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Design of a Tube Vent to Enhance the Role of Roof Solar Collector

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***Abstract*—**The objective of this paper was to designing a ventilation system to enhance the performance of roof solar collector (RSC) for reducing heat accumulation inside the house. The RSC has 1.8 m^2 surface area made of CPAC monier roof tiles on the upper part and gypsum board on the lower part. The space between CPAC monier and gypsum board was fixed at 14 cm.

Ventilation system of modified roof solar collector (modified RSC) consists of 9 tubes of 0.15m diameter and installed in the lower part of RSC. Experimental result showed that the temperature of the room, and attic temperature. The average temperature reduction of room of house used modified RSC is about 2^{o}C. and the percentage of room temperature reduction varied between 0 to 10%. Therefore, modified RSC is an interesting option in the sense that it promotes solar energy and conserve energy.

***Keywords*—**roof solar collector, heat accumulation

I. Introduction

IN tropical countries, such as Thailand, the greatest heat gain in single-storey buildings occurs through the roof, since this is the surface most exposed to solar radiation [1]. Solar radiation is composed of short-wave radiation which, on arriving at the surface of the roof tiles, is absorbed and the tiles heat up. Part of this heat is lost through convection and long-wave radiation to the external environment and another part is absorbed by the roof tiles and transmitted to the space corresponding to the attic[2]. The effect of heat accumulation in attic causes the upstairs rooms to be hotter. The reduction of heat in attic space can be achieved by natural ventilation [3]. There are many research to develop a ventilation in attic space such as Nankongnab, N.[4] has done many research works on temperature from the humidity under the attic and the roof made of wood and gypsum and to be tested and compared in the house in the Bangkok metropolitan area. The research results showed that the holes in the roof affected the temperature and the humidity in the attic because sunlight radiation during the daytime caused the ventilation of heat and humidity in the toilet and under the attic. After the sunset, the temperature under the attic would be close to the surrounding air, resulting in energy consumption and thermal comfort.

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The major heat load of buildings and workshops, made of metal structures, is the solar energy supplied through the roof. Several passive modifications have been introduced to the roof in order to reduce the temperature of indoor air in arid areas. The bio-climatic roof is designed in response to the Tropical climate of Thailand with respect to human thermal comfort. It has two functions in operation: In daytime the roof acts as a solar chimney and induces natural ventilation[5]. The use of photovoltaic (PV) panel can increase the induced ventilation rate of RSC considerably [6]. Maneewan et al.[7] has proposed a new concept of roof design named ‘‘thermoelectric roof solar collector’’ (TE-RSC) for both reducing roof heat gain and enhancing attic and house ventilation. the experiment results using real house configuration showed that a TE-RSC unit of 0.0525m^2 surface area can generate about 9W under 972W/m^2 global solar radiation and 35^{o}C ambient temperature. The induced air change varied between 20 and 40 and the corresponding ceiling heat transfer rate reduction is about 3–5W/m^2. The annual electrical energy saving was about 362 kWh. However, the house owners normally designed their house to become beautiful for the main reasons. Thailand is located in the tropical area and the roof cannot escape the sunlight. Therefore, to make the house owner get satisfied with the beauty of their house, this research was aimed to reduce the accumulated heat stored in the Thai house with gable and to ventilate the accumulated heat above the ceiling surface which is important for the heat transfer into the house.

II. Description Of The Test Houses

Two small houses (figure 1) for testing was built near the engineering building, Kasem Bundit University, Romklao campus, Bangkok, Thailand.

Fig. 1 Experimental houses

The roof of the house is gable roof with blue roof tile, the base area dimensions of 1.5 m × 1.5 m and height is 2.5 m. The slope of two sides of roof is 30°. The RSC has 1.8 m^2 surface area (1.2 m × 1.5 m). There are opening the size 1.5 m × 0.15 m at the top of the roof and the bottom of the soffit (Fig.2). The tube was installed in the lower part of RSC.

III. Roof Solar Collector, RSC

An interesting application for Thailand by building two part of roof to act as a solar collector to make air change in the room. The RSC is comprised mainly of two parts, as shown in Fig.2. The RSC has 1.8 m^2 surface area made of CPAC monier roof tiles on the upper part and gypsum board on the lower part. The space between CPAC monier and gypsum board was fixed at 14 cm.

