NEW STORAGE LATENT AND SENSIBLE CONCEPT FOR HIGH EFFICIENT CSP PLANTS

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ABSTRACT

The research reported in this document addresses the concern of what happens to different materials investigated in WP3 (concrete, molten salts, filler) in a new design storage system, when they get in contact with each other for a certain period of time at high temperature.

On the one hand, having temperatures in the range 290-500°C is already a demanding environment, especially taking into consideration the temperature cycling effect of charging and discharging the stored energy. Additionally, molten salts (MS) can corrode and represent a chemical attack to other materials that are directly exposed to them, a situation that can be addressed when using protective layers to assure long term stability.

This document is structured in the following sections:

- Introduction
- Evaluation of the concrete/MS interaction. The focus of the section is the CAC concrete for the tank. The suitability of refractory coatings to improve the durability to the corrosion of molten salts is also studied. Few tests performed to the blended OPC concrete for the module have also been included.
- Evaluation of the foundation concrete/MS interaction. The focus of the section is the concrete for the foundations of the tank and the module, which is a lightweight concrete. Few tests performed to the insulating foam concrete have also been included.
- Evaluation of the filler/MS interaction

The results obtained in this task cover the concrete/MS and filler/MS interactions, and their results have been considered in WP3 for the selection of the most appropriate compositions of the different materials (concrete, MS, filler). Moreover, the results of this deliverable are affecting the design and the construction of the prototypes (tank and module), tasks included in WP5 and WP6 respectively.

The results of the work performed showed different resistances to the corrosion of molten salts for the three main types of concrete of the project and the main conclusions are:

1) CAC-based concrete shows excellent resistance to both types of molten salts, either Solar Salt or YaraMost, especially when using the aggregates type basalt, CAT and Alentejo Slag. These aggregates are thermally stable and showed good durability against the molten salts. Despite the penetration of the molten salts inside the matrix, reported by electronic microscopy, porosimetry, TG and XRD, the material shows very little to none degradation.

2) Blended OPC concretes tested showed severe cracking, presumably due to their lower chemical resistance to the molten salts, which could be worsened by its higher density, not allowing the salts to expand in the interior of the matrix in the solidification process at cooling. The presence of fibers in this mix is thought to have arrested even further cracking.

3) Concrete with lightweight aggregates is especially sensitive to the interaction with molten salts, due to the higher porosity of these porous aggregates. The study has shown severe degradation at isothermal conditions, but especially after performing the interaction under thermal cycles between 290 and 500°C. Foam concrete shows better resistance for the mixes containing CAC and without the aerogel.

In addition, two refractory coatings have been tested to protect concrete from the molten salts contact. The alumina mortar showed better resistance than the zircon paint. However, the molten salt was able to penetrate inside the concrete matrix to some extent, and even though these coatings would improve the long-term behaviour and durability of the system as a whole, the use of a steel liner is the recommended solution for the construction of the concrete tank.

Regarding the interaction of the Alentejo Slag particles with the molten salt, its characterization after 100 and 1500 hours in contact with the molten salt and under thermal cycles, showed the same crystalline structure by XRD and composition by SEM analyses. These results demonstrate its long-term stability to the contact with molten salts and thus, their suitability to be used in the Thermocline tank as filler material. Filler from extraction point nr.1 is considered to perform best.