Research internship of 6 months (Master level)

Nanoparticles and thermo-physical properties characterization of a carbon-based nanofluid for solar thermal collectors

Place : PROMES CNRS – Font-Romeu-Odeillo-Via (France)

Supervisors : Gilles Flamant, Cyril Caliot, Miguel Sainz-Manas

Gratification : ~600 €/month

Starting date and duration of the internship : February 2023 – 6 months

Introduction to the subject :

In the current energy context, the development and optimization of renewable energy conversion processes is receiving more and more attention. Solar thermal energy is among the most efficient and environmentally friendly renewable energy sources. Unfortunately, thermal losses to the environment limit the performance of solar collectors associated with linear concentration systems when operating at medium temperatures (> 100°C). New volumetric solar collectors are being studied to reduce thermal losses and increase overall efficiency. Among these innovative solutions, direct absorption solar collectors (DASC) offer several advantages. These solar thermal collectors use a nanofluid (fluid with suspended nanoparticles) as absorbing medium. In these collectors, the absorber tube used by conventional collectors is replaced by a transparent surface allowing solar radiation to penetrate the nanofluid, which has the function of absorbing solar energy and transforming it into heat (***Figure 1***). The main advantages of this new system compared to conventional collectors are to reduce the heat losses with the environment, not to be constrained by the flow regime (laminar or turbulent) and to add versatility to the system by playing with the concentration of nanoparticles (PV-T hybrid systems). According to the scientific literature, carbon-based nanofluids offer the best optical (over 90% absorption) and thermal properties among the nanofluids studied so far. DASC collectors show particular potential to provide medium temperature heat (150-400 °C) and increase the efficiency of conventional collectors.

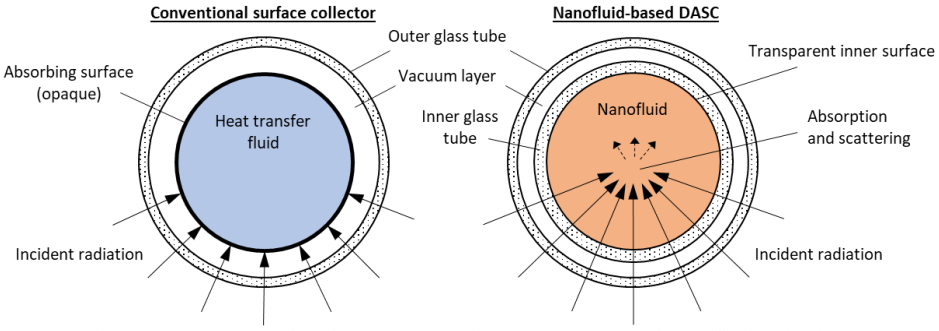

Figure 1 *: Comparison between a conventional surface receiver and a DASC receiver with nanofluide. The diagram represents the cross-section of a tubular receiver typical of parabolic trough collectors.*

In a previous work, the properties of an original nanofluid were experimentally evaluated with a high precision spectrophotometer and several samples with different nanoparticle concentrations (concentrations between 0.025 and 0.1 g/l). The results show an absorption in the visible range of over 80% and 96% for low graphene concentrations, 0.1 and 0.2 g/l respectively. These results allowed to validate the concept and to consider the use of such a nanofluid as an absorbing liquid in DASC collectors.

In this context, a PhD has started in early 2022 to develop and evaluate the performance of a DASC solar collector using a nanofluid based on graphene nanoparticles. The proposed solution consists of a conventional parabolic trough concentrator associated with a transparent glass receiver containing the absorbing nanofluid. Numerical models and an experimental prototype of the system are under development. The experimental pilot aims at evaluating the performance of the collector and verifying the feasibility of the system. In this context, the characterization of the nanoparticles as well as the thermo-physical properties of the nanofluid is an important step for the evaluation of the collector's performance, the framework in which this internship is situated.

The internship student will have to work on the following points:

- Bibliographical study on the characterization of nanoparticles and associated thermo-physical properties.

- Determination of the temperature stability of the nanofluid: realization of experiments with a water bath and a spectrophotometer to evaluate the evolution of the optical properties of the nanofluid with the temperature according to the vertical position in a cell.
- Characterization of nanoparticles: realization of microscopic measurements by SEM.
- Bibliographical analysis of the models allowing the calculation of the optical properties of non-spherical nanoparticles.
- Exploitation and interpretation of the results.

This internship is part of the PhD work of Miguel Sainz Mañas.

Application: CV et motivation letter to miguel.sainz-mana@promes.cnrs.fr.