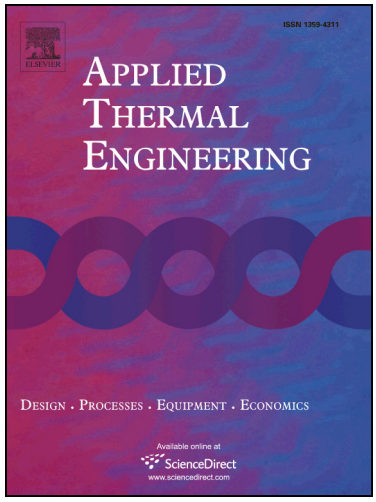

A detailed working fluid investigation for solar parabolic trough collectors

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A detailed working fluid investigation for solar parabolic trough collectors

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Abstract

Solar energy is a promising energy source for covering a great variety of applications from low up to high temperature levels. In this study, the most mature concentrating technology, a commercial parabolic trough collector (Eurotrough ET-150), is investigated energetically and exergetically for a great temperature range from 300K to 1300K. Pressurized water, Therminol VP-1, nitrate molten salt, sodium liquid, air, carbon dioxide and helium are the examined working fluids; each one to be studied in the proper temperature range. In the first part of this study, the optimum mass flow rate is determined to every working fluid separately. After this point, the exergetic and the energetic performance of the collector operating with all these working fluids is examined. The final results prove that the liquid sodium leads to the global exergetic maximum efficiency (47.48%) for inlet temperature equal to 800 K, while the maximum exergetic performance of helium, carbon dioxide and air to be 42.21%, 42.06% and 40.12% respectively. Moreover, pressurized water is the best working medium for temperature levels up to 550 K, while carbon dioxide and helium are the only solutions for temperatures greater than 1100 K. The thermal analysis is performed with the EES tool.

Keywords

Parabolic trough collectors, exergetic analysis, working fluid investigation, thermal performance

1. Introduction

The increasing rate of the global energy consumption [1] is a basic issue that our society has to manage due to the consequent problems, as the increase of CO_2 emissions and the fossil fuel depletion [2-4]. Moreover, the increasing price of the electricity and the new lifestyle trends [5], which are connected with the high energy consumption, create the need to use alternative and renewable energy sources. Solar energy utilization is a promising way for facing all the environmental threads and for producing low cost thermal energy and electricity [6].

Solar collectors are the devices which capture solar energy and transform it partially to useful thermal output. The conventional solar collectors are flat plate collectors which operate usually in low temperature levels up to 100 ^{o}C [7]. Higher temperature levels up to 200 ^{o}C can be achieved with evacuated tube collectors [8], while for greater