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Experimental Study of Solar - Phase Change Material Wall for Domestic Hot Water Production under the Tropical Climate

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Abstract

This paper reports experimental performance investigation of a solar-phase change material wall for domestic hot water (S-PCMW) in tropical climate. The S-PCMW objectives are to provide domestic hot water and reduce heat transferred from outside. It consisted of a glazed solar hot water collector, 0.22 m thick with PCM and painted black pipes 0.01 m. diameter to produce hot water which can hold approximately 10 litters. The internal glass insulator was 0.020 m thick. Comparison between S-PCMW and Simple Concrete Wall (SW) using two small house models of the same dimensions are presented and discussed. The experiment revealed that indoor temperature of the room mounted with S-PCMW was lower than that of the SW. Heat gain through the south wall of S-PCMW decreased significantly when compared with the other type. The S-PCMW wall can produce hot water at temperature varying from 45°C to 51°C. Thus, it has been proved that the S-PCMW is energy efficient in term of heat gain reduction and energy saving.

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Keywords: Energy Saving, Solar- Phase Change Material Wall (S-PCMW), Reduced heat gain, Under Tropical Climate.

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Nomenclature

T_G	clear glass pane temperature (°C)
T_C	concrete wall temperature (°C)
Tair grill	air grill temperature (°C)
Tair gap	air gap temperature of glazed solar hot water collector (°C)
Tp	wax temperature (°C)
Troom	indoor air temperature (°C)
Tin	inlet cold water temperature (°C)
Tmiddle	collector middle temperature (°C)
Tout	outlet hot water temperature (°C)
Tstorage	hot water storage tank (°C)
Tamb	ambient temperature (°C)
Home 1	house model with Solar - Phase Change Material Wall: S-PCMW
Home 2	house model with Simple Concrete Wall: SW
HF 1	heat flux of Home 1 with S-PCMW, (W/m^2)
HF 2	heat flux of Home 2 with SW, (W/m^2)

Introduction

Heat transfer into building interior caused by solar radiation. In general, an advantage of the traditional concrete wall is its insulation properties to protect directly against solar heat (long-wave radiation) and its non-permeability properties to protect directly against rain and moisture from penetration into the building. In contrast, the disadvantage of the traditional concrete wall is that it's incapable of preventing indirect leakages of heat and moisture. There are two major impacts of the indirect leakages. First is encountered at the opening area such as doors, windows and other openings where hot air or exhaust was naturally blown into inside of buildings. Second is the accumulative heat on surface of the walls which is resulted from direct sunlight striking the buildings and then brings heat accumulation on the outdoor surfaces. Some of the accumulative heat would be lost to the outdoor ambient by heat convection and distribution. The accumulative heat on the outdoor surface will transfer through the thickness of the wall to the outdoor surface by heat conduction and then result in heat convection and distribution from the indoor surface to objects and air that leads to higher temperature inside the house. Thailand locates in a humid tropical zone alternate between hot and rainy weather year round. The average of ambient temperature is 20°C – 30°C, average relative humidity 59 - 100% and solar radiation 17 MJ/m^2.day [1-6]. Architectural constructions in the country mostly focused on modern grandeur and aesthetics without concern of saving energy and the environment which has an effect on electricity use, especially in air conditioning for air circulation, temperature reduction and humidity control. Statistics pointed out that the proportion of direct electricity consumption is 60%, electrical appliances 20%, and artificial light 20% [7]. To resolve the problem, the government conduct a policy of reducing energy use and energy conservation inside of buildings. A policy is providing grants for educational institutions research and promoting the uses of renewable energy such as solar energy; because it's clean, non-polluting and reliable source of electricity. The applications of solar energy for heating and cooling in combination with natural ventilation were presented in [8]-[10] and the studies on the development of solar water heater can be found in [11]-[15]