



Experimental investigation of transparent parabolic trough collector based on gas-phase nanofluid



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HIGHLIGHTS

- A new PTC, with transparent receiver tube, has been experimentally studied.
- Two axes solar tracking PTC, with 4 m² reflecting surface has been realized.
- A mixture of CuO nano-powder and air has been used as working fluid.
- The experimental tests showed nanopowder deposition within the receiver pipe.
- In a day of measurement, the mean efficiency of about 65% has been reached.

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ABSTRACT

An experimental study on new high temperature parabolic trough collector (PTC), with transparent receiver tube, based on gas-phase nanofluid, has been carried out for the first time in this work. Two-axes solar tracking PTC, with 4 m² reflecting surface has been realized. Besides, two coaxial quartz tubes, with vacuum in the inner space were used as receiver pipe, with air-dispersed CuO nano-powders as working fluid. The aim of this work was to investigate the technological issues related to the use of gas-based nanofluid coupled with transparent quartz receiver and to evaluate the performance of the first prototype, comparing numerical and experimental results. The experimental campaign highlighted a critical issue related to nanopowder deposition within the receiver pipe, due to humidity. Moreover, in a day of measurement, the fluid temperature higher than 145 °C has been maintained for about 10 h, reaching a maximum value of 180 °C, with a mean efficiency of about 65%.

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1. Introduction

In recent years, several types of parabolic trough collector (PTC) have been largely investigated and tested, renewing worldwide interest in this technology, that is suitable for electric power generation [1–4].

As known, PTC is the most common type of concentrating solar power technology. These systems typically use synthetic oil or molten salts as heat transfer fluid. Notwithstanding its characteristics of flammability and toxicity and its relatively low maximum working temperature (<400 °C), synthetic oil represents the most common heat transfer fluid in PTC power plants [5].

On the other hand, molten salts, while can work up to 600 °C [5–8], require expensive anti-freezing systems because of their solidification temperature of about 220 °C [9,10].

To overwhelm the limitations of synthetic oil and molten salts, according to de Risi *et al.* [11], in this work the authors proposed to use gas-phase nanofluid as heat transfer fluid in parabolic trough collector, with transparent receiver tube (named transparent parabolic trough collector, TPTC). The main difference between traditional opaque and innovative transparent receiver is related to the heat transfer mechanism between solar radiation and working fluid: in the first case the fluid is heated by thermal convection through the opaque receiver tube, while in the second case, the nanofluid is directly irradiated and heated by solar radiation. Several studies conducted on direct absorption liquid based nanofluids demonstrated advantages of direct absorption with respect to indirect one [12–15].

In recent years, numerous works have been carried out on thermal conductivity and heat transfer in nanofluids [16–26]. Furthermore, the high absorption coefficient of solar radiation, which characterizes different nanofluids [27–32] has been the inspiration for several studies. About that, Miller and Koenigsdorff [33]

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