COURSE: CONTROL AND INSTRUMENTATION OF CHEMICAL PROCESSES

STUDIES: CHEMICAL ENGINEERING (2nd cycle)

CODE: 21038

TYPE: TR YEAR: 5th SEMESTER: 1st
CREDITS (hours/week): 6,0 (4)
ECTS CREDITS: 4,5
PROFESSOR: Dr. Eduard Barberà Moral
LANGUAGE: Spanish

PREREQUIREMENTS: Calculus I, Linear Algebra, Differential Calculus, Applied Digital Computation, Electrical Engineering, Electronics and Instrumentation, Basic operations of Chemical Engineering

PREVIOUS KNOWLEDGES: Complex variable, differential equations, Laplace transform, Matrix algebra, Electric circuits, frequency reply, Bode diagrams, basic electronics, unitary processes, informatics

COURSES THAT HAVE TO BE STUDIED SIMULTANEOUSLY: Laboratory for Process Engineering

COURSE DESCRIPTION:
The Process Control is the technique that studies methods and procedures whose aim is the maintenance of operating processes in such a way that the best productivity could be reached and remained within security margins. Therefore, the objectives of this Process Control are: to guarantee the process stability, eliminate the influence of disturbances and optimise its function.

OBJECTIVES OF THE COURSE[1]:

The aim of this course is to communicate the student the essential principles and ideas to study the continuous and digital control linear systems.

1.- learn practical principles for the automatic control in production, in order to improve efficiency and product quality [1]
2.- make it easier the learning of analysis and design techniques of control modern systems with continuous variable, that can be either analogical or digital [2, 5]
3.- introduce the student in the concepts of control within state space [1, 5]
4.- present the most usual instrumentation in the following and control of chemical processes [1, 7]

There are other important objectives [3, 6, 7] than can also be reached during the practices, and are studied in the course of Laboratory for Process Engineering

CONTENTS:

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1 Numbers in brackets refer to the *outcomes*

1.- INTRODUCTION
- 1.1.- Objectives of the process control
- 1.2.- Historical review
- 1.3.- Types of control
- 1.4.- Control techniques
- 1.5.- Integration of process control in company management

2.- LINEAR SYSTEMS
- 2.1.- Transfer function concept
- 2.2.- Block diagram

3.- TEMPORARY ANALYSIS
- 3.1.- First-order systems
- 3.2.- Second-order systems
- 3.3.- Upper-order and dead time systems
- 3.4.- Temporary response parameters
- 3.5.- Classification of systems

4.- CONTROLLERS
- 4.1.- Proportional, integral, derivative and on-off actions
- 4.2.- Real controllers
- 4.3.- Error measurement
- 4.4.- Error criteria

5.- ADJUSTMENT OF CONTROLLERS
- 5.1.- Plant characterization
- 5.2.- Methods based in open loop response
- 5.3.- Methods based in closed loop response
- 5.4.- Methods based in the use of error criteria

6.- STABILITY AND SENSIBILITY
- 6.1.- Concept of stability
- 6.2.- Routh test
- 6.3.- ("root - locus")
- 6.4.- Sensibility

7.- FREQUENCY ANALYSIS
- 7.1.- Bode diagrams
- 7.2.- Relationship between the Bode diagram and the error static coefficients
- 7.3.- Phase range and profit margin
- 7.4.- Nyquist diagrams
- 7.5.- Nichols diagrams

8.- COMPENSATORS
- 8.1.- Advance compensator
- 8.2.- Retard compensator
- 8.3.- Design of compensators

9.- DISCRETE SYSTEMS
- 9.1.- Introduction
- 9.2.- Z transform
- 9.3.- Measurement and error judgement

- 9.4.- Stability
- 9.5.- Algorithms derived from PID
- 9.6.- Algorithms derived from the Ragazzini synthesis method
- 9.7.- Smith predictor

10.- STATE SPACE
- 10.1.- Introduction
- 10.2.- Continuous systems
- 10.3.- Discrete systems
- 10.4.- Discrete model of a continuous system

11.- SENSORS AND TRANSDUCERS
- 11.1.- Basic blocks
- 11.2.- Classification according to the operation principle
- 11.3.- Classification according to the variables measured
- 11.4.- Operation characteristics
- 11.5.- Pressure
- 11.6.- Flow
- 11.7.- Level
- 11.8.- Temperature
- 11.9.- Closeness and displacement
- 11.10.- Other magnitudes

12.- SIGNAL TRANSMISSION
- 12.1.- Analogical, discrete, quantified and digital signals
- 12.2.- The transmission of digital signals

13.- ACTUATORS
- 13.1.- All or nothing actuators
- 13.2.- Continuous actuators

METHODOLOGY:

The course is essentially given in master classes supported with modern audiovisual techniques.
During the class the student may interrupt when he considers it appropriate to ask for any doubts or explanations.
Some problems are presented in class as examples, with the objective to help the student in problems resolution and the student can also require help either in class or in private consultations.
Notes, collections of problems and questions are supplied at the beginning of the course. The aim of having these notes is to help the student to be more watchful in class because the essential things are already in the notes, and in this way the student will make an effort and write only the explanations. Problems and questions have the objective to be on one hand a collection of tests for the self-evaluation and on the other hand to help the student to familiarize with the exams.

