COMPARISON OF HEAT PIPE AUGMENTED SOLAR WALL WITH CuO-H_2O NANOFLUID AND CONVENTIONAL BUILDING WALL

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ABSTRACT

The heat pipe augmented solar wall is a type of isolated gain system which greatly increases the insulation value of the solar cooling device with the advantage of the "thermal diode" phenomenon in heat transfer with heat pipes. These units perform similar to ground-based isolated gain collection units but can be installed in any solar-facing wall. The increased insulation value of these systems and their ability for installation in any building with solar exposure makes them much more likely to have the greatest impact on the building cooling market.

Keyword- *Solar Wall, Heat pipe, nanofluid, LPH, Efficiency.*

1. INTRODUCTION

Solar systems can be used for day lighting, ventilation, and space heating. By developing a passive solar system for space heating a large portion of energy consumption in the residential sector can be alleviated. Traditional passive solar systems experience net gains during sunny weather conditions, however, system losses occur during nighttime and cloudy periods. To offset these losses, solar systems have to be supplemented with conventional heating sources. Climate variations such as temperature and cloudiness affect the net gains of passive solar systems and design considerations can be made to limit thermal losses.When designing passive solar systems for space conditioning there are two different designs - direct gain and indirect gain. Direct gain systems use south facing windows to allow solar radiation into the living space . Many times, buildings with large window apertures and small living space can incorporate the use of a thermal mass. Traditionally this is a concrete floor, and the thermal mass storage helps provide a more constant energy source throughout nighttime and cloudy periods. The advantage of direct gain systems is the fast response time; however, the thermal losses through the window are its greatest disadvantage.

1.1 Literature Review

V. Badescu [1] this paper represents environmental control devices and/or designs in buildings that are capable of harvesting solar thermal energy can effectively capture and store this solar energy and provide energy through the use of, for instance, a hot water system or a low-power thermoelectric material. Thermal energy storage (TES) is the key component for such solar energy use, and it is one of the most promising and sustainable methods for energy storage in buildings.

Wan JW [8] studied the large windows on the south-oriented facade of a passive house strongly contribute to building space heating. These windows constitute the passive solar heating system. This paper studies the active heating system of a passive house, which includes the following sub-systems: (1) solar thermal collectors, (2) a water storage tank, (3) a secondary water circuit, (4) a domestic hot water preparation system and (5) an air ventilation and heating system. Models for all sub-systems are presented.

H. N Chaudhry [2] have carried out extensive work on determining the response of heat pipes to the external climate conditions when used as a passive cooling system. An analysis of the thermal cooling capacity for different heat pipe working fluids determined that water was the most efficient working fluid in comparison to ethanol and R134a when operating under inlet temperatures between 20°C and 45°C. Furthermore, the findings have revealed that under low Reynolds Number airstreams, the cooling capacity of heat pipes increases by 0.1°C for every 1°C rise in external inlet temperature.
Heat pipe heat exchangers have been commonly used in energy systems to recover heat from the exhaust air streams and transfer it to the supply fresh air stream thereby reducing active pre-heating requirements. They are often employed as a heat recovery unit in air-conditioning systems for the built environment although the prospect of achieving passive cooing from natural ventilation air streams is not well-established.

Hassam Nasarullah Chaudhry [3] was studied detailed investigation into determining the passive airside cooling capability of heat pipes in response to gradually varying external temperatures was carried out. The city of Doha, Qatar was taken as the location of case-study and the climatic data for June 21st, 2012 was incorporated in the transient thermal modeling. The physical domain comprised of 19 cylindrical heat pipes arranged in a staggered grid subjected to varying source temperatures. Wind tunnel testing was carried out for the duration of 24 h in order to establish a relationship between the source temperatures and their effect on the climate responsive behavior of heat pipes. Infrared thermal imaging was used to capture the surface temperature formations at regular intervals of time during the test. The findings from the study showed that under a low Reynolds Number airstream, the cooling capacity of heat pipes increases by 0.1 0C for every 1 0C rise in external source temperature. Conversely, the investigation showed that the thermal response of heat pipes reduces by 0.3 0C when subjected to decreasing source temperature gradients of 1 0C, thus indicating a low effectiveness. The highest temperature reduction was recorded at 2.3 0C indicating a convective heat transfer of 1546W and a heat pipe effectiveness of 8.5%. The test confirmed that in general, the heat pipes performed better during the day-time when external temperatures reached over 40 0C in comparison to night-time operation when external temperatures dropped below 35 0C. The present work successfully characterized the sustainable operation of heat pipes in reducing air temperatures without the requirement of any mechanical intervention.

