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The performance of first transpired solar collector installation in Turkey

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Abstract

In 2014, Turkey consumed 12 billion cubic meters of natural gas for space heating which accounts 26 percent of general natural gas consumption. Using several technologies to collect solar heat is one of the solutions to reduce the energy consumption in buildings. Among these technologies are transpired solar collectors, which are relatively new solar energy technology in Turkish energy market despite its wide and effective use in North America and Europe over the past 30 years to save energy in buildings by heating ventilation air using solar energy. In 2012, the first transpired solar collector on an industrial building was installed in Turkey, Cayirova. The installation on the south facing wall of PIMSA manufacturing building is a total of 770 m² with six large associated air handling units.

This paper presents a review of the performance of the first transpired solar collector in Turkey. The energy drawn from solar collector and delivered to the building each month over the period of two years is monitored and analyzed. Results cover monitoring for the period of February 2013 - April 2013 and January 2014 - March 2014, when the transpired solar collector was operating. The monitoring system includes twenty-four thermocouples embedded in transpired solar collector with connected air handling units, two in the building, two outside on the wall and twenty-four automatic damper controllers all connected to a building management system. It has shown that transpired solar collector provides a significant amount of the heating required by the building. Heat outputs from transpired solar collector installation are also compared with the simulation outcomes of Retscreen solar air heating analysis software developed by the Canadian government.

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Keywords: Transpired solar collector; Solar air heating

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1. Introduction

Nomenclature

M	fan mass flow rate
C_p	specific heat capacity
ΔT	the temperature difference between outside air temperature and TSC duct temperature

A solar air heating system, also called a transpired or perforated plate collector (TSC), is a building-integrated renewable energy technology that pre-heats or re-heats building ventilation air. One of the most important features of the TSC is a synchronized heat and fresh air operation, also the system provides energy savings by reducing temperature difference between the building wall and ambient.

This paper presents a review of the performance of the first TSC installation in Turkey, Cayirova, which was installed in 2012 in an automotive production plant, owned by PIMSA Automotive. The energy drawn from solar collector and delivered to the building each month over the period of two years is monitored and analyzed. Results cover monitoring for the period of February 2013 - April 2013 and January 2014 - March 2014, when the transpired solar collector was operating.

2. Overview of solar thermal collectors in Turkey

According to the report of Turkish Renewable Energy General Management, the estimated thermal solar energy potential of Turkey is approximately 380 billion kWh per year. Turkey is one of the leading countries with 4 million m^2 solar thermal collector and 7.1 GW_{th}, in the world. However, in Turkey, solar thermal collectors are mainly used in private households to heat water, despite the fact that the potential of solar thermal energy is much higher comparing to other types of energy. On the other hand, it should be noted that solar air heating market is relatively new in Turkey. Although various researches and applications have been made about TSCs in Turkey, commercial use in building heating is not as common as in the rest of the world. In general, the first idea that comes to mind is system that provides hot water by solar energy, when solar energy heating system is mentioned.

3. Transpired solar collectors

A transpired solar collector (TSC) is a solar thermal system which can be used to preheat the ventilation air supply in buildings, using solar radiation as its energy source. John Hollick first developed TSC that was used for heating outside air directly [1]. Research and investigation into using solar air collector for solar heating systems first appears in the 90s. The basic heat loss theory for solar air collector was presented by Kutscher and Christensen [2]. Kutscher used the derived equations to develop a predictive model for thermal performance [3]. Van Decker investigated heat exchange effectiveness more thoroughly for three-dimensional flows [4]. Van Decker and Hollands extended the correlation for the effectiveness to no-wind conditions circular holes on a square or triangular pitch [5, 6]. Gunnewiek included the effects of wind on flow inside the plenum in their previous study [7]. Leon and Kumar developed a model used for drying [8]. High absorbing efficiency can be realized in TSCs compared to conventional solar air heating collectors [9-13].

The scheme of TSC, which heats fresh air by using solar energy, is seen in figure 1. The absorber plate is mounted on the wall with a distance of 10 cm - 30 cm. With the effect of negative pressure, which is created by a fan, the fresh air passes through the plenum air via the holes on the absorber plate. Solar energy is transferred to the air while the ambient air passed through the plenum. The heated air moves towards the top of the plenum and then is sent to the ventilation duct.