next-CSP

High Temperature concentrated solar thermal power plant with particle receiver and direct thermal storage

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Deliverable D5.5

WP5 – Testing of the complete high temperature solar and heat conversion loops including a gas turbine

Deliverable D5.5. Report on the engineering model

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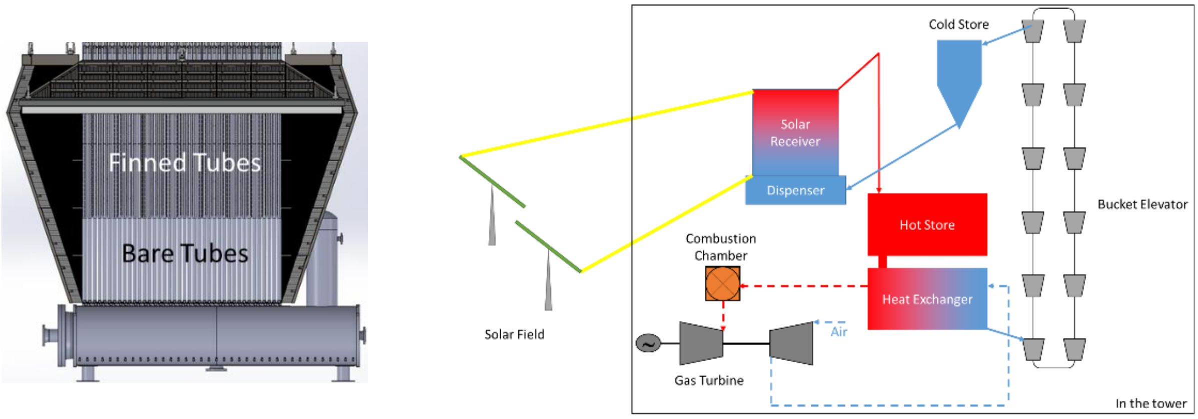
Introduction and objectives of D5.5

In WP5 dedicated to the testing of the Next-CSP prototype, T5.5 aims at developing an engineering model validated based on experimental results. This model includes the simulation of the solar field, the solar receiver, the heat exchanger and the gas turbine. It is based on simple 0D/1D or 2D description of the pilot loop components linked together by particles and gas flows, and subjected to a logic control system. Solar power, heat injected in the turbine and heat losses are the heat sources and the heat sink respectively.

The solar receiver consists in a multi-tube absorber and a half cavity made of refractory panels. A refractory panel is also installed behind the tubes to reflect the concentrated radiation passing through the tube spacings. The fluidized particles flow upward in forty 3m-long tubes before flowing out in a hot storage tank. Then, the hot particles fall into a multi-staged fluidized bed heat exchanger to preheat the pressurized air exhausting from the compressor of a hybrid gas turbine. Figure 1 presents the design of the solar receiver as well as the layout of the Next-CSP facility.



(a) (b)

Figure 1. Typical objective normalized flux distribution

In this deliverable, each model is explained and results are presented. The last section presents the comparison between simulated and experimental results.

Conclusion

An engineering model was developed to simulate the Next-CSP prototype. The results of this model were compared to the experimental data of the solar receiver (See also D5.2).

We know since the design phase that the complete system is not optimized because the main objective of the project was to operate the particle loop at prototype scale demonstrating the coupling with the gas turbine whatever the efficiencies. This last step was not reached due to the late achievement of the heat conversion loop implementation.

Many characteristics limit the overall system efficiency. The solar field layout is not adapted to the solar receiver that results in large spillage. The solar receiver is not a cavity receiver, which would have limited the radiative losses, due to the solar field characteristics. Moreover, the heat exchanger includes only 6 stages and standard tube diameter due to cost issues, leading to a high temperature difference between inlet hot particles and outlet air and low heat transfer coefficient between the working air and the tubes. Finally and most importantly, the GT is a commercial engine [9] that was solarized to be adapted to the particle loop. As a result, the turbine inlet temperature (TIT), approximately 1000°C, is by far too high to reach high solar share. Nevertheless, the capacity of the concept to reach high efficiency and high solar share is demonstrated in [1].

Concerning the receiver efficiency, the uncertainty on the real solar power at the cavity aperture prevents accurate comparison with calculated data. This issue will be solved by a comparative test campaign of fluxmeters at the CNRS 1 MW solar furnace before the end of the 2021 year.

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