1.2 Objectives of the Study

1) Design a heat pipe augmented solar wall with nanofluid as working fluid in heat pipe emphasis on thermal performance assessment

2) Build a full-scale experimental modular unit and test under actual weather conditions, with emphasis on the prototype unit being as close as possible to building configuration from actual evaluation point of view.

3) Conduct performance analysis of the experimental model including component thermal resistances, conductivities, and overall system efficiency.

4) Give design considerations for further research which may impact the performance of the unit.

2. EXPERIMENTAL METHOD

An experimental model can be constructed to test the performance characteristics of the heat pipe augmented solar wall with nanofluid as working fluid. The design consisted of five individual heating units each consisting of an absorber plate clamped to a heat pipe. The heat pipes can be mounted at 5 degrees and consisted of an evaporator, adiabatic, and condenser section. The adiabatic section of the heat pipe can run through a layer of thermal insulation and then can be placed within a water tank which acted as a thermal mass. An aluminum frame can be built to support the absorbers, heat pipes, and water tanks, and the five heating units can be enclosed within an aluminum sheet metal skin with a glazing on the front of the unit.

Fig. 2.1 Layout of Elliptical TPCT collector

2.1 Selection and preparation of nano fluid

The selected nanopowder for the proposed study is CuO/$H_2$0 nanofluid 50nm size with water as base fluid. This selection of nanoparticle material is done on the basis of enhancement of thermal conductivity obtained with addition of nanoparticle material. As the thermal conductivity of CuO is high hence it is expected that addition of nanoparticle material with higher thermal conductivity leads to enhancement in thermal conductivity and higher heat transfer coefficient. The nanopowder is to be purchased from the Nanoshel USA. The amount of nanopowder required for the same can be calculated as below.

1. Nanoparticles with 2% concentration of CuO in the water is prepared and tested on the setup.

Calculation for mass of nanoparticles:

Inner diameter of heat pipe= 1.4 cm

Total length of heat pipe= 60 cm

Inner single volume of heat pipe = $\frac{\pi}{4} * d^2 * l$

$= \frac{\pi}{4} * (1.4)^2 * 60$

= 92.3 cm2 or ml

Total volume of 8 heat pipe = 92.36*8

= 738.9 ml

2. Filling ratio= 50%

Total volume of nano fluid= 0.5*738.9

= 369.45 ml

Adding 400 ml of distilled water in total volume of nanofluid in order to get CuO nanofluid with 2% volume fraction.

Total volume of nanofluid = 369.45+400

= 769.45 ml

3. Volume of Nano powder with 1% volume fraction = 0.01*769.45

= 7.7 ml

Volume of hybrid nano particles for 1% volume fraction = volume of 75% of CuO nanoparticles

Volume of 75% of CuO nanoparticles for 1% volume fraction = 0.75* volume of nanofluid

= 0.75 * 7.7

= 5.78 ml

Mass of 75% of CuO nanoparticles for 1% volume fraction = Density of CuO * Volume of 75% of CuO nanoparticles for 1% volume fraction

= 0.79 * 5.78

= 4.57 gm of CuO nanopowder for 1% volume fraction

Mass of Nanoparticles with 2% concentration of CuO= 4.57*2

= 9.14 gm

Thus 9.14 gm of CuO nanopowder is added in the 400 ml of water in order to get CuO nanofluid with 2% volume fraction.

