CHE-323: Instrumentation and Process Control

Credit Hours: 3-1

Pre-requisites: None

Course Objectives

- The aim of studying Instrumentation and Process control is to familiarize with basic concepts process control and instrumentation required for controlling.
- Various control strategies, controlling equipment behaviors and their response analysis.

Course Contents

i. Incentives for process control
ii. Principles of measurement of temperature. Pressure level, flow, and concentration. Description of sensors for these process variables, Characteristics, and calibration of sensors. Transmitters and transmission lines
iii. Laplace transform of differential equations and characterization of systems
iv. Transfer functions and Block diagram
v. Dynamic behavior of first and second order systems
vi. Feedback control; types of feed-back controllers
vii. Control valves; Fail safe mode, valve characteristics and valve sizing
viii. Dynamic behavior of feedback-controlled processes, closed loop response, servo and regulator problems
ix. Stability analysis of feedback control system
x. Tuning of feedback controllers
xi. Multi-loop Control; cascade control, ratio control, split range control, feed-forward control
xii. Safety instrumented system; alarm, trip and Inter lock system.
xiii. P&ID Diagram
xiv. Process control in the industry 4.0 era.
xv. Overview of AI applications in process control
xvi. Simulink based design and analysis of control loops for temperature, pressure, and flowrate of process stream/equipment

Course Outcomes

After completing this course, students must possess:

- Basic understanding of instrumentation, their principles of operation, advantages and disadvantages.
- Essential understanding of various instruments used and applied din process industry for process control.
- Complete knowledge of control system, its characteristics and components.
- Recognition and identification of various Process diagrams and symbols used in IPC.
- Different types of controllers, their application in industries, advantages and disadvantages.
- Basic design concepts of different controllers.
- Requirement for a successful installation, instrument checkout and controller tuning.

List of Practicals

i. Calibrate the automatic flow sensor with rotameter in the flow control unit and perform its line tracing
ii. Calibrate the automatic temperature sensor with thermometer in the temperature control unit and perform its line tracing
iii. Calibrate the automatic level sensor with manual scale reading in the level control unit and perform its line tracing
iv. Calibrate the automatic pressure sensor with manometer in the pressure control unit and perform its line tracing
v. Implement the feedback control loop in ON/OFF mode in flow control unit to achieve required set point using different values of the tolerance band
vi. Implement the feedback control loop in PID mode in flow control unit to achieve required set point using different values of the proportional band Kc
vii. Implement the feedback control loop in ON/OFF mode in level control unit to achieve required set point using different values of the tolerance band and analyze the graphical variation of level with respect to time

viii. Implement the feedback control loop in PID mode in level control unit to achieve required set point using different values of the proportional band Kc and analyze the graphical variation of level with respect to time
ix. Implement the PID mode control loop in the pressure control unit for achieving different set points; also analyze the behavior of PID controller in case of an external disturbance
x. Implement the PID mode control loop in the pressure control unit for achieving required set point using different values of the proportional band Kc and conclude it graphically
xi. Implement feedback control PI mode in the flow control unit for achieving required set point using Ziegler-Nichols control loop method.
xii. Implement feedback control PID mode in the flow control unit for achieving required set point using Ziegler-Nichols control loop method.

Recommended Books

- Smith, C. A., Corripio, A. B. (2006). Principles and Practice of Automatic Process Control, 3rd Edition. John Wiley.
- Marlin, T.E. (2000). Process Control, 2nd Edition. McGraw Hill Book Co.
- Hughes, T.A. (2002). Measurement and Control Basics. ISA Publication.
- Coughanowr, D.R. and LeBlanc, S.E. (2009). Process System Analysis & Control, 3rd Edition. McGraw Hill.
- Seborg, D.E., Mellichamp, D.A., Edgar, T.F., and Doyle, F.J. (2011). Process Dynamics and Control, 3rd Edition. John Wiley.
- Stephanopoulos, G. (2002). Chemical Process Control: An Introduction to Theory and Practice. Prentice Hall.
- Anderson, N.A. (1998). Instrumentation for Process Measurement and Control, 3rd Edition. CRC Press.