IV. Methodology Of Experiment

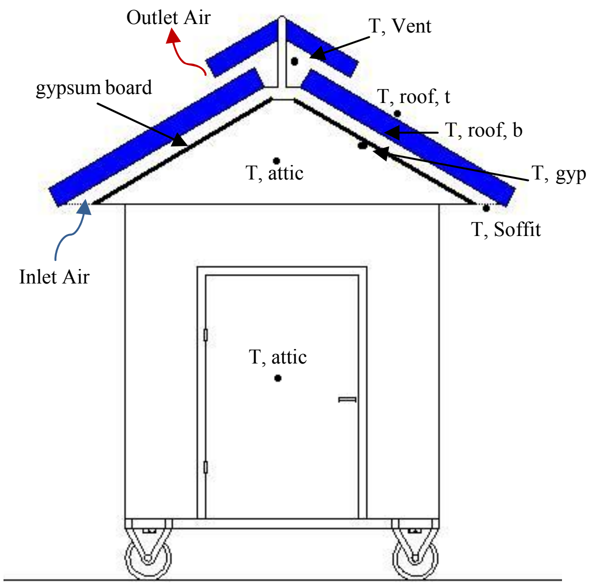
To test the thermal performance of the system, the comparable houses as shown in figure 1 (the left side is house with RSC, and the right one is house with new RSC). Thermocouples type K (range: 0-1250oC, accuracy ±0.5oC) are connected to the data logger (Hioki, Model: 8422-52, accuracy ±0.8%). The thermocouple wire was shielded to reduce any electrical noise. For surface temperatures, the thermocouples were bonded with epoxy to the surface and covered with cloth construction tape. The thermocouple measuring exterior air temperature was protected from solar radiation by a radiation shield. Solar intensity is measured using a CM11 Kipp & Zonen pyranometer. The data were averaged and saved every 10 min and every hour. The measuring positions are shown in figure 2, and it started at 9:00 a.m. and end at 6:00 p.m.

V. Result And Discussion

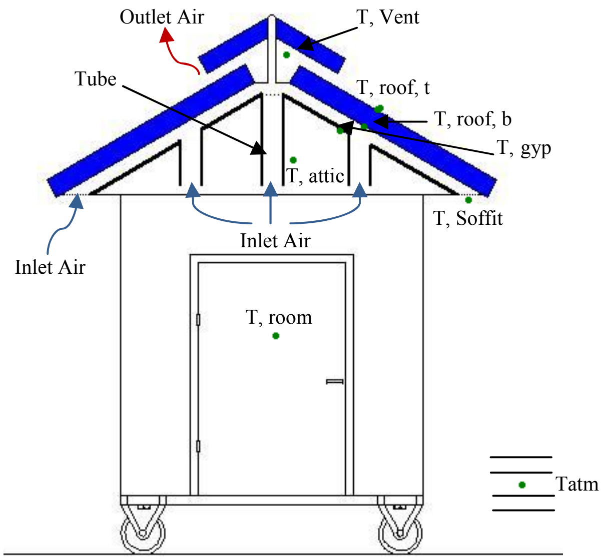
This study presents to the temperature reduction of the RSC. Testing the performance of two houses had been undertaken on same conditions. The result showed a comparison between the two configurations (Normal RSC and Modified RSC).

- *Attic temperature*

The figure 3(a) shows that attic temperatures followed ambient air temperature. The attic temperature of house used normal RSC higher than that of house used modified RSC by about 1 to 5°C. Temperature of attic is nearly closed to the ambient condition because of stack-effect ventilators (RSC and modified RSC) that use passive solar heat to boost their performance and to generate air movement by buoyancy force drawing air through them to induce natural ventilation. Figure 3(b) shows relationship between attic temperature and solar radiation. Certainly, attic temperature is same trend with solar radiation. During the daytime, the roof tiles will absorb large amounts of incident solar radiation and transfer heat into attic space. Heat will transfer through the ceiling into the room.

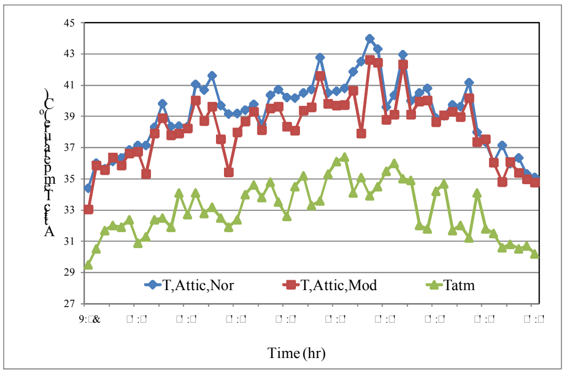


(a) House with RSC.

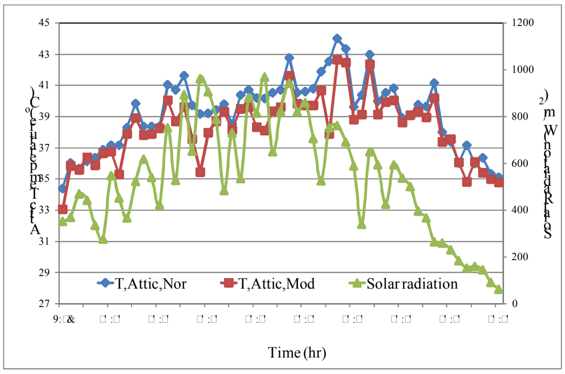


(b) House with RSC mod.

