GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3171710
Semester – VII
Subject Name: PROCESS DYNAMICS AND CONTROL

Type of course: Professional Elective Course-1

Prerequisite: Process Instrumentation, Process Loop Components, Control System Design

Rationale: In the process industries like petrochemical, chemical, cement, textile, power plant, pulp & paper, certain sub-processes are part of the main process stream. For continuous production, it is very much important to know the dynamic behavior of such process units and their control. The content of this subject focuses on such sub-processes and it's control.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1.	**Introduction to process control** Dynamics and stability of controlled systems. Dynamic behavior of linear and non-linear first-and second-order systems. The development of mathematical models to describe process dynamic behavior	6
2.	**The Dynamics and Control of Heat Exchangers** Basic control strategies, dynamics of the heat exchangers, response to changes in steam temperature, measurement lag and control schemes	6
3.	**The Dynamics and Control of Boilers** Boiler basic controls (safety interlocks, single element, two and three element level control, shrink, swell effect, inverse response, feed forward control of feed water, dynamic compensation, fuel–air ratio, stochiometric calculations, steam temperature and pressure control) Boiler dynamics, burner management system, boiler optimization	6
4.	**The Stability and Control of Chemical Reactors** Types of reactions and reactors (overview),factors governing the conduct of reaction, stability of reactors, time constant, effects of lag, flow control, temperature control, pH control, end point detection of continuous and batch reactors. Sequential & logic control in batch process, batch production management	6

5.	**Dynamic Behavior and Control of Distillation Column** Mass and Energy balance, column feed control, column pressure control, control of overhead and bottom composition, distillate reflux flow control. Frequency response, lag in liquid and vapor flow, concentration lag, predicting the behavior of control system	5
6.	**Unit operations in different industries** Identification and justification of unit operations used in different industries like food, pharma, paper, sugar, cement, fertilizer, Petrochemical industry with help of process flow diagram	7

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
14	**14**	**14**	**14**	**14**	**7**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Instrument Engineers Handbook: Process Control by Bela G Liptak , Chilton book co.
2. Process Dynamics and Control by Dale E. Seborg, John Wiley & Sons,
3. Process Instrumentation and control Handbook by Considine, Mc-Graw-Hill publication

Text Book:

1. Process Control by Peter Harroitt, Tata-McGraw Hill. Fifth ed.
2. Process Control Systems by F. G. Shinskey, Tata-McGraw Hill.
3. Chemical Process Control by George Stephonopolous, PHI
4. Computer based Industrial Control by Krishna Kant, PHI
5. Process Control: Modeling, Design and Simulation by B. Wayne Bequette, PHI

Course Outcome: After learning the course the students will be able to

CO1. Demonstrate an understanding of the fundamentals of process dynamics & its modeling and identify the linear and nonlinear behavior

CO2. Select, design and apply control strategies to control the heat exchanger, Boiler, Chemical Reactor and Distillation Column

CO3. Select pumps & compressors and apply its control strategies for process industries.

CO4 Identify and understand the unit operations used in different process industries.

CO5 Use and apply soft computing tools for the analysis of process dynamics and control.

List of Experiments:

Students are expected to perform minimum 8 experiments based on the above topics

- Modeling and Designing control strategies of a typical process
- Process simulation: using MATLAB Simulink, Simulation of different process
- Problems based on stability, frequency response etc.

Suggested Experiment list

1. Study of Dynamic behavior of 2nd order systems. (suggestion: use RLC circuit and for a given step input in voltage try to find out its second order equivalent model by observing capacitor voltage as output)
2. Study of flow control loop using PID controller
3. Study of Level Control loop using PID controller
4. Simulation study of cascade control preferably for chemical process.
5. Simulation study of feed-forward control preferably for chemical process.
6. Simulation study of ratio control preferably for chemical process.
7. Implement temperature control system with PID controller or ON OFF controller.
8. Perform system identification of first or second order system with input and output data. (Suggestion: use system identification toolbox in MATLAB/Simulink or use open source ware: SCILAB)
9. Use the in-built PID controller in PLC. Implement On/ OFF control for temperature process with PLC. (Suggestion: work on actual PLC like (SIEMENS, ABB, SCHNEIDER, DELTA etc.)

Open ended problem:

Try to obtain the mathematical mode of Tubular heat exchanger with theoretical background and chemical/mechanical engineering. Propose a control strategy for the heat exchanger. Also discuss various issues in control of the heat exchanger.

Major Equipment:

Computers, simulation software, multi loop/ single loop control system, etc.

List of Open Source Software/learning website:

https://nptel.ac.in/courses/103/104/103104050/

https://nptel.ac.in/courses/103/101/103101142/

https://nptel.ac.in/courses/103/105/103105064/