Applied Thermal Engineering
Volume 149, 25 February 2019, Pages 1142-1153

Research Paper

Multilevel comparison between magnetite and quartzite as thermocline energy storage materials

Yousra Filali Baba [a], Hamid Ajdad [a], Ahmed A.L. Mers [a], Yaroslav Grosu [b], Abdessamad Faik [b]

[a] 3ER Team, Department of Energy, Ecole Nationale Supérieure d'Arts et Métiers, B.P. 15290 El Mansour, 50500 Meknès, Morocco

[b] CIC Energigune, Albert Einstein 48, Miñano, Álava 01510, Spain

Received 25 July 2018, Revised 29 November 2018, Accepted 1 December 2018, Available online 3 December 2018.

https://doi.org/10.1016/j.applthermaleng.2018.12.002

Abstract

This paper presents a multilevel comparison between two thermal energy storage materials: quartzite as the most known thermocline energy storage material and magnetite as a new potential candidate. This comparison involves: thermal and thermophysical properties, cycling effect and thermocline thermal energy storage performances. In first, an experimental characterization of magnetite under cycling has been performed, and then magnetite was compared to quartzite from this viewpoint. It has been demonstrated that for the medium temperature range (i.e. from 100 °C to 500 °C), thermal cycling has a positive impact on magnetite characteristics and performances. Thereafter, a numerical model for thermocline storage has been presented and validated. Then, the thermocline behavior and the thermal energy storage performances of both materials during charging and discharging processes have been investigated and tested for various heat transfer fluidscommonly used, including natural oil, synthetic oils and molten salts. This study shows that, for the different HTF tested, no significant difference between the thermocline zone thicknesses can be noted between the two TESM. It has been concluded that for the same storage tank size and the same discharge time, magnetite can store and restore more energy and requires less storage volume although quartzite presents higher efficiencies. For magnetite, this can represent an advantage from an economic and technical standpoint. While for the same storage tank size and the same HTF speed, the magnetite charges and discharges more slowly. On the other hand, the different combinations HTF/TESM tested show that thermocline performances are driven by not only the filler material but also the nature of the heat transfer fluid. In that sense, the molten salt fluids arelargely more efficient for both TESMs than other fluids.