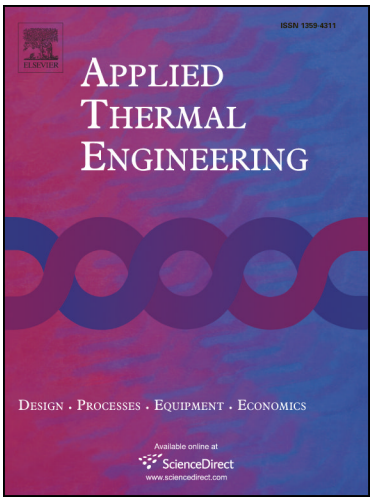

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Natural and by-product materials for thermocline-based thermal energy storage system at CSP plant: structural and thermophysical properties

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Abstract

Thermal energy storage (TES) technology is currently considered as a key solution to improve the performance of Concentrated Solar Power (CSP) plant in terms of its flexibility and dispatchability. Particularly, thermocline packed-bed single-tank configuration was shown to be a promising and economically appropriate solution, which utilizes low cost filler materials as TES working media. In this work, some natural and by-product materials, i.e. Basic Oxygen Furnace (BOF)-Slag, Magnetite and River rock, were evaluated as filler materials for a pre-industrial 20MWh$_{th}$ TES system that will be coupled to a 1 MW$_{el}$ commercial pilot CSP plant. Through their structural characterization, thermophysical properties and comparison with already applied materials for this type of configuration the most promising one in terms of its specifications for sensible TES is selected. The selected most promising material will be validated at a 200 kWh$_{th}$ (1/100 real scale) laboratory scale TES prototype that is being constructed within the framework of the Organic Rankine Cycle (ORC) - Plus project.

Key words: Thermal energy storage, thermocline, thermophysical properties

Introduction

The development of renewable energy technologies is an important step on the way to overcome the constantly increasing global energy consumption ($2.3x10^{11}$ MWh in 2035 against $1.5x10^{11}$ MWh in 2008 [1]) and to reduce global CO_2 emissions ($43.2x10^9$ TPa in 2035 against $28.2x10^9$ TPa in 2005 [1]). Solar energy is considered as one of the pillars in this field and, nowadays, it is represented by two technologies: the well-developed photovoltaic (PV) technology and the raising Concentrated Solar Power (CSP). The latter is based on the concentration of the solar radiation by means of mirrors in a point (central tower and stirling dish technologies) or in an axis (parabolic trough or linear Fresnel systems) to increase the temperature of a Heat Transfer Fluid (HTF) typically synthetic oil or molten nitrate salts. In commercial plants, this HTF is used for electricity production by means of a vapour or an Organic Rankine Cycle (ORC) turbine. As many promising renewable energy technologies like PV or wind power, the development of CSP's full potential suffers from time mismatch between energy generation and consumption peaks. In this regard, Efficient Thermal Energy Storage (TES) systems are a key component in CPS plants in order to increase its number of