Ph.D. thesis position
Energetics / chemical-engineering thermodynamics

■ General information

Topics: Energetics / chemical-engineering thermodynamics.

Title: **Use of the *product-design* approach for the selection of an optimal working fluid flowing in power and refrigeration cycles**

Funding: Grant from the French government.
Possibility to supplement the salary by teaching (only for people speaking French).
Basic salary: 1800 € / month (before taxes).

Dates: October 2017 - September 2020.

Place: Team ThermE (thermodynamics and energy),
of the LRGP (Laboratory for Reactions and Chemical Engineering) – University of Lorraine, Nancy, France.

Ph.D. supervisor: Jean-Noël Jaubert, professor.

Head of the team ThermE, co-supervisor of the French working party of thermodynamics of the SFGP (*French Chemical Engineering Society*), member of the working party of the EFCE (*European Federation of Chemical Engineers*).

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■ Ideal candidate's skills

- Basic knowledge of energetics, thermodynamics and mathematics (numerical methods)
- Problem solving orientation
- Knowledge of a computer-programing language (ForTran ideally)
- Communication skills (in English)

■ Scientific content

European and world context: European and world regulations on greenhouse gases are becoming more and more stringent in terms of environmental impact. In this context, the "F-gas regulation" applicable since January 2015 plans a gradually declining cap on the placement of refrigerants showing a global warming potential (GWP) of 2500 in 2020 and of 150 in 2022. At the world level, the trends are the same; in particular, the recently-signed Kigali amendment emphasizes the necessity to reduce substances depleting the ozone layer. Such injunctions to reduce the use of high-GWP fluids emitted by urban and industrial devices for energy conversion lead scientists and engineers to re-think the conception of classical power- and refrigeration-cycles (e.g., Rankine, Hirn, Brayton ...) and to search for new fluids that are both environmentally-friendly and efficient.

Objectives of the thesis: the main objective is to develop a novel methodology based on the product-design approach for an optimal selection of fluids flowing in thermodynamic cycles. These fluids will be considered as optimal both in terms of energetic efficiency and GWP. While working fluids were essentially chosen among pure species until recently, the use of multicomponent mixtures (and in particular, of binary mixtures) including low-GWP "green" substances is seen as a promising way.

Methods: today, the search for new working fluids for cycles is mainly performed following empirical methodologies based on experience and intuition. As a promising alternative, the *product-design* approach is aimed at determining the optimal formulation of a product characterized by its expected functional properties. By *formulation*, it is here meant: composition and nature of the components. Technically speaking, the *product-design* approach requires the resolution of an *inverse optimization problem*, that is to minimize an objective function combining energetic and environmental criteria, to determine the most appropriate mixture to be used in a given cycle. The proposed methodology will be then applied to various kinds of reference cycles, mainly Brayton and Rankine.
As a validation step and in collaboration with the Polytechnic University of Milan, the optimal fluids determined from the product-design approach will be tested out using an experimental device reproducing a power cycle.