1SC2293 – Microalgae production using a biofilm-based photobioreactor

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Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description

" Microalgae production using a biofilm-based system" is one of the 4 courses (EI) that ends the Thematic Sequence (ST2) Bioengineering: Produce, Protect, Repair.
This course illustrates how bioengineering may contribute to Produce industrial compounds.

Micro-algae are sun-light driven cell factories that convert carbon dioxide into food, feed and high-valuable molecules (pigments, polyunsaturated fatty acids, proteins, ...) with a broad of industrial applications (chemical, pharmaceutical, cosmetics, ...).

They are mostly cultivated as planktonic cells suspended in liquid nutrient medium mainly in open raceways before being harvested for molecules extraction. These production systems are generally located outdoors and therefore subject to significant daily and seasonally variations in light and temperature. These systems are though characterized by low productivities, high energy demand and high operating costs associated to the production and harvesting steps. In this context, the interest of using immobilized microalgae (biofilm-based microalgae cultivation) has increased lately and presented as a very promising technology to overcome the major challenges of the conventional systems. Higher productivities (algal biomass and molecules of interest) and lower energy consumption are therefore reported compared to those of suspended cultures and the biomass is easily harvested by scraping.

A biofilm is an assemblage of microbial cells that are associated with a surface. They are ubiquitous in nature, covering all kinds of surfaces in seawater and freshwater environments, representing therefore the prevailing mode of microbial life. In addition, biofilm-based systems are widely used in bioremediation and industrial bioprocesses.

The use of biofilm technologies is at the heart of the activity of Inalve, a company that industrializes a process for the production of microalgae, in agreement with sustainable development in its social, economic and environmental dimensions.

This course aims to improve the microalgae production system developed by this start-up. The objective is thus to develop a multiphysical model (thermal and biological) able of predicting the productivity of the bioprocess subjected to variations in light intensity and temperature. This modelling tool combined with numerical simulation will make possible to optimize the bioprocess system and finally to propose new strategies for its exploitation.

Bioprocess modeling :

This course focuses on the modelling of the bioprocess used by Inalve.
The approach to be implemented will be as follows :

1) First, a thermal model will be developed and calibrated to predict the evolution of the biofilm temperature in the process subjected to the solar radiative flux. The resulting thermal profile will be compared with the data. In parallel, a biological model will be developed to predict the dynamics of biofilm formation under the different process operating conditions, in particular as a function of the incident light and the temperature of the biofilm.
2) Thermal and biological models will be combined. This will make possible to predict the evolution of algal biomass productivity over an annual cycle.
3) The dynamics of the process will be evaluated in a "qualitative" (i.e. trend) way to make recommendations for the design and operation of the Inalve technological device.

Quarter number
ST2

Prerequisites (in terms of CS courses)
None

Syllabus

- **Presentation of the project by the industrial partner**
- **Comprehensive analysis of the problem**

o Bibliographical review
o Identification of the model objective (thermal/biological)
o Identification of the required data
o Writing the model equations (thermal and mass balances)
o Coupling the thermal and biological models

1. **Numerical implementation**

o Programming
o Validation of the model on test configurations

- **Parametric study**

o Assessment of the impact of process operating conditions on productivity

- **Presentation of the deliverable**

o Report writing and oral presentation.

Class components (lecture, labs, etc.)

"Production of microalgae by a biofilm-based system" is a course dedicated to Problem solving. Students will be confronted to the multiphysics aspects (thermal transfer, biology) of an industrial problem, by implementing the concepts introduced in the basic courses of ST2 Bioengineering and in the common courses of mathematics and computer science. Finally, the student is in the position of a young engineer who must produce a technical report and present his work to experts and an industrial partner in an industrial context.

The course is scheduled over 5 consecutive days. It begins with a half-day project launch (Monday morning) with the client. During the week, students work in groups of 4 to 6 students, supervised by a team of researchers from the LGPM laboratory and INRIA. Each group addresses one of the issues of the multiphysics modeling (thermal or biological model) and have to interact with a second team working on the complementary model.
Updates will be held daily: sharing of information, discussion of the results, methodological input. The week ends with a debriefing session on Friday afternoon in the presence of the industrial partner.

Grading
The evaluation will take into account: individual assiduity, group involvement, relevance of the model, numerical implementation, programming quality (code), oral presentation and discussions, quality of the report.

Course support, bibliography
The handout of courses in Thermal transfer and scientific articles will be provided during the course.

Resources

- Teaching team : F. Lopes (PR, CS, MEP Department, LGPM), O. Bernard (DR, INRIA Biocore Team), industrial (inalve)

- Maximum enrolment: 24 to 28

- Software tools and number of licenses required: Sypder-Python (free software).

Learning outcomes covered on the course

At the end of the course, students will be able to :

1. Identify the different time and space scales taking place in a given process ;
2. Select the most appropriate scale to solve a given problem;
3. Identify and keep the predominant phenomena ;
4. Reduce the dimensionality and complexity of a problem ;
5. Establish a multiphysics model by aggregating knowledge from different disciplinary fields (biology, transport phenomena, process and bioprocess engineering) ;
6. Write a program to implement a mathematical model ;
7. Keep a critical eye on a model and its limitations ;
8. Provide a comprehensive presentation of the modeling approach.

Description of the skills acquired at the end of the course

C1 : Analyze, design, and implement complex systems made up of scientific, technological, social, and economic dimensions
C4 : Create value for companies and clients
C7 : Strengthen the Art of Persuasion
C8 : Lead a team, manage a project.