next-CSP

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

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Deliverable D5.2

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

Deliverable D5.2. Report on solar receiver efficiency

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Introduction and objectives of D5.2

WP5 addresses the testing of the Next-CSP project prototype. In this WP, T5.2 aims at measuring the solar receiver efficiency. Due to the delay of the end of the prototype assembling linked to the Covid 19 pandemic, we had only few days in July 2021 to perform the on-sun experiments of the solar receiver. It is important to understand that we spent several days (and weeks) to learn how to operate such a complex system with particles circulation in closed loop. It was the first time that an experiment of this size has been tested.

The nominal particle flowrate in the receiver is 75 kg/m².s (18 t/h) and the initial objective was reaching a particle outlet temperature of 650°C. This temperature is limited by the maximal temperature of the receiver tubes material (310H stainless steel) of 850°C. In the following, test results at reduced power and mass flow rate are presented (seven batch experiments).

Conclusion

This experimental campaign was performed for particle mass flow rate ranging from 12 to 70% of the nominal value (2.15 – 12.45 tons/h) and for a solar power of approximately 20 to 32% (542 – 811 kW) of the nominal. Main results are the following:

- The instrumentation developed proved to be accurate and reliable. Probes and data recording system allowed measuring precisely the dynamic behavior of every component of the prototype, in particular the solar receiver. An original IR camera flying on a drone (developed by CNRS in addition to the work plan) demonstrated to be very useful for detecting hot zone on the receiver tubes.
- Tuning aeration mass flow rate resulted in a precise control of particle mass flow rate.
- Particle temperature increase as large as 400°C and particle power increase of 362 kW have been measured.
- Maximum solar receiver efficiency reached approximately 60-74%, nevertheless a large uncertainty affects this value.
- Solar receiver starting and shut down are very fast (10-15 minutes) that is a key advantage of the proposed technology with respect to current molten salt solution.

The main issue identified during the test campaign was the stop of particle circulation inside some tubes (detected both by pressure drop data and IR images). This unexpected phenomena is currently under analysis. It is probably related to solar flux inhomogeneity that results in tube length and air velocity differences.

References

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