2SC5193 – Aircraft design

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

Description

The goal of this training is to let you discover the different stages of an aircraft design process in both a theoretical and a practical perspective. You will be introduced to the typical methods used in an aircraft design office, and apply this knowledge by doing the preliminary design of your own aircraft After completing this training course, you will have acquired knowledge and skills that will enable you to work out the main aircraft characteristics and layout in a very short time frame.

Quarter number

ST5

Prerequisites (in terms of CS courses)

Have to follow the elective course "Airplane control".

Syllabus

When a team commits to design a new aircraft or to modify an existing aircraft, the project will always follow the same pattern. The process starts by analyzing the market and existing products. Next is the conceptual design which is followed by the preliminary design and detail design before sending the drawings to the workshop which will build a prototype. Obviously, at each stage, several iterations are made as necessary before proceeding to the next stage. In the process, we will begin by a more global or synthetic approach of aircraft design before getting into more and more detail. We will go from a basic concept into full optimization, from using parameters derived from simple statistical data to using sophisticated algorithms.

Grading

Evaluation will take place the last day of the course and include : an oral presentation to present your project and followed by a question and answer session.

Resources
Teacher: industrial partner.

Learning outcomes covered on the course
Student will learn how to:
• Define the layout and configuration of the new aircraft.
• Work out estimates for empty weight and maximum take-off weight.
• Compute wing loading.
• Work out estimates for lift and drag ✧ Work out performance estimates (take-off, climb, cruise, landing).
• Make an analysis of the aircraft's stability and control.
• Compute the applied loads ✧ Select the structural materials.
• Estimate the costs (design, manufacturing, operational).

Of course, the general concepts are not only valid for aircraft design but can equally be applied to the development of any other conceivable product or service.

Description of the skills acquired at the end of the course

- Analyze, design and implement complex systems with scientific, technological, human and economic components (C1).
- Develop in-depth skills in a scientific or sectoral field and a family of professions (C2).
- Act, undertake and innovate in a scientific and technological environment (C3).
- Have a sense of value creation for his company and his customers (C4).
- Be operational, responsible, and innovative in the digital world (C6).
- Know how to convince (C7)

ST5 – 52 – CONTROL OF BIOPROCESSES FOR ENVIRONMENT AND BIOMANUFACTURING

Dominante : VSE (Living-Health-Environment) and GSI (Large Interacting Systems)
Langue d'enseignement : French
Campus où le cours est proposé : Paris-Saclay

Engineering problem

Sustainable development is playing an increasingly important role in the current and future development of various industrial sectors. Solutions for modernizing and evolving the means of production are being developed in order to limit greenhouse gas emissions, in particular by offering alternatives to fossil fuels. Among the solutions studied, this sequence topic is more specifically interested in bioprocesses, efficient and sustainable, as alternative to current production technologies.

Bioprocesses use living systems or their components for producing goods services. Their emergence requires the implementation of multidisciplinary knowledge, in particular for the optimization of their functioning (maximization of productivity and/or degradation of pollutants).

This teaching offers scientific tools for the development of bioprocesses through the design of automatic systems related to:

- Energy (e.g. production of biofuels),
- Production of high value-added molecules (e.g. production of cosmetics, medicines),
- Pollution treatment (e.g. wastewater treatment),
- Greenhouse gas control (e.g. CO2 capture),
- Reduction of the ecological footprint (e.g. production of biopolymers).

In this course, the concept of using bioprocesses for sustainable development is presented, as well as the design of automated systems to maintain the bioprocess in optimal operating conditions (to maximize its productivity). The approach can be extended to other bioprocess applications not covered here in the biotechnology sector (e.g. stem cell culture for medical applications). The concepts presented can also be applied to broader sectors such as pharmaceutical, genetic engineering, cosmetics, agri-food, etc. The intervention of industrialists in the field allows a better understanding of the issues associated with the use and optimization of bioprocesses for sustainable development. within the framework of sustainable development.

In this course, bioprocess sizing is addressed as well as automated systems design to maintain the bioprocess under optimal operating conditions in order to maximize its productivity. The approach can be extended to other bioprocess applications not covered here in the biotechnology sector (e.g. stem cell culture for medical applications). The concepts presented can also be applied to broader application sectors, such as pharmaceutical, genetic engineering, cosmetics, agri-food, etc.

The intervention of industrialists from the sector allows a better understanding of the issues associated with the use and optimization of bioprocesses in a context of sustainable development.

Adviced prerequisites

No prerequisite required

Context and stakes module

This module is organized around half-days aimed at presenting the teaching, the challenge week and introducing the issues associated with bioprocesse and sustainable development. The following presentations are proposed:

- Conference "History and perspectives of biotechnology development" giving an overview of the evolution of biotechnology and the current and future needs of this sector.
- Conference on sustainable development.
- Conference on the energy transition providing an overview of energy sources (fossil, nuclear, renewable) and highlighting the interest and role of bioprocesses in the production and storage of energy, as well as the associated challenges.
- Conference on the environmental transition, taking stock of the environmental issues that need to be addressed (scarcity of resources, pollution, health risks, etc.) and highlighting the interest and role of bioprocesses in the recovery of waste and the conversion of biomass into sustainable products.
- Conference on the contribution of bioprocesses for long duration space missions and the critical importance of their optimal control. These bioprocesses are a relevant solution for nutritional autonomy and for recycling water, air and organic matter in a confined environment. Their control is one of the keys to their reliability, which is absolutely necessary given the needs they meet and the isolation of the space environment.
- Conference on bioprocess control focusing more specifically on the role of automation in the design and optimization of bioprocess for resources recovery.
- Conference on bioethics, showing that the use of bioprocesses raises questions on the ethics of the proposed solutions, in particular when these solutions call upon the design of organisms whose genome is modified. This

conference is an introduction to the issues related to the use of biotechnologies and, more generally, to the place of Man in the biosphere and to the respect of nature and the environment.

