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Impact of different internal convection control strategies in a non-evacuated CPC collector performance

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Abstract

Over the last decade the technological advances observed in solar collector materials, namely better spectrally selective absorber coatings and ultra clear glass covers, contribute to performance improvements and translate into higher operational temperature ranges with higher efficiency values.

While the use of Evacuated Tube Collectors (ETCs) is becoming widespread in the thermal conversion of solar energy, non-evacuated solar collectors still hold advantages at manufacturing, reliability and/or cost levels, making them interesting and competitive for a large range of applications, in particularly, in temperature ranges up to 80 °C. However, these advantages have not prevented the major drawback of these collectors when compared to ETCs: thermal losses due to internal convection which prevent their general use in the range of operating temperatures up to 150 °C.

Insulation, double glazing or selective coatings can be used in non-evacuated collectors to reduce heat losses. To prevent internal convection losses in these solar collectors, different control strategies have been studied, such as the adoption of different inert gases within the collector cavity, physical barriers reducing air flow velocities over the absorber or cover surfaces or the use of concentration.

In the present article, an assessment of adopting such internal convection control strategies in a CPC collector is presented. Each of the presented strategies is assessed in terms of the resulting collector optical and thermal characterization parameters and yearly collector yield. For this purpose, an integrated tool allowing the design, optical and thermal characterization of CPC collectors was developed. The results obtained provide valuable guidelines for anyone wishing to implement any of these strategies in a new collector design.
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Keywords: CPC collector; Convection losses; Medium temperature

1. Introduction

The energy balance in a solar collector results from: the radiative flux effectively transferred into the absorber surface and other internal exposed surfaces; the useful heat removed to the heat transfer fluid; and all thermal losses to the surrounding environment (Rabl, 1985; Duffie and Beckman, 2006). Since most non-evacuated collectors possess insulation and a glazed absorber enclosure, internal convection must be carefully handled if collector heat losses are to be reduced. That is clearly shown by ETCs, when compared to non-evacuated collectors: after elimination of internal convection, due to the vacuum created between absorber and cover surfaces. As a result, ETCs present a much reduced heat loss coefficient and may operate at higher temperatures. However, non-evacuated collectors have some advantages in manufacturing, reliability,

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