consistent vs inconsistent control exercises. Control design for simple reactor-separator-recycle process (SV)
		16:30-17:00	Open Discussion - Q&A
4	19-12-2019 (Thursday)	9:00-10:30	**Lecture:** Systematic regulatory plantwide control system design procedure. TPM selection, energy balance control, quality control, material balance control (SV)
		11:00-12:30	**Lecture:** Economic considerations in plantwide control Process operation modes, economic optimum operation and active constraints, handling equipment capacity constraints (SV)
		14:00-15:00	
		15:30-16:30	**Tutorial:** Plantwide control system design exercises Cumene process, ethyl benzene process, ethyl acetate process, ammonia process (SV)
		16:30-17:00	Open Discussion - Q&A
5	20-12-2019 (Friday)	9:00-10:30	**Lecture:** Systematic economic plantwide control system design TPM at bottleneck, pair close for fast regulatory control, use self-optimizing control or RTO for economic unconstrained DoFs (NK)
		11:00-12:30	**Lecture:** Economic plantwide control design application examples (NK)
		14:00-15:00	**Tutorial:** Economic plantwide control design exercises (SV)
		15:30-16:30	Test
		16:30-17:00	Certificate Distribution and Closing Ceremony

You Should Attend If…	Executives, engineers and researchers from process industries and government organizations including R&D laboratories, who are involved with the analysis of problems in Instrumentation and Control, chemical and other engineering disciplines. Students at all levels (B.Tech./M.Tech./Ph.D.) or Faculty from reputed academic institutions and technical institutions.
Fees	The participation fees (Excluding Lodging & Boarding) for attending the course is as follows: **Attendees** / **INR** B.Tech/M.Tech student participants — 2,000/- PhD Scholars — 3,000/- Faculty [Internal/External & Scientists] — 5,000/- Persons from Industry/Consultancy firms — 8,000/- Participants from abroad — US $500 The above fee include all instructional materials, tutorials, assignments and internet facility. Fee does not include accommodation and food. On request, accommodation will be provided to the participants on payment basis.
How to Register?	**Stage 1: Web (Portal) Registration:** Visit GIAN Website at the link: http://www.gian.iitkgp.ac.in/GREGN/index and create login user ID and Password. Fill up blank registration form and do web registration by paying 500/- on line through Net Banking/ Debit/ Credit Card. This provides the user with life time registration to enroll in any no. of GIAN courses offered. **Stage 2**: **Course Registration (Through GIAN Portal):** Log in to the GIAN portal with the user ID and Password created. Click on "Course Registration" option given at the top of the registration form. Select the Course titled "Economic Plantwide Control of Integrated Chemical Processes" from the list and click on "Save" option. Confirm your registration by Clicking on "Confirm Course". Only Selected Candidates will be intimated through E-mail by the Course Coordinator. Last date for Registration: 6th Dec,2019 They have to remit the necessary course fee in the form of DD drawn in favour of "**The Director, NIT, Tiruchirappalli - 620015**" payable at **NIT-Tiruchirappalli**. The DD has to be sent to the Course Coordinator after registration.
Course Coordinator and Contact Information	**Dept. of Instrumentation and Control Engg,** National Institute of Technology, Tiruchirappalli **Dr. N. Sivakumaran** - Associate Professor 0431-2503362 9443745705 nsk@nitt.edu **Dr. S. Narayanan** - Assistant Professor 0431-2503364 9486437744 narayanan@nitt.edu

Profile of Course Faculties

Dr. SURAJ VASUDEVAN

Suraj Vasudevan is a Lecturer in the Department of Chemical & Biomolecular Engineering (ChBE) at National University of Singapore (NUS). He obtained his Bachelor's degree and Ph.D. from NUS in 2004 and 2011, respectively. His Ph.D. dissertation was on dynamic simulation and plant-wide control of industrial processes. He was then a Research Fellow for the Singapore National Research Foundation's Carbon Capture and Storage/Utilization Roadmap project. He subsequently worked as a Lecturer with the School of Chemical and Biomedical Engineering (SCBE) at Nanyang Technological University (NTU) for 4.5 years.

At NTU, he was the main coordinator for the final year design project in his school, in addition to teaching other modules. He is the recipient of two teaching awards: SCBE's Teaching Excellence Award (Gold) and the Nanyang Education Award (School). At NUS, he is involved in teaching several modules such as separation processes, process synthesis and simulation, and control of industrial processes. He is also one of the coordinators for the design project. He has published 9 peer-reviewed journal articles, and 4 book chapters in 'Plant-Wide Control: Recent Developments and Applications'.
Website: http://www.chbe.nus.edu.sg/teaching/chesura

Prof. NITIN KAISTHA

Nitin Kaistha received the B.Tech. degree in Chemical engineering from the Indian Institute of Technology, Kanpur and Ph.D. (Chemical Engineering) degree from the University of Tennessee, Knoxville in 1996, 1999, respectively.

In Aug 2002, he joined Unilever Research as research scientist and he is currently with the department of Chemical engineering at Indian Institute of Technology, Kanpur. He has published 44 per-reviewed journal articles and authored 3 book chapters.
Website: https://www.iitk.ac.in/che/nk.htm

Profile of Course Coordinator's

Dr. N. SIVAKUMARAN

Natarajan Sivakumaran is currently an professor of Instrumentation and Control Engineering Dept., National Institute of Technology, Tiruchirappalli, India. He obtained Ph.D. from NIT, Tiruchirappalli under National Doctoral Fellowship, AICTE in the year 2004 where he worked on Identification and Control of Nonlinear Processes using Recurrent Neural Networks. His research interest includes Real Time Implementation of problems that arise out of optimization methods in Process Control and Biomedical Instrumentation applications. He has several significant papers in international conferences and journals. He was a recipient of Government of India's Young Scientist grant under DST in 2007 and Young Research Fellow under Meity in 2017.

Dr. S. NARAYANAN

Narayanan received the Ph.D. degree from MIT Anna University in the area of PID control. In May 2007, he joined National Institute of Technology at Tiruchirappalli as a lecturer in the department of Instrumentation and Control Engineering. His research interests includes multivariable decoupling control, PID control, state feedback control.