Laboratory practices take place in the course: Laboratory for Process Engineering (QILEP)

EVALUATION:

A. Exams

M. Others

The final exam consists of a part of theory (formed by 4 to 5 questions) and a part of problems (2 to 4 problems), and none of the parts can be approved separately. Each part means 50 points.
The final result is calculated by the sum of both parts.
During the course there will be compulsory monthly controls (M), whose aim is to obtain a gradual learning of the course distributing the effort along the year. The result obtained in the controls will let the student decide (even in the moment of the exam) whether he decides to make the final exam of theory or not.
In case of doing a test of problems, one of the problems of the final exam will be eliminated.

CRITERIA FOR THE EVALUATION OF RESULTS[2]:

Objective 1
- The student must show enough knowledge of the practical principles of the automatic control that can be applied in production to improve the efficiency and quality of the product [A, M]

Objective 2
- The student must show enough skill to read and interpret the problems [A, M]
- The student must show enough control of the techniques for the analysis of modern control analogical or digital systems of the continuous variable [A, M]
- The student must show enough knowledge of the design techniques for modern control analogical or digital systems of the continuous variable [A, M]

Objective 3
- The student must show enough knowledge about control concepts in state space [A, M]

Objective 4
- The student must show enough knowledges about the most usual equipment in the follo-up and control of chemical processes [A, M]

ORDINARY BIBLIOGRAPHY:

Notes of the professor

BIBLIOGRAPHY or COMPLEMENTARY MATERIAL:

Classical texts

- K. Ogata, Ingeniería de Control Moderna, Prentice Hall

- F.G. Shinskey, Process-Control Systems, McGraw-Hill

- P. Harriott, Process Control, McGraw-Hill

Modern texts

- G. Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall

2 Letters in brackets refer to the way of evaluation

- C.L. Phillips and H.Troy Nagle Jr., Digital Control System Analysis and Design, Prentice Hall

- K. Ogata, Sistemas de control en tiempo discreto, Prentice Hall

- P.H. Lewis, C. Yang, Sistemas de control en ingeniería, Prentice Hall

PREPAIRED BY: Dr. Eduard Barberà Moral

DATE OF THE LAST REVIEW: February 2005

1.- INTRODUCTION
- 1.1.- Process control objectives
- 1.2.- History of automatic control
- 1.3.- Open and closed loop control systems
- 1.4.- Process control techniques
- 1.5.- Process control and management integration

2.- LINEAL SYSTEMS
- 2.1.- Transfer function concept
- 2.2.- Block diagrams

3.- TIME-DOMAIN ANALYSIS
- 3.1.- First order systems
- 3.2.- Second order systems
- 3.3.- Higher-order and dead time systems
- 3.4.- Transient parameters
- 3.5.- System classification

4.- CONTROLLERS
- 4.1.- Proportional, integral, derivative and on-off actions
- 4.2.- Actual controllers
- 4.3.- Error measurement
- 4.4.- Performance indices

5.- CONTROLLER TUNING
- 5.1.- Plant characterization
- 5.2.- Open loop methods
- 5.3.- Closed loop methods
- 5.4.- Performance index methods

6.- STABILITY AND SENSIBILITY
- 6.1.- The concept of stability
- 6.2.- Routh-Hurwitz stability criterion
- 6.3.- The root - locus method
- 6.4.- Sensibility

7.- FREQUENCY RESPONSE METHODS
- 7.1.- Bode diagrams
- 7.2.- Bode diagram and static error coefficients
- 7.3.- Gain and phase margin
- 7.4.- Nyquist diagrams
- 7.5.- Nichols diagrams

8.- COMPENSATION NETWORKS
- 8.1.- Phase-lead network
- 8.2.- Phase-lag network
- 8.3.- Design

9.- DIGITAL CONTROL SYSTEMS
- 9.1.- Introduction
- 9.2.- The Z transform
- 9.3.- Error measurement and performance indices

- 9.4.- Stability
- 9.5.- PID algorithms
- 9.6.- Ragazzini's direct synthesis algorithms
- 9.7.- Smith predictor

10.- STATE SPACE
- 10.1.- Introduction
- 10.2.- Continuous systems
- 10.3.- Sampled systems
- 10.4.- Sampled model of a continuous system

11.- SENSORS AND TRANSDUCERS
- 11.1.- Basic blocks
- 11.2.- Characteristics classification according to the operation principle
- 11.3.- Classification according to the measured variables
- 11.4.- Operation characteristics
- 11.5.- Pressure
- 11.6.- Flow
- 11.7.- Level
- 11.8.- Temperature
- 11.9.- Proximity and displacement
- 11.10.- Other magnitudes

12.- SIGNAL TRANSMISSION
- 12.1.- Analogical, sampled, quantified and digital signals
- 12.2.- Digital signal transmission

13.- FINAL CONTROL ELEMENTS
- 13.1.- Two position actuators
- 13.2.- Continuous actuators