Specific course (60 HEE)

Chemical Engineering: *Chemical Engineering: application to environment and biomanufacturing*

Brief description: Modern chemical engineering deals with designing, operating, and optimizing environmentally friendly processes for the development of a variety of products and services in many traditional and high-tech sectors (pharmaceuticals, petroleum, fine chemicals, food processing, cosmetics, water and waste treatment, materials, biotechnologies, etc.), and for the production of traditional (nuclear, thermal, etc.) and renewable energies. Chemical engineering methodologies are widely used to ensure the recycling and recovery of numerous products and the purification of liquid and gaseous effluents, thus becoming tools of choice in the strategy of sustainable development on a global scale.

The challenges associated with this environmental issue are numerous: reducing costs, risks and dangers, waste, and energy and raw material consumption. Process intensification is the major lever for taking these challenges up. This course is an introduction to chemical engineering and its methodologies, allowing students to acquire generalist tools that can be easily transposed to multiple fields, such as biotechnology and the environment. It is fully in line with the environment, energy and health issues. Most of the case studies are focused on bioprocesses used in industrial biotechnology. The development of these bioprocesses is growing rapidly due to the use of living organisms to transform matter and purify polluted systems, and the employment of biomass to replace fossil resources.

The bioprocess is studied at the industrial bioreactor scale. The description and understanding of biological processes (metabolism, maintenance, etc.) at the cell level are not addressed. The biological agents are thus considered as cellular catalysts transforming raw materials into products according to known kinetic laws.

Challenge Week

The three integration courses cover the same learning objectives and have a similar structure. The aim is to start from a performance specification for a given bioprocess, to proceed to choices of bioprocess design and control law in order to ensure the expected performances and maximize the productivity of the designed system.

Challenge Week n°1: *Optimized biological treatment of urban wastewater*

- **Associated partner:** VEOLIA
- **Location:** Paris-Saclay campus
- **Brief description:** In urban wastewater treatment plants, biological processes are designed to eliminate carbon and nitrogen pollution through the action of microorganisms that develop spontaneously in aerobic or anaerobic environments.
The eliminated pollutants are concentrated in the form of aqueous biomass suspensions or sludge, constituting voluminous waste with fermented target and toxic materials. The treatment of sludge is therefore an important phase of wastewater treatment systems that must ensure the reduction of its volume and odor nuisance. One of the most common processes for this treatment is anaerobic digestion, which produces liquids with a high concentration of nitrogen that must be treated again. The amount of nitrogen contained in these effluents can represent up to a 20% increase in the nitrogen load to be eliminated by the plant. There are two solutions to this problem: (1) a so-called classical one, in which these concentrated effluents are directly returned to the head of the plant or (2) the anaerobic ammonium oxidation process, or Anammox, an innovative alternative to the traditional nitrification/denitrification processes, allowing the direct transformation of nitrite and ammonium into gaseous nitrogen.

In this challenge week, the objective is to propose control strategies for the two mentioned solutions in order to meet the minimum purification requirements of the treated water and to compare their performance in terms of operating costs and biogas production as a vector for energy recovery from sludge.

Challenge Week n°2: *Life support system for space missions*

- **Associated partner**: European Space Agency (ESA)

- **Location**: Paris-Saclay campus

- **Brief description**: ESA is developing a bioregenerative life support system that allows astronauts to live autonomously, without refueling from Earth, during long-duration space missions. This integration teaching concerns the bioprocess that allows regeneration of the habitat atmosphere. It is a photobioreactor implementing microalgae that consume CO_2, produce O_2 and nutrient supplements.

In this week challenge, the objective is to model and size a photobioreactor for 5 astronauts in total autonomy for 1000 days and to ensure the control of the O_2 production via the transfer of light for reasonable performance criteria. These criteria are related to the reliability of operation, safety and risks for the crew, the rate and efficiency of recycling, the activities required for the crew, the energy consumption, the size and mass of the system.

Challenge Week n°3: *Advanced supervision of biogas production from waste*

- **Associated partner**: BioEnTech

- **Location**: Paris-Saclay campus

- **Short description**: Anaerobic digestion is a natural process of degradation of organic matter by micro-organisms (bacteria and archaea) in the absence of oxygen (anaerobic conditions). This process allows to recover a fraction of the energy contained in the waste in the form of biogas, a mixture of methane and CO_2. The generalization of these technologies would allow considerable reduction of the energy demand necessary to treat the waste (10% of the energy used on the planet) but could in the long term constitute a source of energy. However, the anaerobic digestion process is complex and involves several hundred species of microorganisms. Moreover, it is unstable, and intermediate compounds (volatile fatty acids) can, under certain conditions, accumulate and lead to the total shutdown of the reactor. To avoid this type of accident, a very precise and costly monitoring is necessary.

In this challenge week, the objective is to propose and develop supervision and control strategies to reduce the risk of reactor acidification and to optimize the production of energy from the waste.