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Design, Fabrication and Experimental Study of a Novel Loop-heat-pipe based Solar Thermal Facade Water Heating System

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Abstract

This paper investigated a novel loop-heat-pipe based solar thermal facade heat-pump system for hot water from concept design, prototype fabrication and experimental test. Given the specific testing conditions, the solar thermal efficiency of the facade module achieved nearly 0.71 in average and the mean system's COP was about 5.0. It is expected that such novel LHP based solar thermal facade technology would further contributed to the development of the renewable (solar) driven heating/hot water service and therefore lead to significant environmental benefits.

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Kyewaords: Solar; Thermal facade; Loop heat pipe; Heat pump

1. Introduction

The current available solar thermal facade devices are creating a considerable energy saving potential and therefore are expected to boost in the near future [1]. However, these technologies have also been identified with several inherent problems that may become the barrier in future widespread deployment. The common problems lie in: (1) complex structures containing numbers of heat absorbing pipes and heat exchanging units; (2) relatively low solar efficiencies owing to less effective heat absorption of the water pipes (or air ducts) and less efficient heat transfer within the heat exchanging units. As a result, a larger solar facade area and higher system cost become the obvious disadvantages of the existing devices. An innovative solar loop-heat-pipe (LHP) thermal facade is therefore proposed by the authors to remove above critical problems remaining with the current solar thermal facade application in buildings. LHP is

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an advanced two-phase heat transfer mechanism that is capable to transport large heat flux in long distance. Combination of the facade loop with a heat pump would further enable an efficient thermal control and management of the whole solar thermal system.

The article is implemented as an integration of concept design, prototype fabrication and laboratory testing into the proposed system. By delivering an effective, building integrated and aesthetically appealing solar collecting module/system, the research is expected to promote development of the renewable (solar) driven heating/hot water service for building, district and city scale application, which would lead to significant saving in fossil fuel consumption and reduction in carbon emission.

2. Design and Fabrication

2.1. Concept Design

Schematic of the novel solar LHP facade water heating system is presented in Fig 1.This system includes outdoor and indoor parts by the connection of transportation lines. The outdoor part initially converts the absorbed solar energy into the thermal energy in form of low-temperature vapour, which is prefabricated with a glazing cover, a fin-sheet absorber, a group of novel LHPs incorporated with three-way fitting, the compressed metal chips filer and the thermal insulation. This low-temperature vapour is further transported to indoor part through the transport line and then condensed by releasing heat in the heat exchanger (heat-pump evaporator). A secondary (buffer) water tank here is designed to temporarily store the additional instant condensation heat and reduce the corresponding heat dissipation, which also mitigates the fluctuation of heat-pump evaporation temperature. Thereafter, the condensed heat is further uplifted by the heat pump cycle to required level and stores in the primary water tank for later utilization.

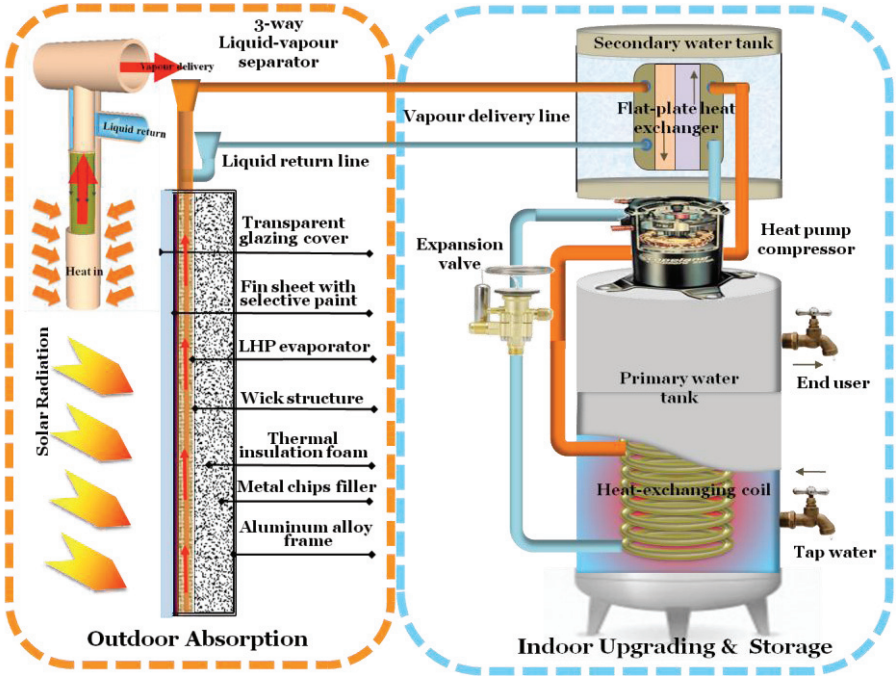

Fig 1. Schematic of the novel solar LHP thermal facade heat pump water heating system

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