	Name of the PhD candidate: **Antoine GROSJEAN** Title of the PhD thesis: **Study, modeling and optimization of solar surfaces for concentrated solar collectors** Dates (start/end): 01-11-2014 / 08-03-2018
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Other contributor	Co-funding CIFRE-HELIOPROCESS and SOLSTICE

Context and objectives

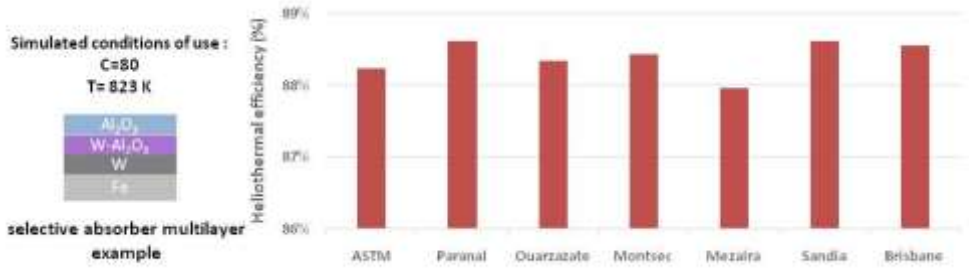
The solar field is a major part of a total investment of solar plants (40%) and the first cause of energy losses: only 50% of the incident solar energy is converted into heat. To decrease the cost of solar energy it is thus important to increase solar field efficiency. Solar coatings deposited on collector surfaces are key elements: reflective coatings for mirrors, antireflective coatings for glass windows and selective absorber coatings for receivers are required for solar technologies. The goal of this thesis is the modeling and advanced optimization of each type of coating, in order to identify the most pertinent ways to improve the thermo-optical efficiency of complete solar collectors in different geographical locations.

Approach

To increase the total energy available in the heat transfer fluid per square meter of the solar field, we use different approaches:
1) Identification of existing performance limits of solar collectors and coatings;
2) Identification of advanced materials and complex architectures of solar coatings to increase the collected energy;
3) Use of local solar spectra with local atmospheric conditions to study and optimize solar coatings performance;
4) Adaptation of solar coatings to solar collector geometries;
5) Use of thermodynamics and exergy calculations to maximize the total part of energy convertible into mechanical work in concentrated solar plants.

Main results

To comply with the complexity and large variety of existing solar coatings and collectors, as well as to better explore potential new solutions, a specific modeling and optimization tool was developed in Scilab, fed with a wide database of material properties gathered from a thorough literature review. A database of local solar spectra in typical sites for CSP implantation was also calculated using atmospheric models, to serve as input for solar performance estimation. A state of the art and technique on the three types of coatings and on solar collectors was also established.
Overall, this work demonstrated that it is possible to improve all kinds of solar coatings, depending on their operating conditions. Indeed, standard and advanced coatings have been modeled and optimized using the abovementioned tools, leading to performance increasing up to a few efficiency points. First, each type of coating was studied and optimized separately. Then complete solar collectors, with different geometries and installed in various locations, were considered and the corresponding coatings were optimized simultaneously. The best improvements were found with optimizing selective absorber coatings, the optical performance of which is very sensitive to operating conditions (temperature [T], solar concentration [C]), and the most sensitive to collector geometry and solar local conditions (as these coatings receive a solar spectrum modified in a cascade by both mirror and glass). The tools and results of this work will serve as reference for future developments in the laboratory, especially regarding selective absorber coatings.



Heliothermal efficiencies of selective thermooptical multilayers optimized using ASTM solar spectrum reference and local spectra (case of W/W-Al_2O_3/Al_2O_3 selective multilayer used at C = 80 and T = 823 K)

Publications

- Antoine Grosjean, Audrey Soum-Glaude, Pierre Neveu, Laurent Thomas, Comprehensive simulation and optimization of porous SiO_2 antireflective coating to improve glass solar transmittance for solar energy applications, Solar Energy Materials and Solar Cells 182 (2018) 166–177.

International conferences

- A.Grosjean, A.Soum-Glaude, L.Thomas, P.Neveu, Coatings layers optimization following the evolution of solar spectrum inside 2D solar thermal collectors, SolarPACES 2016, Abu Dhabi, UAE, 11-14 Oct 2016.
- A.Grosjean, A.Soum-Glaude, L.Thomas, P.Neveu, Coatings optimization for CSP with different solar spectra, SolarPACES 2017, Santiago, Chile, 26-29 Sept 2017.
- A.Grosjean, A.Soum-Glaude, L.Thomas, P.Neveu, Study, modeling and optimisation of solar surfaces for concentrated solar collectors, SolLab 2017, Berlin, Germany, 15-17 May 2017.
- Pierre Neveu, Antoine Grosjean, Audrey Soum-Glaude, Laurent Thomas, Analyse exergétique des convertisseurs d'énergie solaire concentrée, Conférence Internationale Francophone d'Energétique et de Mécanique (CIFEM 2018), 23-25 avril 2018, Cotonou, Benin.