SOLPART

High Temperature Solar-Heated Reactors for Industrial Production of Reactive Particulates

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Deliverable D2.4

WP2 – Lab scale development and testing of 800 – 1000 °C solar reactors

Deliverable D2.4 – Critical analysis of solar reactor design suitable for scaling up

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1. Introduction and objectives

Deliverable D2.3 detailed the main results obtained with the laboratory scale solar reactor developed and tested at DLR and CNRS. For solar calcination, CNRS has developed the horizontal fluidized bed reactor design and DLR the rotary kiln design.

At CNRS, the experiments have been carried out with the 1 MW solar furnace using a part of the heliostat field and off-focus configurations. At DLR, main part of the experiments have been made with a 20 kW solar simulator.

Concerning the particles, both laboratories performed a first set of experiments with inert particles. Then, CNRS focused effort on dolomite calcination whereas DLR studied cement raw meal (CRM) calcination. It is important to note that the mean particle diameter and the particle size distribution of the two feedstock are very different. The mean diameter for dolomite is about 85 µm (d_{40}) whereas CRM has a much smaller mean particle size, 50 % below 5 µm. This latter is very cohesive whereas the former can be easily fluidized.

In both cases, incident power was in the range 10-20 kW and the reactive particle inlet mass flow rate was ranging from 5 to 15 kg/h.

The objective of this deliverable is to analyse the experimental results obtained at laboratory scale by the two partners and to choose the reactor design that will be tested at pilot scale. The results have been discussed and validated during the 24-month meeting of the project, December 12-13 2017, in Sevilla.

2. Conclusions

- None of the two reactors satisfies all the criteria.
- CRM proves to be the most difficult feedstock to process, confirming initial concerns raised in Deliverable 1.2.
- It is necessary to include integration constraints in the choice (particle size decreases in the cyclones due to erosion and attrition at tangential gas velocities of 25 to 40 m/s). Consequently, the CRM size is coarser at the feeding point of the multicyclone preheating, and more easily manageable.
- For the rotary kiln (RK)
    - High temperature (1000°C) can be obtained
    - Agglomeration can clog the particles inlet and outlet. Further analysis on the mixing are needed
- For the fluidized bed (FB)
    - Reliable continuous operation at more than 800°C was achieved
    - Residence time and heat transfer can be improved (correction of dead zones and heat transfer improvement)
- General criteria
    - Scale up is easier with FB than for RK
    - A close reactor allows an easier and more efficiency dust capture and reaction gas recovery than an open one
    - With CRM, a preliminary size classification is necessary even with rotary kiln

Finally, it is decided to scale up the fluidized bed but to continue the study with the rotary kiln at lab scale in the framework of WP2 (extension of the WP2 duration).

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