Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 88 (2016) 470 – 475

Energy Procedia

CUE2015-Applied Energy Symposium and Summit 2015: Low carbon cities and urban energy systems

An Optimized Model for Solar Thermal Collectors Based on Concept of Effective Heat Collection

Yuexia Lv[a,b], Pengfei Si[c,*], Xichen Liu[c], Xiangyang Rong[c], Ya Feng[c], Jinyue Yan[d,e]

[a]*School of Mechanical & Automotive Engineering, Qilu University of Technology, Daxue Rd No.3501, Jinan 250353, China*
[b]*(Ningbo) RK Solar Energy Tech. Ltd., Zhongguan WestRoad No.777, Ningbo 315201, China*
[c]*China Southwest Architecture Design and Research Institute Corp., Ltd., Tianfu Avenue No.866, Chengdu 610041, China*
[d]*School of Business, Society and Energy, Mälardalen University, Västerås SE-72123, Sweden*
[e]*School of Chemical Science and Engineering, Royal Institute of Technology, Stockholm SE-10044, Sweden*

Abstract

The performance of solar collector highly relies on its tilt angle with respect to horizontal plane and orientation (surface azimuth angle) of the collector. The effective heat collection concept was proposed and an optimized mathematical model was further developed to determine the optimum tilt angle and orientation for the solar collector. The developed model was applied in a case study of the Lhasa district, in comparison with the results obtained in accordance with conventional optimization results. The research results showed that, there is about 5° deviation between the optimum results obtained according to effective heat collecting capacity and the optimum results obtained according to maximum total solar radiation falling on the solar collector.

Peer-review under responsibility of the organizing committee of CUE 2015

Keywords: Solar collector; Optimum tilt angle; Effective heat collection; Mathematical model

1. Introduction

As an effective, renewable, safe and eco-friendly energy resource, efficient utilization of solar energy has undoubtedly been regarded as an encouraging solution to global energy shortage and a means to achieve sustainable development for human beings. Due to rapid development of solar energy technologies and continuous decreased cost of solar energy equipment, percentage of renewable energy by solar thermal and photovoltaic are increasing as the energy supply for buildings. The surface azimuth

* Corresponding author. Tel.: +86-28-6255-1510; fax: +86-28-6255-1510
E-mail address: 175987342@qq.com

Peer-review under responsibility of the organizing committee of CUE 2015
doi:10.1016/j.egypro.2016.06.037

angle and tilt angle of a solar collector with respect to horizontal surface highly affect the solar radiation reaching the collector surface.

In recent years, a number of studies have been carried out to investigate the optimum tilt angle and orientation of solar surface for different building applications, and several models have been developed to determine the optimum tilt angle and amount of solar radiation on an inclined surface [1-3]. Despotovic et al. [4] determined the yearly, biannual, seasonal, monthly, fortnightly and daily optimum tilt angles of solar collectors for Belgrade, by searching for the values for which the solar radiation on the collector surface is the maximum for a particular day or a specific period. Gunerhan et al. [5] recommended that the solar collector should be mounted at the monthly average tilt angle and the slope should be adjusted once a month to increase the utilization efficiency of solar collectors in Izmir. Khorasanizadeh et al. [6] established a diffuse solar radiation model to determine the optimum tilt angle of south-facing solar surfaces in Tabass of Iran, and calculate the fixed monthly, seasonal, semi-yearly and yearly adjustments.

Nevertheless, in most models, the optimum results were obtained by achieving the maximum irradiation on the collector surface, without considering the influences of atmospheric temperature and working medium temperature on the collector performance. In practical applications, the atmospheric temperature, average temperature, fluid average temperature, fluid inlet and outlet temperature and other parameters are dynamically changing, which may result in a certain deviation from the optimum results obtained without taking above variables into account.

Therefore, it is the corresponding interest of this paper to propose the effective heat collection concept and further develop an optimization model to evaluate the collector performance in a better reasonable manner.

2. Methodology

In this section, a concept of available/effective heat collection has been proposed, based on which an optimized mathematical model has been further developed.

2.1. Concept of effective heat collection

Available/effective heat obtained by the collector within a certain period is the energy difference between the captured solar energy and the energy lost to ambient environment, in which absorbed solar energy is the solar energy reaching the collector surface subtracted by thermal loss due to collector radiation. Figure 1 is the energy balance schematic drawing of a solar collector.

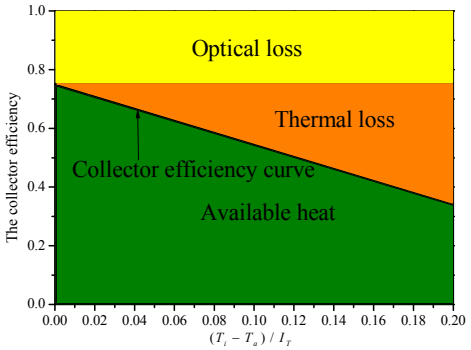

Fig. 1. Energy balance of a solar collector

The concept of effective heat collection is illustrated using example located in Lhasa. As shown in Figure 2, the heat collecting capacity of the collector installed varies against time. Minus zone indicates