Plantwide Control of Chemical Processes - Video course

COURSE OUTLINE

The issue of control structure selection, where the control system designer must make decisions as to what variables need to be controlled and the corresponding manipulated variables, is usually treated in a very perfunctory manner in courses on control theory.

In practical chemical process operation, it is this choice of the control structure that turns out to be crucial towards effective disturbance rejection and maximizing process profitability.

Given the large number of control degrees-of-freedom even for the simplest of chemical processes with material/energy recycle, how does one systematically design an effective plant-wide control system? This course addresses the same using an engineering common sense approach.

Essential process control theory fundamentals are very briefly covered followed by control structure design for common unit operations such as reactors, distillation columns, heat exchangers and miscellaneous operations (furnaces, refrigeration systems etc).

Issues in plantwide control such as proper inventory management and effect of material/energy recycle are then highlighted followed by comprehensive plant-wide control system design case-studies on example processes.

Control structure design considerations for maximizing plant profitability are explicitly covered.

Based on the case-studies, a systematic plant-wide control system design procedure is developed and demonstrated on example processes.

The course broadly covers process control as practiced in the process industry and prepares the ChE student for a career in process operations.

Practicing engineers will also find the material useful for improving the efficiency and profitability of their processes.

Contents:

Essentials of process control: process dynamics, model fitting (identification), PID feedback control and tuning, advanced control structures, multivariable control, DMC.

Control of common unit operations: Control of reactors, distillation control including complex column configurations, heat exchanger control, control of miscellaneous unit operations such as compressors, furnaces, refrigerators and boilers.

Plant-wide control fundamentals: Snowball effect, propagation of variability, inventory management, through-put manipulation.

Plant-wide control case studies: Recycle process with side reaction, Cumene process, HDA process. Systematic plant-wide control system design procedure with example applications.

COURSE DETAIL

S.No	Topics	No. of Hours

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Chemical Engineering

Pre-requisites:

UG level course on process control.

Coordinators:

Dr. Nitin Kaistha
Department of Chemical EngineeringIIT Kanpur

Essentials of Process Control		
1	1. Process dynamics, Laplace transform models and identification. 2. Concept of feedback control, block diagram representation, PID control algorithm and tuning.	4
2	1. Multivariable control: Niederlinski Index, Relative Gain Array, SVD. 2. Decoupling, Decentralized controller tuning, dynamic matrix control.	4
3	Advanced control structures: Feedforward control, ratio control, cascade control, override control and optimizing control.	1
Control Structures for Common Unit Operations		
1	Control structures for simple distillation columns: LV, LB, DV, DB. Single ended and dual ended temperature inferential control, criteria for temperature control tray selection.	3
2	1. Control of complex column configurations: Side draw columns, side rectifier/side stripper columns, heat integrated columns. 2. Petlyuk and Kaibel columns, homogenous and heterogenous azeotropic distillation. 3. Reactive distillation, Do's and dont's of distillation control.	4
3	1. CSTR control: Reaction heat removal and corresponding control schemes. 2. Multiple steady states and stability analysis, heat integration.	2
4	PBR control: Adiabatic operation, Reaction heat removal schemes and control structures, heat integration.	1
5	Control of heat exchangers.	1
6	Control of miscellaneous operations: Compressors, furnaces, refrigeration systems, boiler systems, decanters.	1
Plant-wide Control Fundamentals		
1	1. Degrees of freedom: control dof, steady state performance dof, dynamic dof.	3

	2. Rigorous dof analysis for example processes. 3. Simple dof calculation procedure, Equivalence of control structures and steady state dof specs.	
2	Plant-wide implications of material (energy) recycle: 1. The snowball effect, effect on process time constant, component inventory balancing.	1
3	1. Through-put manipulation and its relation to local inventory control loops. 2. Consistent and inconsistent control structures for a simple recycle process.	1
4	Plant-wide regulatory Control Structure Design Case Studies: 1. Recycle process with side reaction, cumene manufacture process, hydrodealkylation of toluene, vinyl chloride process.	4
Plant-wide Control for Improved Economics		
1	1. Process operation for a given throughput and for maximum throughput. 2. The concept of a bottleneck constraint. 3. Application of optimizing controllers for throughput maximization on case-study processes.	3
2	Considerations in plant-wide control structure design for throughput maximization: 1. Throughput manipulator, inventory loop tuning, plant-wide propagation of process variablility.	2
3	Recycle process plant-wide control design case-study: 1. Economic operation for given throughput and for maximum throughput. 2. Control system design for multiple active constraints.	2
4	Systematic approaches for plant-wide control system design: 1. Luyben's bottom-up design approachand Skogestad’s top-down optimization based approach. Example case-studies.	3
	Total	40

References:

Luyben, W.L., Tyreus, B.D. and Luyben, M.L. (1998) Plantwide Process Control.McGraw Hill: New York.