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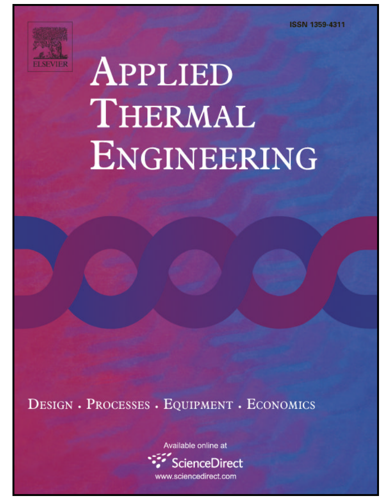

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Abstract:

Concentrated solar energy associated with thermal storage is gaining consideration among renewable energy sources since it provides efficient and low-cost solutions along with dispatchability. However, solar energy is intrinsically variable. In this context, a multi-domain numerical simulator can be a valuable aid to tackle the operation and control problems. In the present paper, we build a dynamic model of a concentrated solar power plant prototype using oil as the heat carrier fluid and combining a Fresnel solar field, an Organic Rankine Cycle and a dual media thermocline for thermal energy storage. The simulator takes the form of a large-scale Modelica model including both the physical and the control problems. The model is described component by component and the numerical results are compared to experimental data. Critical operational cases are studied to highlight both the model's capabilities and limitations: startup procedure, storage management and outlet temperature control.

Keywords: concentrated solar energy, dynamic simulation, thermocline thermal storage, control.

1 Introduction

Solar energy can respond to humankind electricity needs. PV (PhotoVoltaic) capacities are rapidly growing with more than 200 GW_{peak} currently installed. However, PV plants are not competitive with CSP (Concentrated Solar Power) plants when energy storage is considered (Stark et al, 2015). Storage is the key component in order to use solar energy as base load. Thermal storage is now unavoidable for future CSP projects. Hybridization could be another option but at the price of a reduced solar share (Soares et al. 2017). The current leading technology is the two-tank thermal storage system. However, reduced costs could be obtained with thermocline thermal storage since this technology relies on a unique tank.

When thermal storage is integrated in a CSP power plant, various options arise for the operator since thermal power can be charged, discharged or directly used in the power cycle. In order to guarantee a baseload capacity with a variable resource, dynamic simulations are required for the sake of optimizing the control of the plant. Many works (Manzolini et al, 2011a, 2011b, Morin et al, 2009) and tools (SAM, Greenius) have been released for steady state simulation of solar power plants to estimate the annual electricity production, generally on an hourly basis. Current researches are focusing on dynamic simulations of solar power plants (Reddy et al., 2013). Among them, works have been dedicated to dynamic simulation for the control of direct steam generation solar power plants (Eck et al, 2007; Birnbaum et al. 2011; Valenzuela et al. 2005). A recent review has been proposed for direct steam generation power plant control (Aurousseau et al., 2016). The present study focuses on