NEW STORAGE LATENT AND SENSIBLE CONCEPT FOR HIGH EFFICIENT CSP PLANTS

Schweizerische Eidgenos
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

H2020 Grant Agreement Nº: 720985

H2020 Grant Agreement Nº.: 720985

Project acronym: NEWSOL

Project full title: NEW StOrage Latent and sensible concept for high efficient CSP plants

Deliverable D3.5 - Report on new Ca-ternary mixtures and nanoparticles

ABSTRACT

Molten salts, in particular Solar Salt (60-40 wt% $NaNO_3$-KNO_3), are state-of-the-art heat transfer fluids (HTF) and energy storage materials in Solar Tower Plants. Among other HTFs such as synthetic or organic oils they have distinct advantages; they are non-hazardous, low priced, comparably cheap and have a lower environmental impact. Nonetheless, this advantage is flanked with a higher operating temperature range which is limited by the melting point (plus a safety margin) at the lower end and the high temperature stability at the higher end.

Thermal Energy Storage (TES) is a viable technique that is readily implemented in Concentrating Solar Power (CSP) plants and two major techniques are distinguished: direct and indirect storage techniques. In direct molten salt storage systems, the storage medium serves as HTF at the same time. This technique is state-of-the-art in Solar Tower plants which utilize Solar Salt as HTF/storage medium. Indirect molten salt storage is typically utilized in parabolic trough or linear Fresnel power plants where the risk of freezing events due to the presence of long pipe-networks is significantly enhanced. Typically, synthetic oils are used as HTF due to their low melting point (T_m = ±0 °C) and Solar Salt acts as storage medium due to its lower price (compared to synthetic oil).

This deliverable summarizes thermo-physical properties of the Yara Most (CaNaK//NO_3) mixture with a particular focus on heat capacity and upper operating temperature limit. The heat capacity can be considered in the range of 1.4 to 1.45 J/(g·K) in the temperature range from the melting point to 400 °C. It is reasonable to assume that the same heat capacity is valid up to the decomposition temperature.

Dehydration experiments were performed in three different scales, the mg- the g- and the kg- scale. All of which showed that full dehydration is finished up to 250 °C regardless of the size of the molten salt batch.

Regarding thermal stability, different approaches for assessing the upper operating temperature stability limit have been assessed. In the first attempt 200 g of Yara Most were isothermally stored at different temperatures, at 500 °C and 525 °C for each 1.000h and finally at 550 °C.

Steady nitrate and nitrite levels were observed at 500 °C and 525 °C indicating that the molten salt is stable. At 550 °C rapid decomposition is observed especially in terms of oxide and carbonate formation. Storage experiments were repeated at 500 °C and 525 °C and very similar results in terms of molten salt chemistry were obtained leading to similar conclusions. Finally, scale-up was performed and 100 kg of molten salt were first dehydrated and then isothermally stored at different temperatures up to 525 °C. The same molten salt chemistry was similar to that in the 200 g scale, despite the fact that kinetics for chemical equilibration are slower. Overall this leads to the conclusion that Yara Most is per se stable up to 500 °C but that impurity control must be considered since accumulation of such has been observed in some experiments. A temporary operation up to 525°C may be applicable but will ultimately lead to excessive degradation of the molten salt over time.

A nanofluid based on Solar Salt and 1% wt. of Alumina nanoparticles was successfully synthetized at a laboratory scale. The distribution of sizes of ANP was within the nanometrical range (<100 nm). However, the ANPs showed very low stability over time in the molten salt. After 5 hours of test, the ANP were agglomerated and their sedimentation was evident. This process started on the first 30 minutes. Therefore, there was no enhancement of the specific heat of the nanofluid. Further research should be done to understand the mechanisms governing the stability of nanoparticles on molten salts and find strategies to avoid this phenomenon.