Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 91 (2016) 415 – 420

Energy Procedia

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

Research on solar heating system with phase change thermal energy storage

Deli Ling[a], Genmao Mo[a], Qingtai Jiao[a,*], Jiajie Wei[a], Xiaojing Wang[a]

[a]Sunrain Group Co., Ltd, Lianyungang,222243, China

Abstract

In order to apply solar energy for heating purpose, we study the performance of solar heating with phase change thermal energy storage. Tests and analysis have been carried out to obtain the useful energy and thermal efficiency of the system, the energy consumption for room heating and the solar fraction, The research results showed that the heating efficiency of the system would be 31.7% and the solar fraction would be 83.6% while the average temperature indoor was 14.9℃ and outdoor was -1.5℃The temperature change in the heating room was bigger than that in the contrast. Compound heating systems with solar collectors and phase change materials are popular nowadays as they are meeting the design requirements of buildings with energy conservation integration.

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

Keywords: Solar heating, phase change energy storage, system heating efficiency, solar fraction

1. Introduction

As a clean nonpolluting and renewable energy source, solar energy attracts more and more attention and researches all over the world especially in China that a developing country with a large population and huge demand of energy primarily conventional energy for heating, power generation, etc. which cause a series of environmental problems. Solar heating system is one of the most wide used solar energy systems which can replace those high energy price ratio heating systems that rely on electricity or coal etc. However, the solar energy is not steady and changes with climates and seasons and that's why we choose to use phase change energy storage in the solar heating system.

Many researchers have used the phase change energy storage for heating. Salyer and Sircar [1] suggest phase

* Corresponding author. Tel.: +86 518 85051197;
E-mail address: delylin@163.com

Peer-review by the scientific conference committee of SHC 2015 under responsibility of PSE AG
doi:10.1016/j.egypro.2016.06.277

change materials can be used for energy storage indoor and that can control the indoor temperature fluctuations in a more comfortable range probably. Athienitis and Chen [2] discuss the thermal performance and the using effect of concrete floor heating system with thermal storage. Relative to concrete, the phase change materials have better characteristics of high density of energy storage. Farid and Kong [3] do some researches on the performance of an electric floor heating system using $CaCl_2 \bullet 6H_2O$ as the phase change material for energy storage and indicate that those special floor with energy storage materials is much better than usual which can meet the whole day heating load while being electrified for 8 hours. Yamagushi and Sayama etc. [4] develop a compound heating system by adding inorganic phase change materials into low temperature hot water floor and discuss the thermal performance of this kind of heating system.

However the experimental study on the inorganic phase change energy storage floor system with hot water as the medium is less currently since the inorganic phase change material has some problems of over cooling, encapsulation and integration.

In this paper, the solar system applies vacuum tube solar collector generate hot water. The heat of hot water is transited to the phase change energy storage box by the heating pipelines. And by filling with phase-change material, it solves those problems such as over cooling, encapsulation etc. The phase change material releases the stored heat at night to heat the floor as well as the room. Research on the thermal performance of the system provides the basis for the experimental data for further optimization of solar energy storage heating system

Nomenclature

A	Aperture area of collectors, m^2
Q	Useful energy of the solar collector system or energy consumption of the heating system, MJ
$T_{2.75}$	Average temperature of 2.75m high from the floor in heating room, ℃
T_a	Average ambient temperature, ℃
$T_{1.75}$	Average temperature of 1.75m high from the floor in heating room, ℃
T_d	Average temperature in the contrast room, ℃
H	Cumulative solar radiation, MJ/m^2
c_{pw}	Specific heat capacity of the working medium, J/(kg•K)
t_{dji}	Outlet temperature for the i th record of the solar collector system, ℃
t_{bji}	Inlet temperature for the i th record of the solar collector system, ℃
ΔT_{ji}	Time interval for the i th record of the solar collector system, ≤600s
n	Total record number
Q_j	Useful energy per aperture area of solar collector system, MJ/m^2
m_{ji}	Total flux for the i th record of the solar collector system, m^3/s
t_{dzi}	Inlet temperature for the i th record of the heating system, ℃
t_{bzi}	Outlet temperature for the i th record of the heating system, ℃
ΔT_{zi}	Time interval for the i th record of the heating system, ≤600s
m_{zi}	Total flux for the i th record of the heating system, m^3/s
f	Solar fraction

Greek Symbols

η	Efficiency of the solar collector system

2. Experimental object and methods

2.1 Object and instruments

The solar heating system described in this paper designed for a heat load of 133.9 m^2 located in the Jiahoutuan village in Tongzhou district of Beijing city of China is a compound system with phase change materials with an entire covered area of 340m^2 and a collector aperture area 55.35 m^2. It contains 9 groups of all-glass vacuum tube collectors (double sided water in glass manifold) with each group incorporating 50 tubes in size of Φ58mm×1800mm assembled at an inclination of 15° and a 150L buffer tank with 50mm thick polyurethane foam insulation layer and an electric heater in size of 2.7kW as auxiliary thermal source to meet the heating demand in bad weather. At the end of the system, the low-temperature floor radiant heating system (phase change energy