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SOLPART

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

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Deliverable 3.4

WP3 – Development of High Temperature Storage and Handling Technologies for Reactive Particles

Deliverable D3.4 Proof of feasibility of lab scale particle handling system (test operation of lab-scale system).

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Abstract

The main objective of the deliverable 3.4 is to provide the proof of feasibility of high temperature particle handling system. In this deliverable a preliminary analysis of the plant configurations also have been proposed in order to identify those handling systems with most aggressive (high temperature, high mass flow and the high distance) requirements. In this analysis, three different scenarios are taken into consideration, which are no hybridization (100 % solar and no storage), 40 % solar hybridization with 6 hours of storage and 40% solar hybridization with no storage. In this preliminary analysis, three different values of thermal losses 15, 30 and 45 % in the solar receiver are considered. A detailed optimized process of the solar integration with cement plant will be performed in the WP7.

From the preliminary design, five handling systems were identified and selected with specific operation parameters such as mass flow, temperature, distance and height to cover, etc. The five main systems are *System 1* **–** system to transport the hot particles from the preheater system to the solar receiver (***modified bucket elevator***), *System 2* **–** system to feed the hot particles into the solar receiver (***screw feeder***), *System 3* **–** system to transport the hot particles form the solar receiver to the storage system (***insulated pipe***), *System 4* **–** system to feed the particles into the cement plant (***slide plate with discharge aid (vibration) connected to screw feeder***) and finally *System 5* **–** this system would highly depend on the distance to be covered and the availability of land close to the cement plant (***plate conveyer or transport by mine truck***). Followed which, the experimental analysis of the handling system is presented.

Handling requirement for the pilot unit is different that of the commercial scale plant, hence detailed flow sheet for the pilot handling unit is presented here for both the reactor (rotary kiln and fluidized bed reactor). Most of the handling issue arises due to non-flowability of the particles; hence an experiment setup was developed to analyze the comparative flowability of the particles (CRM Poland, CRM Croatia and dolomite). Flowability analysis for the CRM Poland, CRM Croatia and dolomite are also presented in this documentation. Finally, the schematics and overview of the high temperature flowability setup is provided. Temperature dependent flowability study at different temperature ranges would be carried out in the near-term for WP7.

1. Introduction & Objectives

Transport of particles at high temperature is a technical challenging task and additionally the requirement of solutions with minimum thermal losses increase the difficult to define optimal handling systems. In this section a conceptual solar cement plant proposal is described to later identify and propose the most critical handling systems involved. The task has been addressed in different section as follows.

1. Preliminary conceptual design: As it has been commented, the technologies proposed in the SOLPART project requires the systems very specific for the particles handling that cannot be covered with conventional solutions due to the combination of many factors, the high temperature of the particles, the high mass flow typical of this types of plants and the high distance to overcome in same cases. Due that, a preliminary analysis of the plant configuration has been proposed in this deliverable in order to identify those handling systems with most aggressive requirements. A detailed study regarding the optimal plant configuration will be elaborated during the development of the WP7.

2. Identification and selection of the main handling system. From the preliminary design, the main handling systems will be identified, additionally, it will specified the main operation parameters like mass flow, temperature, distance and height to cover, etc. Analysis for the selection was developed in the task 3.2 and the conclusions are included in the deliverable D3.2. In some cases, the conventional systems will not cover the requirements specified for the different handling systems and new concepts have been proposed to meet them. Followed which, the experimental analysis of the handling system is presented

3. The process flow sheet of the two reactors, solar rotary kiln of DLR and fluidized bed reactor of CNRS are presented. The process flow sheet the handling requirement for the pilot unit.

4. Finally the experimental results for the pilot unit are presented. This section covers the handling issue encountered by both the reactors, results of the low temperature flowability setup and schematics of the high temperature flowability scheme (experiments will be covered in WP7).

2. Conclusion

This report delivers the main objective to provide the proof of feasibility of particle handling system with most aggressive requirements (high temperature, high mass flow and the high distance) for the European funded project SOLPART. The main activities that were carried out in order to prepare this document involved preliminary analyses of the plant configurations, identification, selection and experimental analysis of the high temperature particle handling. These comprehensive investigations were very useful in tapering the most appropriate particle handling system such as modified bucket elevator **(**system to transport the hot particles from the preheater system to the solar receiver), screw feeder **(**system to feed the hot particles into the solar receiver), insulated pipe **(**system to transport the hot particles form the solar receiver to the storage system), slide plate with discharge aid (vibration) connected to screw feeder (system to feed the particles into the cement plant) and finally plate conveyer or transport by mine truck (this system would highly depend on the distance to be covered and the availability of land close to the cement plant). Experimental analyses proves the feasibility of these handling system, however few of the high temperature handling experiment (which not necessary for the pilot, but needed for the commercial plant) are planned for WP7.

Handling issues for both reactors are also presented in this report, it can be inferred that the handling of cement particles is much difficult than the bauxite and dolomite particles, because the cement particle has lot of fine particle. Few handling issue faced by the rotary kiln reactors are screw feeder blocking and dome creation over the stirring system when used with CRM from Poland, CRM have flowability issue from the storage, and granulation due to vibration is another issue seen in both CRM particles. Fluidized bed reactor did not encounter any problem in flowability for cristobalite, calcite and dolomite particles; however the CRM was not tested with this system, due to non-flowability. Most of the handling limitation arises due to the non-flowability of the particles; hence an experiment setup was developed to analyze the comparative flowability of the particles (CRM Poland, CRM Croatia and dolomite).

Experimental investigations carried out in this work package using the low temperature flowability setup clearly show that the flowability of the CRM particles is very much lower than of the dolomite particles. Poland CRM has the lowest flowability when compared to other particles, drying the particle has resulted in improved flowability. Drying the Croatia CRM particle resulted in significant reduction in the flowability, which may be due to granulation and/or agglomeration of the particles. Drying has inverse effect on the CRM particles, because the Poland CRM has lot of moisture in the sample (4.5 % weight loss due to drying), which resulted in improved flowability. In the case of Croatia CRM the moisture content is very low (0.6 % weight loss), hence we infer that the flowability was reduced due to granulation and/or agglomeration (observed during the experiment). Another interesting fact is that the flowability of the dolomite particles is reduced due vibration, whereas in the CRM particles flow is supported using the vibration. Reduction in the flowability of the dolomite particles may be caused due to granulation and/or agglomeration due to vibration. High temperature flowability is necessary for the commercial scale plant, hence, temperature dependent flowability study at different temperature ranges would be carried out in WP7.

3. Bibliography

1. Sebastián González, R. and G. Flamant, *Technical and Economic Feasibility Analysis of Using Concentrated Solar Thermal Technology in the Cement Production Process: Hybrid Approach—A Case Study*. Journal of Solar Energy Engineering, 2014. **136**(2): p. 025001-025001-12.
2. *Beumer Group GmbH & Co. KG, Beumer Conveying Technology*. 2018 23.01.2018]; Available from: https://www.beumergroup.com/en/products.
3. *Continental Conveyor & Machine Works Ltd, Screw Conveyor Catalogue and Engineering Manual*. 2018 23.01.2018]; Available from: http://continentalconveyor.ca/.

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