Fig. 2 Measuring positions of the houses

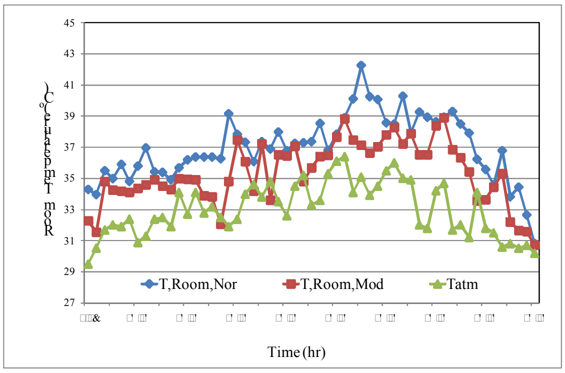


(a)Hourly variation of Attic temperature

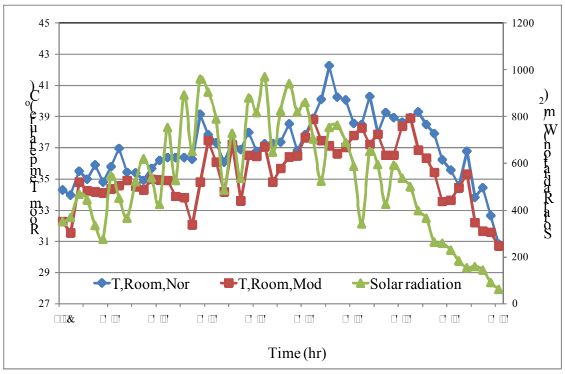


(b)Hourly variation of Solar intensity and Attic temperature

Fig. 3 Hourly variation of Attic temperature, Ambient air temperature and Solar intensity



(a) Hourly variation of Room temperature

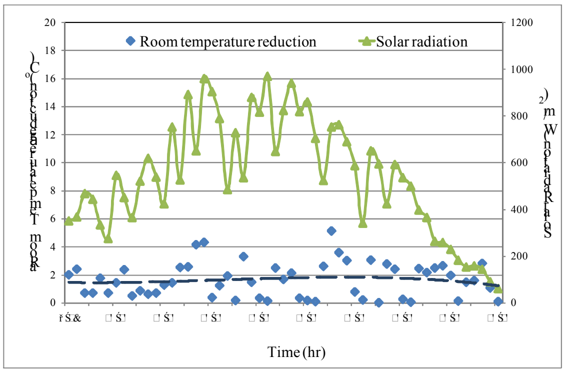


(b) Hourly variation of Solar intensity and Room temperature

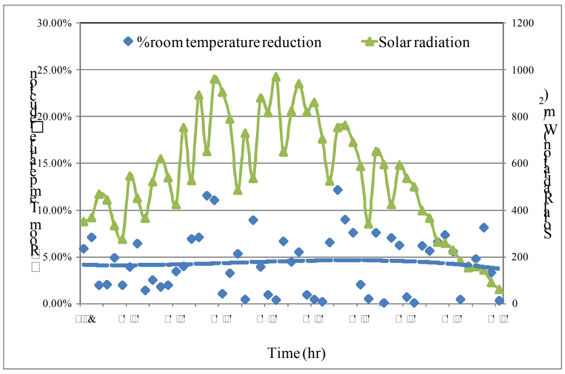
Fig. 4 Hourly variation of Room temperature, Ambient temperature and Solar intensity

- Room temperature

Heat in attic space will transfer through ceiling into the room. The test results showed (Figure 4) that room temperature of house used normal RSC is always higher than that of house used modified RSC by about 0 to 4°C. Temperature of room in. Figure 4(a) shows the hourly variation of room temperatures and ambient air temperatures. It can be seen that the temperature of room is always higher than that of ambient air temperature by about 0 to 5°C. Room temperatures are same trend with solar radiation showed in figure 4(b). Heat accumulate in room can reduce by natural ventilation through ceiling vent and tube(modified RSC) and remove at top of roof.



(a) Hourly variation of Room temperature reduction



(b) Hourly variation of % Room temperature redution

Fig. 5 Hourly variation of Room temperature reduction

- Room temperature reduction

Figure 5(a) showed that average room temperature reduction. Temperature of room of house used modified RSC lower than that house used normal RSC by average 2°C, and figure 7 (b) depicts a percentage of room temperature reduction. Between 9 a.m. to 6 p.m., the percentage of room temperature reduction varied between 0 to 10%.

VI. Conclusions

The use of Roof Solar Collector (RSC) to induce natural ventilation has been studied experimentally. The normal RSC is made by using CPAC monier tiles on the outer side and gypsum board on the inner.The modified RSC reorganize ventilation system consists of 9 tubes of 0.15m diameter and installed in the lower part of normal RSC. The experimental study of the modified RSC shows the high thermal performance. The experimental results show temperature of room of house used modified RSC lower than that house used normal RSC by about 0-4°C and the percentage of room temperature reduction varied between 0 to 10%.

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NOMENCLATURE

T_{amb}	Ambient temperature (°C)
$T_{Attic,Nor}$	Aiitc temperature of normal roof solar collector (°C)
$T_{Attic,Mod}$	Aiitc temperature of modified roof solar collector (°C)
$T_{Room,Nor}$	Room temperature of normal roof solar collector (°C)
$T_{Room,Mod}$	Room temperature of modified roof solar collector (°C)

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