3. TEST METHODOLOGY

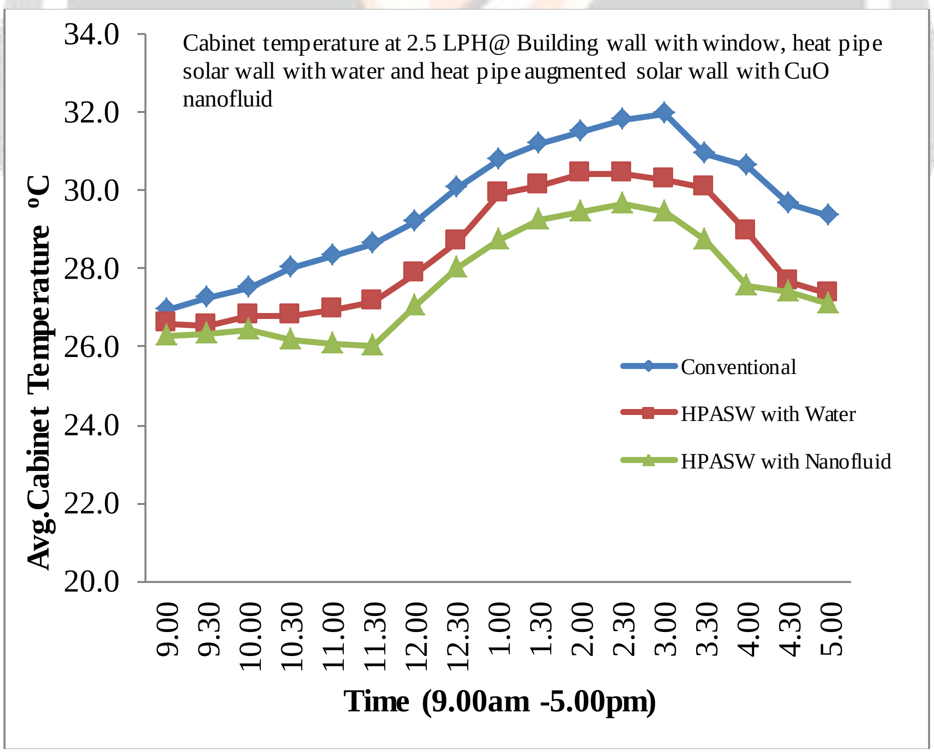
3.1 Introduction

The heat pipe augmented solar wall experimental model was installed on the wall at pune at latitude of 38.18 degrees North. The installation was in a second-story window enclosure on a south-facing wall. The outer face and inner face of the installed experimental unit.

