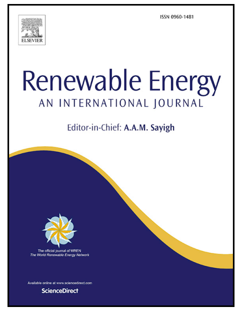

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Thermohydraulic analysis of single phase heat transfer fluids in CSP solar receivers

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Abstract

Theoretical modelling techniques are used to compare the thermohydraulic performance and thermal storage characteristics of molten salt, liquid sodium, and lead-bismuth in a CSP solar receiver concept. For molten salt, the performance of a number of heat transfer augmentation techniques are also studied. Sodium and lead-bismuth both yield excellent receiver thermal efficiency (max ~92%), when compared to molten salt (max ~ 90%), due to high thermal conductivity values that lead to large heat transfer coefficients. A high pressure drop penalty for lead-bismuth largely offsets its thermal performance gain over molten salt, however sodium retains its advantage as a receiver working fluid with a low pumping parasitic. The implementation of heat transfer enhancement techniques can significantly improve the performance of a molten salt receiver when compared to smooth tube designs. The low specific heat capacity and high unit cost of lead-bismuth is prohibitive towards its use as a storage medium in storage-integrated plant designs, resulting in very high LCOE values. Sodium is the most economically feasible fluid for systems with low storage (< 3 hour), however the low per-unit cost and high specific heat capacity of molten salt means that this is the most effective working fluid in systems with larger storage requirements.

Keywords: Concentrated solar power, solar receiver, molten salt, liquid metals, thermohydraulic performance, thermal storage

1. Introduction

Concentrated solar power (CSP) is one of the fastest growing renewable energy technologies [1]. CSP has the potential to contribute towards a significant proportion of commercial electricity generation in years to come, with a 12% share in global electricity capacity forecast for 2050 [2]. A key advantage of CSP over other commercial renewable energy technologies lies in its ability to store thermal energy. Thermal energy storage (TES) allows for generation of electricity at times of little or no solar exposure, adding to the value and flexibility of CSP [3]. A critical challenge with CSP lies in its current high levelized cost of electricity (LCOE) relative to other commercial generation technologies, hindering its competitiveness in the energy market. Research and development into CSP is focussed on

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