2EL2010 – Understanding, optimization and simulation of biotechnological processes

Instructors: Filipa Lopes
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Engineering Sciences
Advanced level : Yes

Description

Biotechnology is defined as "the application of science and technology to the transformation of materials by biological agents and enzymes to produce goods and services". Its fields of application are very broad and include many industrial applications, particularly in the health, food, waste treatment, energy production, cosmetics or pharmaceuticals sectors. Biotechnological processes are undergoing very strong development and recruitment. The overall objective of course is to introduce the modern approaches to bioprocess engineering necessary to understand, improve, optimize and design innovative, competitive and more environmentally friendly bioprocesses.
In this context, the bioprocess and its different stages (from the choice of the microorganism to the recovery of products of interest and including the bioreactor) will be addressed by a multi-scale (from the cell to the bioreactor) and multidisciplinary approach at the interfaces, guided by simulation and optimization tools. This course is located between transfer sciences, process engineering, physics and life sciences. The concepts covered in this course will be used for some other courses of the dominant (Life science, health and Environment, Energy,...) as well as in support of some Project Poles (Biotechnology and Health, Energy,...).

Quarter number

SG6

Prerequisites (in terms of CS courses)

Transport Phenomena (1A)

Syllabus

Microbiology :
- The cell;
- Microbial metabolism and its regulation.

Principles of bioprocess engineering:
- The bioreactor;
- The implementation of a bioprocess;
- Studies of emblematic examples: methanisation, alcoholic fermentation, microalgae, activated sludge, etc.
- Operating modes;
- Mass transfer within the bioreactor.

Multi-scale modeling of the bioprocess:
- Macroscopic modeling ;
- Metabolic modeling ;
- Ownership of mass balance models;
- Calibration and validation of models.

Processes for the separation and purification of molecules of interest: overview of techniques used in biorefinery.

Class components (lecture, labs, etc.)

General principles will be discussed and illustrated with industrial examples and applications during lectures and tutorials. The students will thus implement the knowledge acquired on practical engineering cases. In parallel, students will develop a project whose goal is to propose a bioprocess scheme for a given industrial application. Students, organised in groups, will apply their knowledge to a case study. They will choose a topic from among different biotechnological objectives. They will have to propose both processes, suitable microorganisms and implement a bioprocess model.

Grading

Final control (written) (65%) and oral presentation of the project by the team (35%).

Course support, bibliography

Presentations of the speakers and books (Madigan, M. (2007). Brock Biology of microorganisms; Doran, P. M. (1995). Bioprocess engineering principles. Academic press,...).

Resources

Teaching team (names of the teachers of the lectures): Filipa Lopes (Process Dep.), Julien Lemaire (Process Dep.) and Olivier Bernard (Biocore team, Inria).

Learning outcomes covered on the course

By the end of this course, the student will be able to:

- Explain the basics of living organisms functioning.
- Identify the phenomena (chemical, physical and biological) that occur within the bioreactor.
- Write the reaction network characterizing the main mass flows within the bioreactor, and adapted to the objectives of the model.
- Identify the mathematical expressions of the reaction kinetics associated with the reaction network.
- Study the main properties of dynamic bioreactor models (positivity of variables, boundarity, equilibrium, local stability).
- Calibrate a bioreactor model from experimental data.
- Explain the principle of operation of different downstream processes usually used in biotechnology, identify their applications and estimate their advantages and disadvantages.
- Propose a bioprocess scheme for a given application.

Description of the skills acquired at the end of the course

C1 - Analyse, design and implement complex systems made up of scientific, technological, social and economic dimensions
C2 - Acquire and develop broad skills in a scientific or academic field and applied professional areas