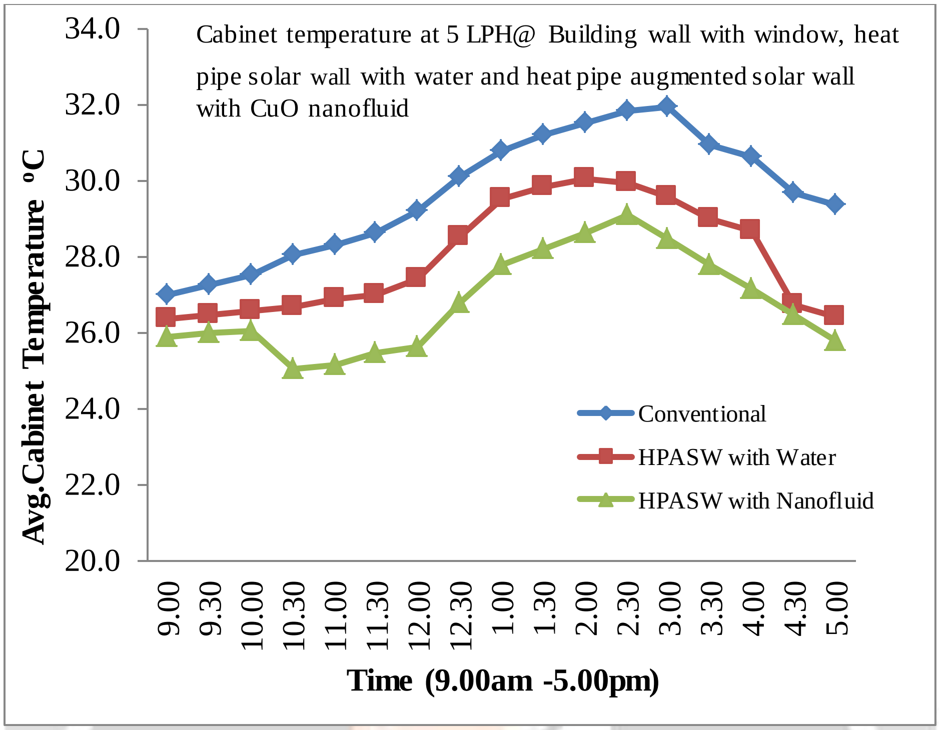
4. RESULTS AND DISCUSSIONS

4.1 Introduction

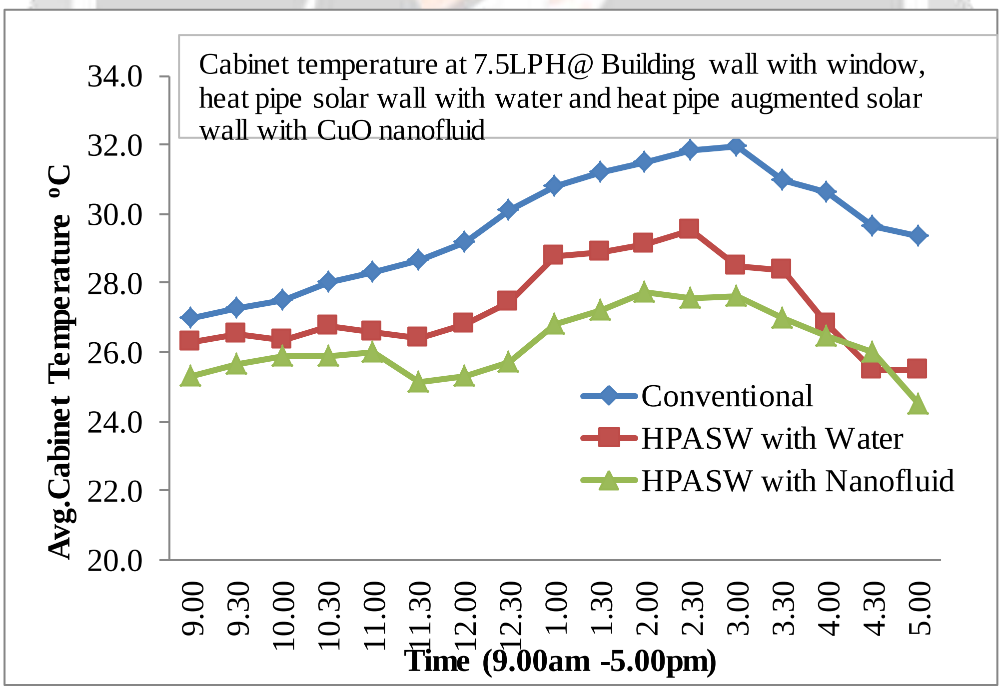
The performance of heat pipe augmented solar wall was experimentally evaluated. Experimentation was carried out to investigate the effect of model on the cooling enhancement. On the basis of the observations recorded the effectiveness of the heat pipe augmented solar wall with nanofluid and water can be recorded. The variation of effectiveness of heat pipe wall with nanofluid are represented graphically. The effect of temperature on the room temperature was recorded and difference between conventional building wall and heat pipe wall also observed. Also the efficiency of solar wall calculated by considering various parameters.



Average cabinet temperature vs Time (@ 2.5lph)



Average cabinet temperature vs Time (@ 5lph)



Average cabinet temperature vs Time (@ 7.5lph)

4. CONCLUSIONS

1) After performing no of experiment temperature of the cabinet are decreases up to 30C.
2) From experiment it is found that the temperature of the cabinet is decreases when heat pipe solar wall with nanofluid is installed comparatively conventional building wall and heat pipe solar wall with water.
3) By the application of CuO nanofluid collector efficiency is increases more than conventional collector
4) From experimental investigation it is found that the maximum solar intensity is in the time interval between 11am to 3pm is maximum.

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