1SC2410 – Studying and modeling electromagnetic conversion systems and unsteady thermal transfer

Instructors: Mohamed Bensetti
Department: DÉPARTEMENT SYSTÈMES D'ÉNERGIE ÉLECTRIQUE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 22,50

Description

This course will provide students with a knowledge base that will be necessary for them to complete the project in the end of this sequence. It focuses on the development of models to study electromagnetic conversion systems and unsteady heat transfer. The course will on one hand adress basic concepts of electrical and magnetic circuits as well as the principles of magnetic coupling to ensure the students' understanding of the functioning of electromagnetic systems, and on the other hand, the fundamental concepts of unsteady heat transfer (problem formulation, solving some typical academic problems, highlighting characteristic lenghts and times). Several modeling approaches (analytical, semi-analytical and numerical) will be presented to solve the electromagnetic and/or thermal problems.

Quarter number
ST2

Prerequisites (in terms of CS courses)

- The SPI courses " electric energy" and " Introduction to heat, mass and momentum transfer" are recommended

Syllabus
Electromagnetic part :

- Basic principle of electric and magnetic circuits (calculation of electric power, calculation of magnetic field, self and mutual inductance, magnetic energy ...).
- Different modellig approaches (analytical and numerical) to solve an electromagnetic problem
- Wireless power transmission by induction
    - Different approaches for modelling of a magnetic coupler to determine the element of an electric equivalent circuit

- The electromagnetic radiation and reduction of the magnetic field
- Compensation of reactive energy
- Power converters (inverter/rectifier)
- Calculation of losses and the energy efficiency

- Tutorial 1 : Analytical study of an electromagnetic energy conversion system
- Tutorial 2 and 3 : Modelling of magnetic system by COMSOL software
- Tutorial 4 : Study of electromagnetic radiation

Thermal part :

1. Energy balance, boundary conditions, thermal diffusivity, superposition theorem, Π theorem; Response of a semie-infinite medium (response after a short time): imposed temperature, imposed heat flux, periodic excitation.
2. Response of a finite medium, diffusion characteristic time, conducto-convection characteristic time, Biot number, Fourrier number ; Analytical and numerical methods for unsteady heat conduction.
3. Tutorial 5 : Cooling of a transparent ball + thermal inertia of a building (beginning)
4. Tutorial 6 : Thermal inertia of a building (end)
5. Tutorial 7 : Semi-analytical analysis and numerical solve of the problem "Thermal inertia of a building"
6. Tutorial 8 : Presentation of the BuildSysPro model libraray: structure, modularity, assembly of elementary models to build a complete building model, presentation of existing building libraries, introduction to new building models.
7. Tutorial 9 : Use of the model library: choice of a building model, change of building properties, integration of new models, building simulations and post-processing.

Class components (lecture, labs, etc.)
5 courses of 1,5h
9 tutorials sessions of 1,5h (group with 25 students)

Grading
Examen of 1,5 h :45mn for electromagnetic part and 45mn for thermal part.

Course support, bibliography
Course materials in ppt form
Principles and components of electrical engineering - course material - G. PIERRON.
Comsol software website: https://www.comsol.fr/models.

J. Taine, F. Enguehard, E. Iacona, "Heat Transfer - Introduction to Energy Transfers", 5th edition, Dunod 2014.
F. Incropera, D. Dewitt, T. Bergman, A. Lavine, "Fundamentals of heat and mass transfer", 6th edition, Wiley, 2007
BuildSysPro software installation website and tutorials to use the software : https://github/edf-enerbat/BuildSysPro

Resources

Teaching team :

- Courses : Mohamed Bensetti (CentraleSupélec) & Laurent Soucasse (CentraleSupélec)
- Tutorials 1, 2, 3 and 4 : Mohamed Bensetti (CentraleSupélec), Amir Arzandé (CentraleSupélec) et Mike Kirkpatrick (CentraleSupélec)
- Tutorials 5, 6 and 7 : Mehdi Ayouz (CentraleSupélec), Fabien Bellet (CentraleSupélec), Mathieu Niezgoda (CentraleSupélec) et Gabi Stancu (CentraleSupélec)
- Tutorials 8 and 9 : Research Engineer from EDF (R&D - Centre des Renardières)

TD class size : 25 students
Software tools: Comsol and Matlab

Learning outcomes covered on the course
At the end of this course, students will be able to :

- Study, analyse and model electromagnetic and/or thermal
- Apply the fundamental concepts of unsteady heat transfer to study the energy performance of a building
- Modelling of a wireless power transfer charging system and determination of its electrical and magnetic parameters
- Use and implement appropriate models to solve electromagnetic and/or thermal problems
- Use multi-physics software Tools (electromagnetic and thermal)
- Validate and analyse the results obtained by modelling.

Description of the skills acquired at the end of the course
C1.1: Study a problem as a whole and an overall situation
C1.2 : Identify, formulate and analyse a problem in its scientific, economic and human dimensions
C1.3 : Use and develop appropriate models, choose the right modelling scale and the relevant simplifying hypotheses to deal with a problem
C2.1 : Thoroughly master domain or discipline based on fundamental sciences or engineering sciences.