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ScienceDirect

Energy Procedia 91 (2016) 661 – 667

Energy Procedia

SHC 2015, International Conference on Solar Heating and Cooling for Buildings and Industry

Study of applications of parabolic trough solar collector technology in Mexican industry

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Abstract

In Mexico, a local enterprise has developed a parabolic trough solar collector to produce thermal energy. This collector has modular characteristics and it has been installed in some industries around the country to meet the thermal load for their processes or diminish the consumption of fossil fuels. Besides this, a local university has made a computational program that predicts the energy output of system with this type of solar collector. This paper presents the results of two systems installed comparing the results with computational and experimental data.

Peer-review by the scientific conference committee of SHC 2015 under responsibility of PSE AG

Keywords: Thermal efficiency; solar collector; parabolic trough; industrial applications; numerical model.

1. Introduction

Inventive Power® is a mexican enterprise that has been participating on the renewable energy market around the country since 2010. It started as an initiative of two Master in Energy Engineering Program students of Instituto Tecnológico y de Estudios Superiores de Monterey, Campus Monterrey, with the support of CONACYT (the National Secretary of Science and Technology in Mexico). Aldo Agraz and Angel Mejía made a technical and economical analysis of a parabolic trough solar collector (respectively) as their thesis project [1,2]. For the thecnical analysis, the ASHRAE 93 standard was used. The solar collector was entirely manufactured by them. The results of their investigation shows that the collector can get a thermal efficiency up to 60% with a feasible economical investment and including its modularity, ideal characteristics for small and medium enterprises (SME`s). After, Agraz and Mejía continued with the enterprise they founded, entering to the energy market in Mexico with the solar collector system they developed as the principal product, and also started a relationship with the University

Peer-review by the scientific conference committee of SHC 2015 under responsibility of PSE AG
doi:10.1016/j.egypro.2016.06.227

Graduate Program as an extension of their Research Department.

Later, Pablo Tagle realized a technical analysis using the SRCC standard 600, which is different than ASHRAE 93 [3]. SRCC standard evaluates both reliability of the entire system (collector and control devices) and thermal efficiency and ASHRAE 93 only make the thermal efficiency analysis for solar collectors. A second part of this study consisted on a numerical evaluation of the collector under different conditions using a computational software, the same that is used to compare the numerical analysis with experimental data on thermal efficiency. The results show that the collector has a good reliability but its fabrication can be improved to make both reliability and maintenance better, so some improvements were proposed. For the thermal analysis it was found that the software predicts the behaviour of the collector with good accuracy. The improvements proposed were realized on a new collector model, and this is now commercialized by the enterprise.

This study presents the results of comparing two cases of systems installed by the enterprise and the computational model. Both the collector system and computational model is explained in detail.

Nomenclature

ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
SRCC	Solar Rating and Certificate Corporation
SME	Small and medium enterprise
A	Effective area of collector (m^2)
C_p	Heat capacity (J/kgK)
D_i	Diameter of surface i (m)
I	Solar irradiance (W/m^2)
K_{ij}	Thermal conductivity of material between surfaces i and j (W/mK)
L	Length of collector (m)
$\dot{m}$	Mass flow (kg/s)
Nu	Nusselt number (dimensionless)
Pr	Prandtl number (dimensionless)
q'	heat flux per unit of length (W/m)
T_i	Temperature (ºK)
α_i	Absorptance of surface i (dimensionaless)
ε_i	Emittance of surface i (dimensionaless)
η_N	Thermal efficiency of a system of N collectors (dimensionaless)
η_{opt}	Optical efficiency of collector (dimensionaless)
τ_i	Transmittance of surface i (dimensionaless)
σ	Stefan-Boltzmann constant ($5.67x10^{-8}$ W/m^2K^4)

Subscripts

1 - 5	Surface of measurement
in	inlet
out	outlet
w	measurement at wall

2. Description of the system

The solar collector system has 3 components: the collector, the solar tracking and the data measurement device. The principal product is the solar collector, but in order to increment the efficiency of the collector the enterprise has developed their own control devices. Each of the components is detailed below.